ESTIMATING TURKISH STOCK MARKET RETURNS WITH APT MODEL: COINTEGRATION AND VECTOR ERROR CORRECTION

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ABSTRACT

Multifactor financial models are of great importance in analyzing practical asset prices. As an alternative to CAPM, Arbitrage Pricing Theory (APT), developed by Ross (1976), describes the expected returns on any financial asset with respect to macroeconomic factors. There are limited researches into APT and its applications in emerging markets. In this respect, it is crucial to analyze the Turkish stock market under APT perspective. The goal of this study is to investigate expected returns of Turkish stock market with APT during the period 2000-2012. Eight major indices of Borsa İstanbul (BIST) have been analyzed as benchmarks. The relationship between main stock indices and macroeconomic variables has been submitted to cointegration tests and vector error correction model analyses. The results have revealed that significant macroeconomic variables vary upon sectors and have a long-run effect in determining stock indices. Consequently, it should be noted that empirical tests of APT have robust estimations in analyzing the Turkish stock market.

Keywords: Arbitrage Pricing Theory, Cointegration, Emerging Markets, Turkey.

JEL: C32, G12.

1. INTRODUCTION

In the finance literature the most popular problem is to predict the risky asset prices. With the study of Harry Markowitz in 1952 the modern financial theory about risky assets started. In the study, he stated that investors want to maximize the expected returns of their risky investments and that risk modelled with variance of their portfolio is an undesirable thing for them.

Markowitz's (1952) study is crucial to explaining the preferences of investors and to understanding risk factors. The next step should be to determine the market equilibrium conditions and the risky asset prices. This theory was first introduced by Sharpe (1964), Lintner (1965) and Mossin (1966) with Capital Asset Pricing Model *(CAPM)*. In CAPM the non-diversifiable risk of an asset is represented by asset sensitivity to the market portfolio. Although CAPM is one of the most popular asset pricing models, since it has strict assumptions it was critized in many studies such as: Fama & French (1992) and Herrington (1987).

Arbitrage Pricing Theory (APT), a benchmark alternative study to CAPM, was introduced by Ross in 1976. Compared to CAPM it has fewer, less restrictive and reasonable assumptions. In APT the risky asset price is specified with many macroeconomic factors as the parts of systematic risk instead of just using market portfolio as CAPM.

In the finance theory, it is assumed that firm specific risk can be minimized with well

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diversified portfolios. Thus, the important risk for investors is a systematic risk and can be represented by different economic factors in APT.

The restriction of APT is no arbitrage condition. When this property is violated then unlimited risk free profits are possible. Therefore, it is a more realistic assumption than the strict assumptions of CAPM. It is more general than CAPM since it involves the intuition behind CAPM such as mean variance criteria but does not require utility assumption and it is not restricted to a single period modelling. The returns are approximately modelled with linear function of factor loadings (Roll & Ross 1980, p. 1076).

In the literature, there are many multifactor models using a different number of macroeconomic factors based on APT. Their results show that while the individual stock prices may be subject to firm specific factors, the overall stock market index is expected to be influenced by the macroeconomic conditions.

This paper attempts to examine the factors affecting the expected returns of the Turkish stock market, Borsa Istanbul (BIST), under APT by examining the short-run and long-run relations of major BIST-sectoral indices and Turkish macroeconomic variables with well known econometric models, namely Cointegration Analysis and Vector Error Correction Model (VECM).

The paper has three sections starting with introduction and review of the literature, including the papers about the theoretical background of APT and empirical studies conducted in this field. The second section introduces the data and methodology and depicts the empirical findings for the Turkish market. Finally, the last section concludes the paper.

1.1. Literature Review

The asset pricing literature started with the studies of Sharpe (1964), Lintner (1965) and Mossin (1966). They introduced CAPM to determine the market equilibrium conditions and the risky asset prices. The alternative APT model was introduced by Ross in 1976. Although the APT multifactor asset pricing model was introduced by Ross in 1976 as an alternative to CAPM, it was empirically developed by Roll & Ross (1980), Huberman (1982), Chemberlain & Rothschild (1982), Chen et al. (1986), Fama (1990) and Ferson (1991).

Roll & Ross (1980) conducted the emprical tests of APT using the US data. As a result of their study the APT theory is supported. They have found that the expected return depends on four factor loadings of macroeconomic variables. In 1982 Chemberlain and Rothschild extended APT by defining approximate factor structure. In the paper, it is stated that the principle component analysis can be used in application of APT when determining the factors.

Humberlain (1982) stated that APT in Ross's paper is sophisticated to understand since there is no explicit definition of arbitrage and he proved that there is no need for arbitrage condition. Therefore, in the paper the arbitrage is defined explicitly and the intuition behind APT is formalized.

Chen et al. (1986) empirically modelled the stock market returns with economic state variables as systematic factors and their influence on asset pricing was investigated. They found consistent results with APT.

After APT was modelled, many studies such as: Chen et al. (1980), Fama (1990), Ferson and Harvey (1991) showed that

macroeconomic variables are related to stock returns and have an explanatory power.
Several studies generally analyzed the short-run relation between stock returns and macroeconomic variables. Recently, the researchers from the USA and other developed nations attempted to examine short-run and long-run relations with the Cointegration Analysis and Vector Error Correction Model (VECM) of developed economies data.

The literature on testing APT with VECM goes back to the 1990s. Abdullah & Hayworth (1993) tried to explain the S&P 500 index price movements by macroeconomic variables, such as money supply, budget deficit, trade deficit, inflation, industrial production and interest rates with VECM and Granger Causality test. They concluded that there are causality relations between macroeconomic variables except industrial production and stock prices

Thornton (1998) analyzed the relationship between real stock prices, real money balances, real income and real interest rates in Germany with VECM and Granger Causality analysis. The results of the paper show that there is a long-run relationship between stock prices and money balances and that there is a unidirectional relationship from interest rates to real stock prices.

Cheung & Ng (1998) investigated the long-run relation between five developed nations (Canada, Germany, Italy, Japan and USA) stock indices and macroeconomic variables, such as real oil prices, real consumption, real money supply, real output and real gross national product. They found significant relations between stock indices and aggregate economic variables.

Darrat & Dicken (1999) tried to examine the relationship between real, monetary and financial sectors with VECM and Granger Causality test by including variables such as industrial production, money stock, S&P 500 index, consumer price index (CPI) and three month Treasury Bill rate. Their results indicated that the stock market is a significant indicator for money market and economic activity.

Chaudhuri & Smiles (2004) conducted VECM to analyze long-run and short-run relations between the Australian stock index and aggregate macroeconomic variables including real oil prices, real gross national product, real money supply and real private consumption. They found the empirical relation between stock prices and economic activity.

Rahman & Mustafa (2008) studied long-run and short-run effects of money supply and oil prices on S&P500 index. They only found short-run relations.

As mentioned above, many studies analyzing the effects of macroeconomic variables on stock markets for developed economies found a significant linkage. However, for developing economies, the literature on testing APT with VECM on determining the macroeconomic variables effect to the stock prices has not been well developed yet.

As the market participants and the availability of information change more frequently in emerging markets, the significance of macroeconomic variables in emerging markets differ from those of developed economies. What follows is the literature research we have conducted for emerging markets.

Adallah & Murinde (1997) investigated the interactions between exchange rates and stock prices in India, Korea, Pakistan and Philippines. The results show unidirectional causality from exchange rates to stock prices.

İbrahim (1999) analyzed short-run and long-run relations between Malaysian stock index and consumer price index, real industrial production index, money supply, exchange rates, credit aggregates and reserves with Cointegration Analysis and Granger Causality tests. They found the long-run relation between consumer price index, credit aggregates and reserves.

Muradoğlu et al. (2001) examined the long-term relation between Istanbul Stock Exchange composite index stock returns and monetary, such as money supply, overnight interest rates and foreign exchange rates with Cointegration Analysis. Their results display no cointegration relation between these variables. However, they stated that the results may lead to incorrect evaluations as market participants in emerging markets change rapidly.

Maghayereh (2003) studied the long-run relationship between Jordanion stock prices and economic indicators, such as industrial production, inflation, interest rates, trade balance, foreign exchange, oil prices and money supply with cointegration analysis. The results illustrated that the macroeconomic variables provide a direct long-run equilibrium relation with stock index.

Gunasekarage et al. (2004) examined the influence of macroeconomic variables including money supply, Treasury Bill rate, consumer price index and exchange rate on Sri Lanka stock market return. They found both short-run and long-run significance relations.

Hasan & Javed (2009) investigated the long-run interactions between Pakistan equity market and monetary variables, including money supply, consumer price index, interest rate and exchange rate by using multivariate Cointegration Analysis and Granger Causality test. Their results provide evidence on information transmission in stock markets having a significant impact of monetary variables.

Sohail & Hussain (2011) studied long-run and short-run dynamic relations between Pakistani stock index and macroeconomic indicators, such as consumer price index, industrial production index, real effective exchange rate, money supply and Treasury Bill rate with Cointegration Analysis. Their results revealed that there is a positive long-run relation between inflation, Gross Domestic Product (GDP) growth and exchange rate and that there is a negative relation between money supply and Treasury Bill rate.

Bekhet & Mugableh (2012) conducted an empirical examination of long-run and short-run equilibrium relations between Malaysian stock market and macroeconomic variables. They used Pesaron, Shin and Smith (PSS) bounds test approach. The results indicated that all macroeconomic variables are cointegrated with the Malaysian stock market.

Dasgupta (2012) examined the relation between selected macroeconomic variables including GDP, inflation, foreign exchange rate and interest rate and the Indian stock index. The results show no causality relation between these variables. However, they found the long-run relation, which means that stock market did not have informational efficiency.

There are some APT studies with emerging markets data and the Turkish Stock Market data. The studies on the Turkish stock market with macroeconomic variables mostly examine the short-run relations (Kasman et al. 2011; Özlen & Ergun 2012; İnan 2011; Rjoub et al. 2009; Muzır et al. 2010 and Çifter & Özun 2007).

On the other hand, the studies on examining long-run relations between the Turkish stock market and macroeconomic variables are limited, (Muradoğlu & Metin 1996; Muradoğlu et al. 2001 and Açıkalın et al. 2008).

2. EMPRICAL STUDY

2.1. Turkish Equity Market and Economy

In accordance with *"Istanbul Stock Exchange (ISE) Regulations"* dated December 1985, ISE - the organized Turkish stock exchange was officially established. The exchange transactions were initiated on January 3, 1986. The exchanges operating in the Turkish capital markets merged under Borsa İstanbul on April 3, 2013 (BIST 2012).

The main index of the Turkish stock market is the BIST-100 index. In 2012, the BIST-100 Index showed a continuous uptrend and closed the year at 78,208 points, despite downturns in April and May. In 2012, the ISE - 100 Index decreased by 52.6% in TL terms and 62.1% in US Dollar terms as compared to the previous year. In 2012, Industrials Index decreased by 34.0% (42.4% in US Dollar terms), Financial Index by 60.2% *(70.2% in US Dollar terms)* and Services Index by 45.6% *(57.7% in US Dollar terms)* (CMBT, 2012).

The total trading volume of the Turkish Equity Market in Turkish Liras *(TL)* and US dollar *(US$)* is given in Table 2.1. The Table shows the total trading volume decrease of 10.5% in TL terms, and the decrease of 17.8% in dollar terms in 2012 compared to 2011 (CMBT, 2012).

Table 2.1 Total Trading Volume of Turkish Equity Market

Years	TR *(Billion)*	US$ *(Billion)*
2007	387.7	300.8
2008	332.6	261.3
2009	482.5	316.3
2010	635.9	425.7
2011	694.8	423.6
2012	621.9	347.9

Source: (CMBT, 2012).

By the end of 2012, 600 companies were registered with the capital markets board, of which 406 were traded on the ISE. As of the end of 2012, 99 investment companies were authorized to trade in the Turkish Equity Market. The daily average number of contracts, which stood at 405,000 in 2011, decreased by 23 percent to 312,000 in 2012 (BIST 2012).
Economic growth was 8.8% in 2011, nevertheless showing a declining trend throughout the year. The downward trend continued in 2012. The resulting annual growth reached only 2.2% for 2012 (BIST 2012).

Due to the significant depreciation of the TL and the rising commodity prices in 2011, the inflation rate was realized at 10.5 %, quite higher than the targeted rate of 5.5%. In 2012, the depreciation of the TL was limited and the inflation rate fell to 6.2 % while the target inflation was 5 %. Repo interest rate with one week maturity was maintained at a level of 5.75.

Besides, the overnight lending interest rate, which is the lower band of the interest corridor, was maintained at a level of 5 during the year, while the upper band, which is the overnight borrowing interest rate, was decreased gradually from 12.50% to 9%. The foreign currency rate, which followed a volatile trend in 2011, increased sharply towards the end of the year and during 2012 stood at around 1.80% despite small fluctuations (BIST 2012).

The current account deficit reaching 10% of GDP in 2011 and policies implemented to curb the current account deficit in 2012 resulted in a rapid reduction in the growth rate down to 2.2%, along with a 37.5% percent reduction from the previous year in the current account deficit, which declined to 6% of GDP in 2012. Unemployment rate continued to decrease as in the previous years. After falling to 9.8% in

2011 from 11.9 %, in 2012 unemployment rate declined further to 9.2 by a 0.6 point decrease from the previous year (CMBT, 2012).

2.2. Data and Methodology

To identify the relationships between the Turkish stock market indices and macroeconomic variables, quarterly data covering 2000 and 2012 is used. The sample consists of main stock indices[*] such as: *BIST-100, BIST-30, BIST-50, BIST-SERV, BIST-REIT, BIST-FIN, BIST-IND* and *BIST-TECH* that are listed on Borsa İstanbul.

Besides, BIST-100, BIST-30 and BIST-50 stock indices include top 100, 30 and 50 stocks which are selected among the stocks of companies traded on the Turkish Stock Exchange and the stocks of real estate investment trusts and venture capital investment trusts traded on the Collective Products Market. Since some of the macroeconomic variables are determined quarterly, the values of GDP, inflation, oil prices, exchange rates, and logarithmic returns of interest rates are all arranged as quarterly. In addition, logarithmic returns of stock exchanges are estimated[†] quarterly.

Table A1 shows the descriptive statistics and Jarque Berra normality test results. As seen from the Table, distribution of variables shows positive or negative skewness values, which means flatter tails than the normal distribution. The kurtosis statistics also show that data is not normally distributed because values of kurtosis are deviated from 3. However, except for *BIST-SERV* and dollar rate the values are not deviated too much. Jarque Berra test results show that the null hypothesis of normality cannot be rejected for the variables except *BIST-SERV* and dollar rate at %5 significance level.

The aim of this study is to investigate the relationship between the Turkish stock market and some of the macroeconomic variables from the period 2000 to 2012 under APT. APT is a multifactor model of asset pricing defined as:

$$r_i = E(r_i) + \sum_{j=1}^{k} \beta_{i,j} f_j + \varepsilon_i$$

(Eq.1)

where,

r_i is the actual return on i[th] asset,

$E(r_i)$ is the expected return on i[th] asset,

$\beta_{i,j}$ is the coefficient that measures the response or loadings of i[th] asset with j[th] factor,

f_j is the j[th] factor and

ε_i is the unsystematic components of risk for i[th] asset.

Here, the unsystematic risk factor ε_i of multifactor model will be close to zero for well diversified portfolio. In APT any market equilibrium must be consistent with no arbitrage condition. No arbitrage condition indicates that there is no asset in the market which has zero price and strictly positive payoff.

When these conditions are satisfied, then in order to form well diversified portfolio the weight of risk free asset will be $(1-\sum_{j=1}^{k}\beta_{i,j})$ and the weight of other factors will be $\sum_{j=1}^{k}\beta_{i,j}$. Therefore, the expected return of the portfolio would be:

[*] *BIST-SERV* represents services, *BIST-REIT* represents real estate investment trusts, *BIST-FIN* represents financials, *BIST-IND* represents industrials and *BIST-TECH* represents technology sectors.

[†] The data is obtained from BIST, Turkish Central Bank and Turkish Statistical Institute. The inflation is represented by consumer price index and to represent the exchange rate, dollar rate is used.

$$E(r_i) = r_f + \sum_{j=1}^{k} \beta_{i,j} \lambda_j$$

(Eq.2)

Here,
$E(r_i)$ is the expected return on i[th] asset,
r_f is the return on risk free asset,
$\beta_{i,j}$ is the coefficient of j[th] factor and
λ_j is the risk premium of j[th] factor.

That gives us the APT pricing equation with the following assumptions.

- All assets have finite expected values and variances.
- Some investors can form well diversified portfolios.
- In the market there are no taxes and no transaction costs.

As we will investigate the relationship between the Turkish stock market and some of the macroeconomic variables from the period 2000 to 2012, the time series data analysis is needed to analyze the data. In time series modelling, stationarity is a very important concept. In some cases, while regressing one time series variable on another may result high R^2 even though they are not related (Gujarati 2004, p. 792).

The mentioned problem is known as *spurious regression* and caused by *nonstationarity*. Therefore, stationarity is needed for valid inferences. In addition, stationary tests are also needed to determine the order of integration in cointegration analysis. While analyzing relationships between variables to see long-run relations, cointegration analysis is very important.

There are different types of stationarity tests, also known as unit root tests. The widely used test is the Augmented Dickey Fuller (ADF) test which is introduced by Dickey & Fuller (1979). It became popular since extra lagged terms of the dependent variable can be included to eliminate autocorrelation (Sohail & Hussain 2011, p.77).

In order to conduct ADF test with a constant and a trend to test the stationarity of time series variable x, the following regression equation is used:

$$\Delta x_t = \beta_0 + \lambda t + \psi x_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta x_{t-i} + u_t$$

(Eq.3)

Here, Δ is difference operator, β_0 is the constant, and t is the trend term. In ADF the null hypothesis of ψ =0 is tested. In other words, the null hypothesis is that the time series is non-stationary.

The next step of determining relationship between variables is to investigate whether there is a cointegration between variables or not. When the long-run relationship is important then cointegration analysis is needed since it shows us the long-run comovement of the variables. A set of variables is defined as cointegrated if a linear combination of them is stationary although some of them or even all of them are non-stationary.

There are different types of cointegration tests. In this paper, the Vector Autoregressive (VAR) based cointegration test which was introduced by Johansen & Jeselius (1990) is used. This test is known as the Johansen and Jeselius cointegration test. The VAR model is a hybrid model that combines univariate time series analysis with simultaneous modeling (Brooks 2002, p.330).

Therefore, the researcher does not need to determine which variable is dependent and which is independent. The separate equations of each variable in VAR include the lagged terms of all the variables. Suppose the system includes *"k"* variables that are I*(1)* , the VAR model with *p*-lags will be:

$$x_t = \alpha_0 + \sum_{j=1}^{p} \beta_j x_{t-j} + u_t$$

(Eq.4)

where,
α_0 is the $kx1$ vector of constants,
x_t is the $kx1$ vector of non-stationary I*(1)* variable,
β_j is the kxk matrix of coefficients and
u_t is the $kx1$ vector of residuals.
So as to use the Johansen and Jeselius cointegration test, the model given above needs to be turned into the VECM model given as (Brooks 2002, p. 403):

$$\Delta x_t = \alpha_0 + \sum_{j=1}^{p-1} \Gamma_j \Delta x_{t-j} + \Pi x_{t-k} + u_t$$

(Eq.5)

here,
$\Pi = \sum_{j=1}^{p} \beta_j - I_k$ and $\Gamma_i = \sum_{j=1}^{i} \beta_j - I_k$,
Δ is the difference operator,
I_k is the kxk identity matrix,
Γ_i represents the short-run adjustments,
Π is the long-run coefficient matrix.

The Johansen and Jeselius cointegration test is conducted by using rank of Π matrix *via* its Eigen Values. Suppose the Eigen Values are $\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_k$. There are two test statistics for cointegration (Brooks, 2002). The first one is the Trace Test with the following test statistics.

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{k} \ln(1-\hat{\lambda}_i)$$

(Eq.6)

The second test is Maximum Eigen Value test with the following test statistics.

$$\lambda_{\max}(r, r+1) = -T \ln(1-\hat{\lambda}_{r+1})$$

(Eq.7)

where,
r is the number of cointegrated vectors,
$\hat{\lambda}_i$ is the estimated value for i[th] ordered Eigen value of Π matrix and
T is the number of usable observations.

The Trace Test is a joint test where the null hypothesis is that the number of cointegrated vectors is less than or equal to r. The Maximum Eigen Value test conducts separate tests on Eigen value where the null hypothesis is that the number of cointegrating vectors is r against an alternative of *(r+1)* (Brooks 2002, p. 404).

Since in VAR equations of each variable include lagged terms of all the variables, lag length is very important for modelling. In addition, the Johansen and Jeselius cointegration test is sensitive to the lag length. In this paper, the exact lag lengths are determined according to the Akaike Information Criterion (AIC) because it is flexible and it has no assumptions about the distributions.

When cointegration test is applied and no cointegration relation is found, then non-stationary variables can be transformed by taking the differences and the normal VAR model can be used directly. However, when there is cointegration relation and if the relationship between variables is very important, then using VECM will be more appropriate. In that case, there are two main problems of using first differences. First of all, when we use first differenced series then implicitly the error process is also differenced, which leads non-invertible moving average error process. Secondly, the model will not have a long-run solution (Asteriou & Hall 2007, p. 328).

VECM does not only include the lagged terms of the variables but also includes the first differences of the variables in separate equations. That means that it shows short-run and long-run relationships at the same time. When we analyze the VECM results, we may observe some meaningful relations between the variables and lag of variables but since each equation includes many lags of each variable it may be difficult to see which variable has a significant effect on others exactly.

Then, the last step of checking causality relation between the variables is needed. One of the popular causality tests is Granger Causality. In the test, the causality of each variable is tested by using null hypothesis for all lags of the variable In other words it shows whether one variable can be explained by the other or not.

2.3. Results of Estimation Tests for Turkish Equity Market

The first step of our analysis is to test the stationary with ADF test. Table A2 in Appendix shows the ADF results for all the variables on the model including the intercept, intercept and trend and none of the components. It is seen that the null hypothesis that the series is non-stationary is rejected for all stock indices, interest rates and US dollar in their levels. However, macroeconomic variables such as GDP, inflation and oil price series are non-stationary in levels with %5 significance level.

After applying the test for GDP, inflation and oil price first differenced series, we got the results shown in Table A3. The results show that these series are stationary on first difference level. If a non-stationary series becomes stationary when it is differenced d times then its integrating order is d. Then these three variables' integrating order is 1. If variables with differing orders of integration are combined, the combination will have an order of integration equal to largest (Brooks 2002, p. 405).

Then cointegration order for our models is one. For the optimal lag length determination (since the number of observations is limited) the AIC results are checked for lag 1 to 4. The AIC results for the models that include each stock index with all macroareconomic variables are shown in Table 4.

Model-1 shows the results of model for *BIST 100* index. *Model-2* shows the results of model for BIST 30 index. *Model-3, Model-4, Model-5, Model-6, Model-7* and *Model-8* show the results for indices *BIST-50, BIST-SERV, BIST-REIT, BIST-FIN, BIST-IND, and BIST-TECH* respectively. As seen from Table A4 the optimal lag length for each model is four lags.

After determining the optimal lag length and order of cointegration, the Johansen and Jeselius cointegration test can be applied. As we have mentioned, this method uses Trace and Maximum Eigen Value statistics to test the cointegration relation between the variables. It also shows the number of cointegrated relations.

Table A5 shows the results of cointegration test for the models respectively. It is seen that for each model there are long-run relations between the variables. The table also shows that there are four cointegration equations for each model except *Model-4*.

Since we have found cointegration relation, then the model for each stock index is given as:

$$\Delta BIST_t^i = \alpha_0 + \sum_{j=1}^{p-1} \beta_{1,j} \Delta BIST_{t-j}^i + \sum_{j=1}^{p-1} \beta_{2,j} \Delta DOLAR_{t-j} + \sum_{j=1}^{p-1} \beta_{2,j} \Delta GDP_{t-j} + \sum_{j=1}^{p-1} \beta_{2,j} \Delta INF_{t-j} + \sum_{j=1}^{p-1} \beta_{2,j} \Delta INT_{t-j} + \sum_{j=1}^{p-1} \beta_{2,j} \Delta OIL_{t-j} + \Pi BIST^i{}_{t-k} + u_t$$

(Eq.8)

Table 2.2 shows the normalized cointegrating coefficients of the models. The bold coefficients are the significant coefficients. From the table we can observe the long-run relations. As can be seen from the tables given below, we have realized that generally macroeconomic variables have a significant effect on stock indices.

It is seen that GDP has a positive effect; inflation rate and interest rate have a negative significance long-run effect on main stock indices. The rest of the table shows the long-run relationships between sector index returns and macroeconomic variables. The significant macroeconomic variables change from one sector to another. However, interest rate is found as the common macroeconomic determinant and commonly negative effect on each sector index except the technology index. This result is consistent with the related literature.

Table 2.2 Normalized Cointegrating Coefficients of Models in Turkish Security Market

BIST100(-1)	**DOLLAR(-1)**	**GDP(-1)**	**INFLATION(-1)**	**INTEREST(-1)**	**OIL(-1)**	**C**
1	-0.151326	**-4.49E-08**	**4.09E-05**	**0.532724**	0.000869	0.699419
t values	[-1.41926]	**[-3.43244]**	**[3.44929]**	**[3.64941]**	[1.73490]	
BIST30(-1)	**DOLLAR(-1)**	**GDP(-1)**	**INFLATION(-1)**	**INTEREST(-1)**	**OIL(-1)**	**C**
1	**-0.277791**	**-6.12E-08**	**5.88E-05**	**0.615885**	0.001026	1.045274
t values	**[-2.36075]**	**[-4.26859]**	**[4.51245]**	**[3.84585]**	[1.87508]	
BIST50(-1)	**DOLLAR(-1)**	**GDP(-1)**	**INFLATION(-1)**	**INTEREST(-1)**	**OIL(-1)**	**C**
1	-0.203989	**-5.59E-08**	**5.19E-05**	**0.618753**	0.00094	0.902044
t values	[-1.83770]	**[-4.11718]**	**[4.20582]**	**[4.10346]**	[1.82020]	
BISTSERV(-1)	**DOLLAR(-1)**	**GDP(-1)**	**INFLATION(-1)**	**INTEREST(-1)**	**OIL(-1)**	**C**
1	**-0.689394**	**-8.58E-08**	**5.96E-05**	**0.388743**	**0.003085**	2.009356
t values	**[-9.84608]**	**[-11.0346]**	**[8.40330]**	**[5.59738]**	**[12.7990]**	
BISTREIT(-1)	**DOLLAR(-1)**	**GDP(-1)**	**INFLATION(-1)**	**INTEREST(-1)**	**OIL(-1)**	**C**
1	**0.879489**	2.82E-08	**-4.07E-05**	**1.023073**	-0.000858	-1.36229
t values	**[5.41970]**	[1.2339]	**[-2.15391]**	**[4.08110]**	[-0.94556]	
BISTFIN(-1)	**DOLLAR(-1)**	**GDP(-1)**	**INFLATION(-1)**	**INTEREST(-1)**	**OIL(-1)**	**C**
1	**-0.301661**	**-5.30E-08**	**4.27E-05**	**0.46548**	**0.001953**	0.98546
t values	**[-2.32129]**	**[-3.24664]**	**[2.92041]**	**[2.41584]**	**[3.08271]**	
BISTIND(-1)	**DOLLAR(-1)**	**GDP(-1)**	**INFLATION(-1)**	**INTEREST(-1)**	**OIL(-1)**	**C**
1	**0.243764**	-4.79E-09	1.52E-05	**0.442058**	**-0.00119**	-0.33428
t values	**[3.08401]**	[-0.48077]	[1.71947]	**[3.99904]**	**[-2.89925]**	
BISTTECH(-1)	**DOLLAR(-1)**	**GDP(-1)**	**INFLATION(-1)**	**INTEREST(-1)**	**OIL(-1)**	**C**
1	-1.364617	**3.53E-07**	-0.000161	**-4.863006**	-0.00595	-4.06303
t values	[-1.84833]	**[3.66778]**	[-1.90993]	**[-4.59793]**	[-1.53700]	

**The significant coefficients are written in bold.*

Table 2.3 Results of Vector Error Correction Model for Models in Turkish Security Market

Error Correction	**X=D(BIST100)**	**X=D(BIST30)**	**X=D(BIST50)**	**X=D(BISTSERV)**	**X= D(BISTREIT)**	**X=D(BISTFIN)**	**X=D(BISTIND)**	**X= D(BISTTECH)**
CointEq1	**-1.59334**	-1.26327	-1.40758	-1.55446	**-1.598888**	**-1.462996**	**-1.65907**	-0.218797
D(X(-1))	0.661653	0.384080	0.510123	0.246107	0.374588	0.645154	0.465894	**-0.900436**
D(X(-2))	0.755227	0.512274	0.629417	0.333436	0.570101	0.703522	0.678824	-0.655498
D(X(-3))	0.537250	0.440257	0.492578	0.566493	0.196267	0.595534	0.305723	-0.274643
D(X(-4))	0.257138	0.282997	0.262595	0.314880	-0.090013	0.377102	-0.023734	-0.052374
D(DOLLAR(-1))	**-1.05797**	**-1.04145**	**-1.01946**	**-1.01867**	-0.686588	**-1.222075**	**-0.870781**	-0.753558
D(DOLLAR(-2))	**1.060588**	0.909219	**0.995226**	0.192954	**2.625200**	**1.228700**	**1.076996**	0.253437
D(DOLLAR(-3))	0.080547	0.065262	0.108760	0.220857	0.320993	0.041912	**0.070272**	-0.011544
D(DOLLAR(-4))	0.114581	0.117374	0.105204	-0.14629	0.508381	0.193347	0.159988	0.202927
D(GDP(-1))	-4.83E-08	-6.99E-08	-5.78E-08	**-2.02E-07**	**2.13E-07**	-7.72E-08	5.77E-08	-1.43E-08
D(GDP(-2))	8.04E-08	4.52E-08	6.03E-08	-5.57E-08	**3.59E-07**	7.20E-08	**1.69E-07**	6.67E-08
D(GDP(-3))	-2.30E-08	-4.83E-08	-3.22E-08	-9.39E-08	1.44E-07	-5.61E-08	6.20E-08	-1.21E-08
D(GDP(-4))	2.76E-08	3.59E-09	1.72E-08	-3.71E-08	**2.15E-07**	1.37E-08	8.28E-08	-6.88E-08
D(INFLATION(-1))	-0.00044	-0.0004	-0.00041	-0.00051	-0.000208	-0.000615	-0.000225	-0.00064
D(INFLATION(-2))	0.000266	0.000236	0.000241	-2.31E-05	0.000544	0.000323	0.000337	2.57E-05
D(INFLATION(-3))	0.000146	9.17E-05	0.000145	1.11E-05	8.79E-05	5.03E-05	0.000215	-0.00019
D(INFLATION(-4))	-0.00022	-0.00026	-0.00023	-2.28E-05	4.50E-05	-0.000376	-5.79E-05	-0.000705
D(INTEREST(-1))	0.964677	0.729288	0.866149	0.457800	**1.991375**	0.740573	**1.125785**	-0.868753
D(INTEREST(-2))	0.039172	-0.13692	-0.0096	-0.22417	0.372968	-0.289791	0.300415	**-1.421885**
D(INTEREST(-3))	0.176339	0.102732	0.155235	-0.29974	0.415251	0.040820	0.282911	**-1.136604**
D(INTEREST(-4))	0.385699	0.329297	0.372307	0.005127	**0.659727**	0.341956	0.402970	-0.300756
D(OIL(-1))	0.003984	0.003698	0.003713	0.008465	-0.005145	0.006175	-0.000521	0.001678
D(OIL(-2))	-0.0014	-0.00051	-0.00104	0.007510	**-0.016541**	0.001603	**-0.008825**	-0.001126
D(OIL(-3))	0.000404	0.001869	0.001048	0.003789	-0.004709	0.003385	**-0.006436**	-0.002104
D(OIL(-4))	0.004618	0.004304	0.004231	0.005216	-0.00077	0.006603	**0.002256**	0.002085
C	0.039276	0.084571	0.050838	0.180533	**-0.331627**	0.137651	-0.134979	0.479737
R-squared	0.913231	0.895115	0.905680	0.937812	0.909685	0.907027	0.879093	0.872464
F-Statistic	6.735866	5.461949	6.145407	9.651418	6.446331	6.243682	4.653320	4.378203

**The significant coefficients are written in bold.*

Table 2.3 shows the error correction coefficients. Error correction coefficients show us the short-run effects for the variables. Mainly, in the VECM model there are coefficients of each variable for each equation.

However, in this paper our aim is to determine the effect of each macroeconomic variable to the stock indices. We have just given the coefficients of equations for stock indices. Again the coefficients given as bold character are the significant ones.

The US dollar rate has a short-run unidirectional significance effect on stock indices except the technology index. The only significant macroeconomic variable for the technology index is interest rate. The significant macroeconomic variable for main stock indices such as BIST-100, BIST-50 and BIST-30 is the dollar rate in the short-run.

Table 2.4 VEC Granger Causality/Block Exogeneity Wald Tests for Each Indices

Excluded	Prob. Model-1	Prob. Model-2	Prob. Model-3	Prob. Model-4	Prob. Model-5	Prob. Model-6	Prob. Model-7	Prob. Model-8
D(DOLLAR)	**0.0014**	**0.0164**	**0.0041**	**0.0045**	**0.0000**	**0.0092**	**0.0024**	0.7946
D(GDP)	0.2006	0.4059	0.3553	**0.0320**	**0.0003**	0.2787	**0.0056**	0.1620
D(INFLATION)	0.4893	0.6206	0.5777	0.6143	0.2663	0.2826	0.4567	0.2563
D(INTEREST)	0.101	0.2909	0.1727	0.2054	**0.0006**	0.2296	**0.0453**	**0.0418**
D(OIL)	0.2588	0.4640	0.3781	0.2060	**0.0004**	0.2634	**0.0045**	0.9547
All	**0.0032**	**0.0245**	**0.0071**	**0.0000**	**0.0000**	**0.0049**	**0.0011**	**0.0003**

**The significant coefficients are written in bold.*

Table 2.4 shows the Granger causality test results of the models with stock indices. The Granger causality test is appropriate to examine the short-run relations between two variables. The significance relations are given in bold. The results are consistent with VECM short-run coefficient results.

3. CONCLUSION AND REMARKS

This paper examines the relationships between the main Turkish stock indices and some macroeconomic indicators of Turkish economy with the Johensen and Jeselius cointegration tests, VECM model and Granger Causality tests. In the study, in addition to the main stock indices such as *BIST 100, BIST 50* and *BIST 30*, the sectoral stock indices were also used, such as *BIST-SERV, BIST-REIT, BIST-FIN, BIST-IND and BIST-TECH* representing the performances of service, real estimate, financial, industrial and technology sectors.

From the literature it is known that generally the individual stock prices may be subject to the firm specific factors. However main stock indices are expected to be influenced by macroeconomic factors. There are studies investigating the effect of macroeconomic factors on *BIST-100* but there is limited research about sectoral indices.

We have analyzed the effects of macroeconomic factors which differ in each financial sector equities of Turkey. Our empirical findings support our mentioned thesis. The results of cointegration analyses reveal that generally macroeconomic variables have long-run effect when determining the returns of stock indices.

On the other side, the VECM and Granger Causality results have shown that the significant macroeconomic variables change depending upon the sector. The finance sector is affected by the US dollar rate. However, the only macroeconomic variable affecting the technology sector is interest rate.

Finally, our results have shown that significant macroeconomic variables vary depending upon sectors and have long-run effect in determining stock indices and that empirical tests of APT provide robust estimations in analyzing the Turkish stock market.

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4. APPENDIX

Table A1. Descriptive Statistics of the Data Set

	BIST-100	BIST-50	BIST-30	BIST-IND	BIST-SERV	BIST-REIT	BIST-FIN	BIST-TECH	GDP	INTEREST	INFLATION	OIL	DOLLAR
Mean	0.031034	0.030748	0.03041	0.034908	0.024357	0.013936	0.032443	0.011729	23060351	-0.02849	11236.43	89.045	1.429523
Median	0.030986	0.02464	0.050325	0.043243	0.050491	0.038702	0.054114	0.016654	23528095	-0.029422	11311.49	76.82166	1.44947
Maximum	0.57283	0.567704	0.559698	0.452933	0.729079	0.408641	0.598347	0.792676	31088173	0.343158	17831.58	216.5041	1.83121
Minimum	-0.364	-0.35648	-0.34631	-0.30161	-0.40659	-0.39262	-0.46109	-0.62071	15419915	-0.370472	3320.933	18.70536	0.67886
Std. Dev.	0.193248	0.193922	0.194926	0.162702	0.191022	0.213281	0.22381	0.252005	4133602	0.139337	3966.529	54.44363	0.215754
Skewness	0.266304	0.255965	0.250632	0.160891	0.511002	-0.12197	0.080461	0.27422	-0.144202	-0.005618	-0.19153	0.720548	-1.15205
Kurtosis	3.104314	3.03148	2.93491	2.813866	5.85691	2.094435	2.928886	4.078865	2.036757	3.261929	2.129425	2.459945	6.015584
Jarque-Bera	0.576834	0.515166	0.50036	0.270621	18.02925	1.722468	0.060616	2.868444	1.979905	0.134603	1.771579	4.638148	28.20518
Probability	0.749449	0.772917	0.77866	0.873445	0.000122	0.42264	0.970147	0.238301	0.371594	0.934913	0.412388	0.098365	0.000001

Table A2. ADF Stationary Test Results of Variables on Their Own Levels

	BIST-100			BIST-50			BIST-30		
	none	**intercept**	**intercept/trend**	**none**	**intercept**	**intercept/trend**	**none**	**intercept**	**intercept/trend**
ADF test statistics	-7.10977	-7.303836	-7.218756	-7.08586	-7.27627	-7.218756	-7.08312	-7.2667	-7.183965
Prob	0	0	0	0	0	0	0	0	0
Test critical values									
1%	-2.6162	-3.581152	-4.170583	-2.6162	-3.58115	-4.170583	-2.6162	-3.58115	-4.170583
5%	-1.94814	-2.926622	-3.51074	-1.94814	-2.92662	-3.51074	-1.94814	-2.92662	-3.51074
	BIST-SERV			**BIST-REIT**			**BIST-FIN**		
	none	**intercept**	**intercept/trend**	**none**	**intercept**	**intercept/trend**	**none**	**intercept**	**intercept/trend**
ADF test statistics	-8.31242	-8.508668	-8.43482	-6.56633	-6.52354	-6.4786	-7.19686	-7.3367	-7.253507
Prob	0	0	0	0	0	0	0	0	0
Test critical values									
1%	-2.6162	-3.581152	-4.170583	-2.6162	-3.58115	-4.170583	-2.6162	-3.58115	-4.170583
5%	-1.94814	-2.926622	-3.51074	-1.94814	-2.92662	-3.51074	-1.94814	-2.92662	-3.51074
	BIST-TECH			**GDP**			**INTEREST**		
	none	**intercept**	**intercept/trend**	**none**	**intercept**	**intercept/trend**	**none**	**intercept**	**intercept/trend**
ADF test statistics	-7.43958	-7.385602	-7.553094	1.842816	-0.6777	-3.171263	-4.32049	-4.465	-4.401195
Prob	0	0	0	0.9827	0.8411	0.104	0.0001	0.0008	0.0054
Test critical values									
1%	-2.6162	-3.581152	-4.170583	-2.62259	-3.60099	-4.192337	-2.6162	-3.58115	-4.170583
5%	-1.94814	-2.926622	-3.51074	-1.9491	-2.935	-3.520787	-1.94814	-2.92662	-3.51074
	INFLATION			**OIL**			**DOLLAR**		
	none	**intercept**	**intercept/trend**	**none**	**intercept**	**intercept/trend**	**none**	**intercept**	**intercept/trend**
ADF test statistics	7.36723	-2.061761	-4.762287	1.003662	-0.55204	-2.944919	0.926223	-3.56927	-3.527956
Prob	1	0.2606	0.0024	0.9144	0.871	0.1586	0.9029	0.0103	0.0481
Test critical values									
1%	-2.6162	-3.581152	-4.219126	-2.6162	-3.58115	-4.170583	-2.6162	-3.58115	-4.170583
5%	-1.94814	-2.926622	-3.533083	-1.94814	-2.92662	-3.51074	-1.94814	-2.92662	-3.51074

Table A3. ADF Stationary Test Results of Variables on First Differences

	ΔGDP			ΔINFLATION			ΔOIL		
	none	**intercept**	**intercept/trend**	**none**	**intercept**	**intercept/trend**	**none**	**intercept**	**intercept/trend**
ADF test statistics	-1.86804	-2.958651	-2.91338	-1.20611	-3.76114	-2.421623	-7.3122	-7.67409	-4.625614
Prob	0.0595	0.0474	0.169	0.2045	0.0066	0.3632	0	0	0.0033
Test critical values									
1%	-2.62119	-3.600987	-4.198503	-2.62896	-3.60099	-4.219126	-2.61736	-3.58474	-4.205004
5%	-1.94889	-2.935001	-3.523623	-1.95012	-2.935	-3.533083	-1.94831	-2.92814	-3.526609

Table A4. Akaike Information Criterion Results for Optimal Lag Lengths.

	Model-1	**Model-2**	**Model-3**	**Model-4**	**Model-5**	**Model-6**	**Model-7**	**Model-8**
Lag	**AIC**	**AIC**	**AIC**	**AIC**	**AIC**	**AIC**	**AIC**	**AIC**
0	54.71130	54.70394	54.68744	54.48273	54.64111	55.00984	54.98680	55.43495
1	48.22078	48.21863	48.19515	47.75262	48.02825	48.44005	48.59156	49.17774
2	45.30296	45.26799	45.21951	45.30869	45.35252	45.93061	45.53847	46.50393
3	43.51810	43.43617	43.39272	43.83036	43.06639	44.38277	43.66126	45.37072
4	39.52722*	39.37770*	39.52302*	39.15082*	36.39486*	39.51639*	39.87689*	42.40632*

** Indicates lag order selected by the criterion.*
AIC: Akaike information criterion

Table A5. Cointegration Test Results for the Models

Unrestricted Cointegration Rank Test (Trace)

	Model-1		Model-2		Model-3		Model-4		Model-5		Model-6		Model-7		Model-8	
No. of CE(s)	**Trace Statistic**	**Prob.****	**Trace Statistic**	**Prob.****	**Trace Statistic**	**Prob.****	**Trace Statistic**	**Prob.****	**Trace Statistic**	**Prob.****	**Trace Statistic**	**Prob.****	**Trace Statistic**	**Prob.****	**Trace Statistic**	**Prob.****
None *	213.99	0.000	212.37	0.000	213.81	0.000	238.47	0.000	213.63	0.000	220.19	0.000	222.97	0.000	220.97	0.000
At most 1 *	141.27	0.000	137.11	0.000	139.6	0.000	122.94	0.000	147.06	0.000	143.39	0.000	145.27	0.000	151.12	0.000
At most 2 *	84.53	0.000	80.57	0.000	82.97	0.000	64.94	0.001	87.48	0.000	85.74	0.000	86.09	0.000	95.72	0.000
At most 3 *	43.43	0.001	40.19	0.002	42.03	0.001	27.48	0.090	37.38	0.006	44.14	0.001	40.51	0.002	41.61	0.001
At most 4	6.43	0.645	5.78	0.721	6.23	0.669	9.59	0.313	7.11	0.565	5.99	0.696	8.32	0.431	10.43	0.249
At most 5	0.73	0.395	0.76	0.383	0.76	0.385	3.85	0.050	0.39	0.529	0.53	0.466	0.24	0.621	2.43	0.119

Trace test indicates 4 cointegrating eqn(s) at the 0.05 level.

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

	Model-1		Model-2		Model-3		Model-4		Model-5		Model-6		Model-7		Model-8	
No. of CE(s)	**Max-Eigen**	**Prob.****	**Max-Eigen**	**Prob.****	**Max-Eigen**	**Prob.****	**Max-Eigen**	**Prob.****	**Max-Eigen**	**Prob.****	**Max-Eigen**	**Prob.****	**Max-Eigen**	**Prob.****	**Max-Eigen**	**Prob.****
None *	72.73	0.000	75.26	0.000	74.20	0.000	115.53	0.000	66.57	0.000	76.80	0.000	77.69	0.000	69.86	0.000
At most 1 *	56.74	0.000	56.54	0.000	56.63	0.000	58.00	0.000	59.58	0.000	57.66	0.000	59.19	0.000	55.40	0.000
At most 2 *	41.10	0.001	40.38	0.001	40.94	0.001	37.46	0.002	50.10	0.000	41.59	0.000	45.57	0.000	54.11	0.000
At most 3 *	37.00	0.000	34.41	0.000	35.80	0.000	17.89	0.134	30.28	0.002	38.15	0.000	32.19	0.001	31.18	0.001
At most 4	5.70	0.652	5.02	0.740	5.47	0.682	5.75	0.645	6.71	0.524	5.46	0.683	8.08	0.371	8.00	0.379
At most 5	0.72	0.395	0.76	0.383	0.76	0.385	3.85	0.050	0.40	0.529	0.53	0.466	0.24	0.621	2.43	0.119

Max-eigenvalue test indicates 4 cointegrating eqn(s) at the 0.05 level.