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Time-Varying Beta Coefficients of BIST Sector Indices*

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ABSTRACT

The aim of the study is to calculate the time-varying beta coefficients of 21 sector indices in BIST. As a result of the analysis, it has been determined that the beta coefficients of 21 sector indices have a structure that changes over time. At the same time, it has been found that all sector time-varying betas tend to mean reversion. In the study determined that the most volatile beta coefficient belongs to the XFINK index, while the least volatile beta coefficient belongs to the XSPOR index. In addition, in the study determined that the lowest beta coefficient with 0.490 belonged to the XSPOR index, while the highest beta coefficient was found to belong to the XBANK index with 1.248. In the study, it has been determined that the beta of sector indices has similar changes over time.

Keywords: *Time-Varying Beta, Beta Coefficient, Dynamic Conditional Correlation-Generalized Autoregressive Conditional Heteroskedasticity (DCC-GARCH), Systematic Risk, BIST*

JEL Classification: *C58, G10, G32.*

BIST Sektör Endekslerinin Zamanla Değişen Beta Katsayıları

ÖZET

Çalışmanın amacı BIST'te yer alan 21 adet sektör endeksinin zamanla değişen beta katsayılarının hesaplanmasıdır. Analizler sonucunda 21 adet sektör endeksinin beta katsayılarının zamanla değişen bir yapıda olduğu gözlenmiştir. Aynı zamanda zamanla değişen tüm sektör betalarının ortalamaya dönme eğilimde olduğu belirlenmiştir. Çalışmada en oynak beta katsayı XFINK endeksine ait iken, en az oynak beta katsayısı XSPOR endeksine ait olduğu tespit edilmiştir. Ayrıca çalışmada ortalama olarak en düşük beta katsayısı 0.490 ile XSPOR endeksine ait iken en yüksek beta katsayısı ise 1.248 ile XBANK endeksine ait olduğu saptanmıştır. Çalışmada, sektör endekslerinin betası zamanla benzer değişimlere sahip olduğu tespit edilmiştir.

Anahtar Kelimeler: *Zamanla Değişen Beta, Beta Katsayısı, Dinamik Koşullu Korelasyon-Genelleştirilmiş Otoregresif Değişen Koşullu Varyans (DCC-GARCH), Sistematik Risk, BIST.*

Jel Sınıflandırması*: C58, G10, G32.*

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1. INTRODUCTION

The investor decides on the investment based on the risk-return relationship. As such, the risk-return relationship is a frequently researched subject in finance literature. Although it has received a lot of criticism, the Capital Asset Pricing Model (CAPM) is still a model that investors often use in the risk-return relationship. For example, CAPM is used by 73.5% of the chief financial officers (CFO) in the United States and 45% of CFOs in Europe (Ayub et al., 2020:1-2). The reasons for the frequent use of this model are that it is easy to implement and explains the systematic risk, which constitutes an important part of the total risk of the investment, with a single element (Tuna and Tuna, 2013: 190).

CAPM assumes that the beta of the asset or portfolio is constant. According to CAPM, investors have the same subjective expectations about the asset's expected return, variance, and covariance. In response to this assumption of CAPM, Bollerslev et al. (1988) state that economic agents may have common expectations about the asset's expected return, but these expectations are conditional expectations and therefore, they are random variables rather than fixed ones (Bollerslev et al., 1988:117). Based on this, Bollerslev et al. (1988) explain CAMP-based time-varying beta coefficients with empirical tests. Later in the finance literature, it was determined by many researchers that the beta coefficient changes over time (Brooks et al., 1998, Andersen and Bollerslev, 1998; Andersen et al., 2006; Hajizadeh et al., 2012). In addition, when the finance literature is examined, many studies use GARCH models in the determination of beta coefficients that change over time (Bollerslev et al., 1988; Engle and Rodrigues, 1989; Ng, 1991; Choudhry and Wu., 2008; Choudhry and Wu., 2009; Choudhry et al., 2010; Zhang and Choudhry, 2017; Darolles et al., 2018).

The aim of the study is to calculate the time-varying beta coefficients of 21 sector indices in BIST. Estimating the time-varying beta coefficients of the asset is important. Because the beta coefficient is an important determinant that is taken into account in the investment decisions of investors, in measuring the performance of fund managers (e.g., Treynor ratio), in asset pricing, in measuring the cost of capital, in portfolio selection and risk management (Choudhry and Wu, 2008). Therefore, our study is significant for BIST investors and portfolio managers. When the literature is examined in detail, very few studies investigate the beta coefficients that change over time at both stock and index levels in BIST. In their studies, Büberkökü and Şahmaroğlu (2016) and Gümrah and Konuk (2018) investigated the time-varying betas in companies traded only in the BIST Bank index. According to Aksoy et al. In his (2019) and Güçlü (2019) investigated time-varying betas at the single index level. Köseoğlu and Gökbulut (2012) investigated time-varying betas at three index levels in their studies. Unlike these studies, Abiyev (2015) examines the time-varying beta coefficient in 20 sector indexes in the study. However, the aim of the study is determining the model that best predicts the time-varying beta. Unlike other studies, our study examined the time-varying beta coefficients in 21 sector indices. In addition, in the study, the beta coefficients of the sectors were compared with each other and the tendency of the time-varying beta coefficients to the mean reversion was investigated. The study is expected to contribute to the literature on these issues. In the next section of the study, information about the conditional beta coefficient is given, and the relevant literature follows this section. In the fourth section, detailed information about the data set and methodology is given. In the fifth section, the empirical results are mentioned, and this section is followed by the conclusion section.

2. CONDITIONAL BETA

The beta coefficient, which CAPM accepts as a systematic risk measure, expresses the relationship of the return of any asset with the market portfolio return (usually the stock market index) (Karan, 2013: 207). The beta coefficient is calculated as in Eq. (1) (Bodie et al., 2008: 287).

$$\beta_i = \frac{cov(r_m, r_i)}{var(r_m)} \quad 1)$$

Where r_m denotes the return on the market portfolio and r_i denotes the return on the asset. Here, it is assumed that the beta coefficient does not change over time; that is, it is constant. Bollerslev et al. (1988:117) state that investors may have common expectations about future returns, variances, and covariances, but these expectations are conditional expectations. Based on this, conditional betas can be investigated with multivariate GARCH models. Time-varying or conditional betas are calculated as in Eq. (2).

$$\beta_i^{MGARCH} = \frac{cov(r_m, r_i)}{var(r_m)} \quad 2)$$

Similarly, r_m refers to the return on the market portfolio and r_i refers to the return on the asset. However, here, the covariances and variances are in conditional form. In other words, the beta coefficient is the ratio of the conditional covariance value between an asset's return and the market portfolio's return to the market portfolio's conditional variance. Both conditional variance and conditional covariance are obtained from the conditional variance-covariance matrix obtained from multivariate GARCH models.

Theoretically, the beta of the market portfolio is equal to 1 and the beta of the risk-free asset is considered to be 0 (Bayrakdaroğlu, 2018: 122). When the beta coefficient is greater than 1, the asset has more volatility than the market portfolio and therefore is riskier than the market portfolio. More specifically, the increase (or decrease) in the value of this type of asset is expected to occur at a higher rate than the increase (or decrease) in the value of the market portfolio. Such assets are called aggressive assets. When the beta coefficient is less than 1, the asset has less volatility than the market portfolio and therefore is less risky than the market portfolio. More specifically, the increase (or decrease) in the value of this type of asset is expected to occur at a lower rate than the increase (or decrease) in the value of the market portfolio. Such assets are called defensive assets. In summary, a security with a beta greater than 1 is called a risky asset, and a security with a beta of less than 1 is called a low-risk asset (Bolak 2016: 27, Bayrakdaroğlu, 2018: 122-123). The beta coefficient rarely takes a value lower than zero. The fact that the beta coefficient is lower than zero indicates that there is an inverse relationship with the market portfolio (Karan, 2013: 209).

3. LITERATURE REVIEW

When the literature is examined in detail, very few studies have investigated the time-varying beta coefficients at both stock and index levels in BIST. Altinsoy et al. (2010) focused on real estate investment funds in Turkey in their study and found that the betas of real estate investment funds have a structure that has changed over time. Another study belongs to Köseoğlu and Gökbulut (2012). The authors investigated the time-varying beta coefficients of the service, finance, and industrial sector indices traded on the BIST using the BEKK-GARCH method. In the study, it was found that the beta coefficients, especially in the sub-samples, have a variable structure over time. Similarly, Aksoy et al. (2019) investigated the time-varying beta coefficients in the BIST BANK index and Güçlü (2019) the Participation 30 index. They found that the beta coefficients had a variable structure over time. Büberkökü and Şahmaroğlu (2016) and Gümrah and Konuk (2018) focused on banks traded in BIST in their studies. In both studies, it was found that the betas of banks change over time. Unlike all these studies, Abiyev (2015) focused on the model that best estimates the beta coefficients that change over time. In the study, it has been determined that the best model for estimating the time-varying betas is the OLS method based on the Kalman filter and the beta of the sector indices used in the research changes over time. A summary of these studies is shown in Table 1.

Table 1. Related Literature

Author (Year)	Period	Variables	Method	Result
Altınsoy et al. (2010)	2002:02-2009:06 (daily and weekly data)	Real estate investment funds	BEKK-GARCH, Schwert-Seguin, and Kalman filter	In the study, it was determined that the betas of real estate investment funds in Turkey have a structure that changes over time.
Köseoğlu and Gökbulut (2012)	02.01.2001-03.08.2011 (daily data)	Service, finance and industrial sector indices traded on BIST	BEKK-GARCH	In the study, it was determined that beta coefficients were variable in time, especially in sub-samples.
Abiyev (2015)	18.01.2001-02.08.2013 (weekly data)	20 sectors traded on BIST	MGARCH, stochastic volatility, OLS, and Kalman filter	In the study, it was determined that the beta coefficient of twenty Turkish industrial portfolios has a structure that changes over time.
Büberkökü and Şahmaroğlu (2016)	01.01.2002-08.04.2015 (daily data)	10 banks traded on BIST	DCC-GARCH	In the study, it was determined that the betas of banks changed over time.
Gümrah ve Konuk (2018)	28.12.2001-28.02.2017 (daily data)	12 banks traded on BIST	BEKK-GARCH	In the study, it was determined that the betas of banks changed over time.
Aksoy et al. (2019)	20.01.2009-20.02.2019 (daily data)	BIST BANK index	DCC-GARCH	It has been determined that the beta coefficient of the BIST BANK index has changed over time.
Güçlü (2019)	07.01.2011-31.07.2018 (daily data)	Participation 30 index	DBEKK-GARCH	In the study, it was determined that the beta of the Participation 30 index changed over time.

4. DATASET AND METHODOLOGY

4.1. Data Set

The data set consists of the BIST100 index representing the market portfolio and 21 sector indices in BIST. In the study, daily closing data for the period between January 03, 2005 and May 25, 2022 were used. All variables used in the study were obtained from the

Finnet database. The information about the 21 sector indices used in the study is shown in Table 2.

Table 2. Sector indices used in the study

Sector Indices	Code	Sector Index	Code	Sector Index	Code
BIST Banks	XBANK	BIST Chemical, Petrol, Plastic	XKMYA	BIST Textile, Leather	XTEKS
BIST Information Technology	XBLSM	BIST Basic Metal	XMANA	BIST Tourism	XTRZM
BIST Electricity	XELKT	BIST Metal Products, Machine	XMESY	BIST Services	XUHIZ
BIST Leasing Factoring	XFINK	BIST Insurance	XSGRT	BIST Transportation	XULAS
BIST Food, Beverage	XGIDA	BIST Sports	XSPOR	BIST Financials	XUMAL
BIST Telecommunication	XILTM	BIST Non-Metal Mineral Product	XTAST	BIST Industrials	XUSIN
BIST Wood, Paper, Printing	XKAGT	BIST Wholesale and Retail Trade	XTCRT	BIST Technology	XUTEK

The return series were calculated by taking the natural logarithmic differences of the daily price data with the help of Eq. (3) and all analyzes were made using the return series in the study (Bodie et al., 2008: 733).

$$r_{i,t} = ln(p_{i,t}/p_{i,t-1}) * 100 \quad 3)$$

4.2. Methodology

In our study, dynamic conditional correlation-generalized autoregressive conditional heteroskedasticity (DCC-GARCH) model was used to estimate time-varying beta coefficients. The DCC-GARCH method, one of the multivariate GARCH models, was developed by Engle (2002). The autoregressive–moving-average (ARMA) (1,1) mean model created within the scope of our study is as follows in Eq. (4).

$$r_t = \mu + \omega r_{t-1} + \psi \varepsilon_{t-1} + \varepsilon_t \quad 4)$$

$$\varepsilon_t = H_t^{1/2} u_t \quad 5)$$

$$H_t = D_t R_t D_t \quad 6)$$

Where r_t represents the return vector, μ is the constant term vector, ω is the AR coefficients, ψ is the MA coefficients, and ε_t is the error terms vector of the conditional mean model. u_t is random error term vector and H_t is a conditional variance-covariance matrix. R_t

and D_t, respectively, denote the time-varying conditional correlation matrix and the diagonal matrix with time varying standard deviations.

$$D_t = diag(h_{11t}^{-1/2}, h_{22t}^{-1/2}) \quad 7)$$

$$R_t = diag(q_{11t}^{-1/2}, q_{22t}^{-1/2})\ Q_t\ diag(q_{11t}^{-1/2}, q_{22t}^{-1/2}) \quad 8)$$

D_t is obtained from the univariate GARCH(1,1) model and the elements of H_t are expressed as in Eq. (9).

$$h_t = c + \alpha\varepsilon_{t-1} + \beta h_{t-1} \quad 9)$$

Where h_t , c, α and β denote conditional variance, constant term, ARCH and GARCH coefficients, respectively. $Q_t = \begin{pmatrix} q_{11,t} & q_{12,t} \\ q_{21,t} & q_{22,t} \end{pmatrix}$ in Eq. (8) is a 2x2 symmetric positive definite matrix as in Eq. (10).

$$Q_t = (1 - \theta_1 - \theta_2)\ \bar{Q} + \theta_1(u_{t-1}u'_{t-1}) + \theta_2 Q_{t-1} \quad 10)$$

$\bar{Q}$ is the 2x2 unconditional correlation matrix obtained from Eq. (9). From this point of view, time-varying beta coefficients ($\beta_{i,t}$) of sector indices are calculated as in Eq. (11).

$$\beta_{i,t} = \frac{h_{12}}{h_{22}} = \frac{h_{BIST100,Sektör}}{h_{BIST100}} \quad 11)$$

Here, $h_{BIST100,Sektör}$ refers to the conditional covariance of the market portfolio (BIST100) and the sector index, and $h_{BIST100}$ refers to the conditional variance of the market portfolio. Ciner (2015) recommended using structural break tests to test the time-varying nature of the beta coefficients obtained here. Following Ciner's (2015) study, Bai and Perron (2003) multiple structural break test was used to investigate whether beta coefficients contain structural changes or, in other words, whether beta coefficients are in a time-varying form. Finally, in the study, following the study of İskenderoğlu (2012), the tendency of beta coefficients to the mean reversion was investigated with the unit root test.

5. EMPIRICAL RESULTS

Descriptive statistics and unit root test results of the return series used in the study are reported in Table 3. As seen in Table 3, all series are stationary at level. The highest average return belongs to the XMANA index with 0.083, while the lowest return belongs to the XILTM index with 0.025. The average return of the 12 sector indexes is higher than the average return of the XU100 index.

Table 3. Descriptive statistics

Index	Mean	Minimum	Maximum	Standard Deviation	ADF	Observation
XBANK	0.035	-11.862	15.592	2.178	-65.599***	4372
XBLSM	0.068	-15.362	11.306	1.896	-59.415***	4372
XELKT	0.040	-17.361	12.333	1.993	-60.958***	4372
XFINK	0.058	-18.737	14.480	2.382	-59.273***	4372
XGIDA	0.049	-11.889	9.669	1.701	-65.133***	4372
XILTM	0.025	-14.930	11.886	1.973	-67.144***	4372
XKAGT	0.050	-13.492	8.804	1.793	-61.833***	4372
XKMYA	0.077	-10.744	12.050	1.710	-62.494***	4372
XMANA	0.083	-14.510	13.153	2.053	-63.733***	4372
XMESY	0.070	-14.181	9.029	1.699	-43.370***	4372
XSGRT	0.055	-12.701	11.192	1.752	-60.514***	4372
XSPOR	0.041	-20.860	15.567	2.398	-57.863***	4372
XTAST	0.050	-10.773	6.447	1.466	-62.566***	4372
XTCRT	0.073	-12.983	15.376	1.665	-65.061***	4372
XTEKS	0.074	-13.994	8.995	1.659	-43.355***	4372
XTRZM	0.051	-15.746	10.689	2.256	-61.634***	4372
XU100	0.052	-11.064	12.127	1.631	-64.691***	4372
XUHIZ	0.057	-10.064	9.994	1.423	-65.056***	4372
XULAS	0.083	-15.169	11.910	2.287	-43.802***	4372
XUMAL	0.042	-11.295	14.122	1.906	-64.910***	4372
XUSIN	0.069	-11.401	8.388	1.421	-43.026***	4372
XUTEK	0.082	-15.152	10.758	1.874	-63.818***	4372

In the study, ARMA(1,1)-DCC-GARCH(1,1) was estimated using logarithmic sector index return and logarithmic BIST100 index return to calculate the time-varying beta of BIST sector indices. Using the conditional covariance and conditional variance information obtained from DCC-GARCH, the time-varying beta coefficients of the indices were calculated as in Eq. (11). In Table 4, descriptive statistics of the time-varying beta coefficients of the indices are reported.

Table 4. Descriptive statistics of the time-varying beta coefficients

Index	Mean	Minimum	Maximum	Median	Standard Deviation	ADF	Bai-Perron	
							UDMax	WDMax
XBANK	1.248	0.511	8.815	1.012	0.810	-8.629***	470.650	470.650
XBLSM	0.778	0.164	8.740	0.570	0.721	-15.436***	150.734	157.257
XELKT	0.821	0.251	8.830	0.594	0.751	-13.970***	194.994	194.994
XFINK	0.787	0.101	9.631	0.539	0.839	-12.584***	301.550	301.550
XGIDA	0.639	0.186	5.099	0.494	0.486	-11.117***	412.599	412.599
XILTM	0.784	0.262	5.393	0.612	0.559	-9.245***	935.504	935.504
XKAGT	0.780	0.205	8.018	0.570	0.711	-15.134***	236.045	236.045
XKMYA	0.799	0.284	7.793	0.605	0.641	-9.982***	295.237	295.237
XMANA	0.883	0.295	8.417	0.675	0.731	-10.302***	340.516	348.056
XMESY	0.831	0.266	8.176	0.607	0.746	-13.108***	167.510	194.214
XSGRT	0.740	0.094	7.806	0.472	0.833	-7.584***	1457.587	1457.587
XSPOR	0.490	0.035	6.681	0.371	0.451	-12.967***	228.977	228.977
XTAST	0.704	0.226	6.865	0.509	0.631	-13.758***	132.052	156.926
XTCRT	0.627	0.216	7.667	0.485	0.512	-12.123***	219.772	219.772
XTEKS	0.699	0.222	8.426	0.504	0.662	-16.172***	124.882	132.542
XTRZM	0.822	-0.455	8.987	0.570	0.813	-12.776***	294.747	294.747
XUHIZ	0.752	0.278	6.321	0.571	0.595	-12.322***	305.590	305.590
XULAS	0.957	0.235	7.341	0.758	0.661	-10.993***	116.485	169.783

XUMAL	1.139	0.442	8.338	0.901	0.802	-8.627***	514.489	514.489
XUSIN	0.790	0.279	6.615	0.587	0.678	-12.584***	237.518	237.518
XUTEK	0.799	0.216	7.947	0.592	0.707	-14.422***	154.893	173.999

Note: Bai-Perron (2003) states "H_0: there is no structural break in the series". The hypothesis is tested with the UDMax and WDMax test statistics. The critical table values of UDmax and WDmax test statistics at the 5% significance level are 8.88 and 9.91, respectively.

In Table 4, it has been determined that all beta coefficients calculated in accordance with Bai and Perron (2003) test results contain structural changes and accordingly, beta coefficients have a time-varying structure. In addition, it has been determined that all the calculated beta coefficients have a stationary structure. This result shows that all the calculated time-varying beta coefficients tend to the mean reversion.

As shown in Table 4, the lowest mean beta coefficient belongs to the XSPOR index with 0.490, while the highest mean beta coefficient belongs to the XBANK index with 1.248. In addition, the lowest beta coefficient as a median belongs to the XSPOR index with 0.371, while the highest beta coefficient belongs to the XBANK index with 1.012. The most volatile beta coefficient belongs to the XFINK index, while the least volatile beta coefficient belongs to the XSPOR index. In order to see the changes in the beta of the sector indices more clearly, the time-varying beta coefficients calculated are graphically reported in Figure 1. In addition, Table 5 shows the ten dates when the beta coefficients for each sector index were the highest. When Figure 1 is examined in detail, the beta of sector indices has similar changes over time. As shown in Figure 1 and Table 5, the betas of BIST sector indices reached the highest levels in the 2008 global financial crisis, in the Gezi Park events that started on May 28, 2013, in the first coronavirus case on March 11, 2020, and in the announcement of the deposit system with currency protection on December 21, 2021.

Table 5. The first ten dates with the highest beta coefficients

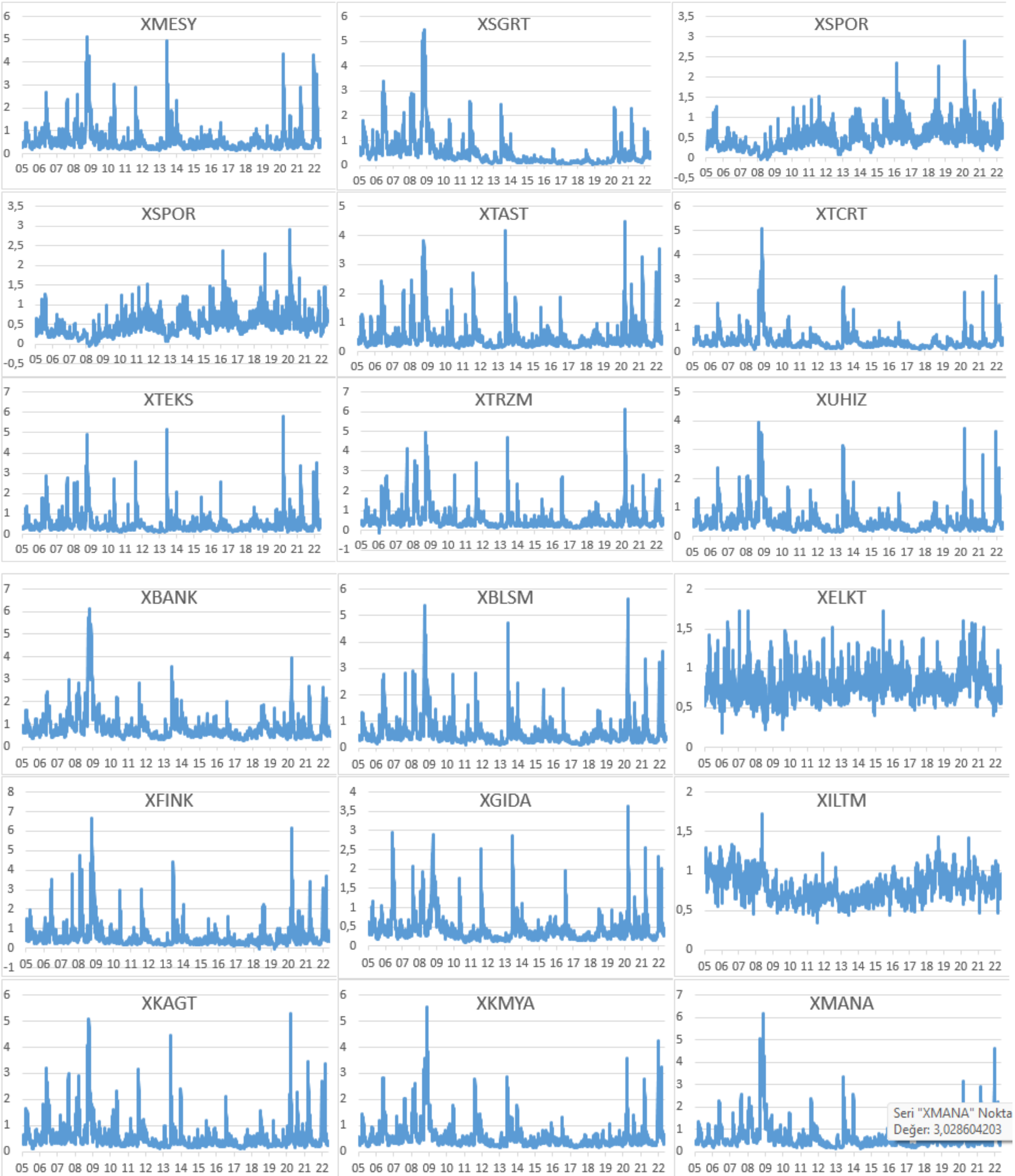
	1	2	3	4	5	6	7	8	9	10
XBANK	22.09.08	20.10.08	21.10.08	23.09.08	25.11.08	07.10.08	17.10.08	13.10.08	24.09.08	22.10.08
XBLSM	22.09.08	17.03.20	13.03.20	05.06.13	04.06.13	18.03.20	23.09.08	16.03.20	13.10.08	06.06.13
XELKT	13.10.08	25.11.08	26.11.08	05.06.13	14.10.08	04.06.13	15.10.08	07.06.13	16.10.08	28.11.08
XFINK	13.10.08	13.03.20	17.03.20	16.03.20	14.10.08	18.03.20	07.10.08	04.06.13	15.10.08	25.01.08
XGIDA	17.03.20	18.03.20	15.10.08	19.03.20	23.05.06	16.10.08	24.05.06	05.06.13	23.03.21	17.10.08
XILTM	22.12.21	23.12.21	24.12.21	22.09.08	27.12.21	07.10.08	28.12.21	23.09.08	21.10.08	08.10.08
XKAGT	17.03.20	13.10.08	13.03.20	05.06.13	14.10.08	17.10.08	04.06.13	22.09.08	16.10.08	15.10.08
XKMYA	25.11.08	26.11.08	23.12.21	22.12.21	27.12.21	27.11.08	24.12.21	17.03.20	20.11.08	07.10.08
XMANA	25.11.08	22.09.08	26.11.08	07.10.08	23.12.21	23.09.08	13.10.08	15.10.08	27.11.08	20.10.08
XMESY	05.06.13	04.06.13	13.10.08	22.12.21	17.03.20	06.06.13	07.06.13	20.10.08	23.12.21	14.10.08
XSGRT	25.11.08	20.10.08	07.10.08	17.10.08	13.10.08	15.10.08	26.11.08	16.10.08	21.10.08	14.10.08
XSPOR	17.03.20	13.03.20	18.03.20	16.03.20	19.03.20	20.03.20	16.08.11	05.06.13	25.03.20	28.02.22
XTAST	17.03.20	05.06.13	04.06.13	18.03.20	07.06.13	28.02.22	13.10.08	06.06.13	23.03.21	17.10.08
XTCRT	25.11.08	26.11.08	27.11.08	28.11.08	22.12.21	20.10.08	23.12.21	24.11.08	01.12.08	22.09.08
XTEKS	17.03.20	05.06.13	04.06.13	13.03.20	13.10.08	18.03.20	06.06.13	16.03.20	14.10.08	09.08.11
XTRZM	17.03.20	13.03.20	22.09.08	04.06.13	18.03.20	05.06.13	16.03.20	23.09.08	20.08.07	19.03.20
XUHIZ	22.09.08	22.12.21	17.03.20	23.12.21	23.09.08	05.06.13	25.11.08	04.06.13	18.03.20	21.10.08
XULAS	17.03.20	05.06.13	18.03.20	04.06.13	07.06.13	06.06.13	19.03.20	13.10.08	10.06.13	22.12.21
XUMAL	20.10.08	22.09.08	21.10.08	17.10.08	25.11.08	23.09.08	07.10.08	13.10.08	22.10.08	23.10.08
XUSIN	23.12.21	22.12.21	17.03.20	05.06.13	22.09.08	25.11.08	04.06.13	13.10.08	27.12.21	18.03.20
XUTEK	22.09.08	17.03.20	05.06.13	22.12.21	04.06.13	23.09.08	13.10.08	23.12.21	18.03.20	28.02.22

In Table 6, the dates of the ten largest increases in beta coefficients of each sector index as a percentage are reported. For example, the betas of the XBLSM, XELKT, XFINK, XKAGT, XKMYA, XMANA, XMESY, XSPOR, XULAS, and XUSIN indices experienced increases ranging from 783.23% to 1597.57% compared to the previous business day on 04.06.2013, which coincided with the Gezi Park events. Similarly, the betas of the XBANK, XGIDA, XILTM, XSGRT, XTCRT, XTEKS, XTRZM, XUHIZ, XUMAL, and XUTEK indices experienced increases ranging from 428.43% to 1669.57% compared to the previous business day on 23.03.2021, which coincided with the sacking date of Naci Ağbal, the President of the Central Bank of the Republic of Turkey. In addition, betas of all indices experienced significant increases on 25.02.2022, which coincided with the beginning of the Russia-Ukraine war. Moreover, betas of all indices experienced significant increases on 19.07.2016, which coincided with the coup attempt of 15 July, except for the XILTM and XMANA indices

Table 6. The Largest Percentage Increases In The Beta Coefficients Of Industry Indices On A Trading Day And Their Dates

		1	2	3	4	5	6	7	8	9	10
XBANK	Date	23.03.21	04.06.13	25.02.22	19.07.16	03.11.15	22.09.08	16.11.21	23.05.06	15.10.19	20.09.07
	%	428.43	339.00	311.51	227.00	192.40	182.31	171.07	159.07	144.80	141.24
XBLSM	Date	04.06.13	23.03.21	25.02.22	19.07.16	28.01.21	22.01.08	20.12.21	03.11.15	09.06.15	18.12.13
	%	1124.33	988.37	721.51	639.54	431.68	403.82	389.19	374.71	360.40	340.58
XELKT	Date	04.06.13	23.03.21	25.02.22	19.07.16	09.06.15	18.12.13	08.03.06	02.07.08	17.12.14	03.11.15
	%	1058.83	992.59	668.48	585.07	452.91	392.54	346.31	318.16	313.03	305.27
XFINK	Date	04.06.13	23.03.21	25.02.22	19.07.16	03.11.15	22.01.08	20.12.21	18.12.13	27.10.20	12.07.18
	%	1268.41	949.02	616.79	609.24	435.06	427.06	389.62	328.91	309.09	302.76
XGIDA	Date	23.03.21	04.06.13	25.02.22	10.05.10	19.07.16	28.01.21	23.05.06	17.12.14	27.10.20	25.11.15
	%	798.57	570.28	382.23	335.40	313.80	220.04	194.29	192.70	174.23	161.89
XILTM	Date	23.03.21	04.06.13	22.01.08	22.09.08	25.11.15	10.05.10	20.09.07	20.12.21	28.03.19	25.02.11
	%	594.84	265.28	245.71	210.09	197.90	162.96	159.29	157.36	150.14	147.28
XKAGT	Date	04.06.13	23.03.21	19.07.16	25.02.22	20.12.21	18.12.13	22.01.08	22.09.08	12.07.18	28.02.07
	%	1007.85	948.10	717.24	653.50	529.13	472.32	290.52	282.67	280.45	261.91
XKMYA	Date	04.06.13	23.03.21	25.02.22	19.07.16	02.07.08	08.03.06	23.05.06	27.10.20	28.01.21	22.01.08
	%	879.52	872.50	482.88	254.25	243.58	215.53	204.75	185.43	183.72	179.74
XMANA	Date	04.06.13	23.03.21	18.12.13	22.01.08	09.08.11	22.09.08	25.02.22	07.11.16	20.09.07	29.01.13
	%	783.23	583.77	217.25	194.21	175.41	172.25	170.33	157.43	156.88	135.89
XMESY	Date	04.06.13	23.03.21	25.02.22	18.03.08	20.12.21	28.08.13	28.01.21	19.07.16	10.05.10	07.08.20
	%	1058.49	636.87	501.71	256.85	235.96	234.50	231.54	222.29	222.11	206.03
XSGRT	Date	23.03.21	04.06.13	19.07.16	27.10.20	25.02.22	22.01.08	11.07.18	28.01.21	18.12.13	22.09.08
	%	659.87	646.32	395.97	300.28	252.93	218.63	204.18	193.49	190.69	183.97
XSPOR	Date	04.06.13	23.03.21	19.07.16	25.02.22	18.12.13	24.05.05	09.06.15	09.10.08	25.11.15	24.07.15
	%	1597.57	894.84	753.24	567.97	357.55	345.12	285.89	284.69	230.52	212.59
XTAST	Date	25.02.22	23.03.21	04.06.13	19.07.16	27.10.20	20.12.21	28.01.21	22.01.08	03.11.15	18.12.13
	%	898.39	891.85	868.78	636.78	398.90	370.20	331.47	317.41	270.75	263.93
XTCRT	Date	23.03.21	04.06.13	25.02.22	23.05.06	19.07.16	20.12.21	02.07.08	28.03.19	13.01.17	22.09.08
	%	1078.16	666.30	392.53	358.52	323.67	257.87	250.69	229.32	189.62	184.89
XTEKS	Date	23.03.21	04.06.13	25.02.22	19.07.16	10.05.10	22.01.08	09.06.15	17.12.14	08.03.06	27.10.20
	%	1669.57	1347.30	816.45	684.79	510.15	453.72	366.34	341.40	317.31	309.55
XTRZM	Date	23.03.21	04.06.13	19.07.16	18.12.13	23.01.06	22.01.08	09.06.15	10.05.10	01.05.07	24.07.15
	%	902.83	839.36	832.47	435.86	426.92	404.03	383.38	351.39	349.57	328.14
XUHIZ	Date	23.03.21	04.06.13	25.02.22	19.07.16	22.01.08	22.09.08	20.12.21	28.03.19	25.11.15	08.03.06
	%	941.78	632.90	426.49	333.77	325.13	257.22	216.53	205.27	204.27	198.42
XULAS	Date	04.06.13	23.03.21	19.07.16	25.02.22	29.01.13	27.10.20	10.05.10	15.10.19	20.12.21	28.01.21

	%	875.58	597.19	476.76	286.39	207.66	191.18	182.66	170.67	151.34	141.75
XUMAL	Date	23.03.21	04.06.13	25.02.22	19.07.16	22.09.08	03.11.15	23.05.06	20.12.21	22.01.08	20.09.07
	%	495.38	379.81	340.01	251.34	180.05	179.65	157.01	149.78	145.14	144.36
XUSIN	Date	04.06.13	23.03.21	25.02.22	19.07.16	28.01.21	10.05.10	27.10.20	08.03.06	22.01.08	25.11.15
	%	932.63	930.22	452.24	314.74	239.00	217.33	213.86	211.81	207.18	198.67
XUTEK	Date	23.03.21	25.02.22	19.07.16	04.06.13	09.06.15	22.01.08	28.01.21	27.10.20	08.03.06	03.11.15
	%	878.88	744.65	667.43	535.96	407.97	339.89	326.56	310.82	292.63	285.13



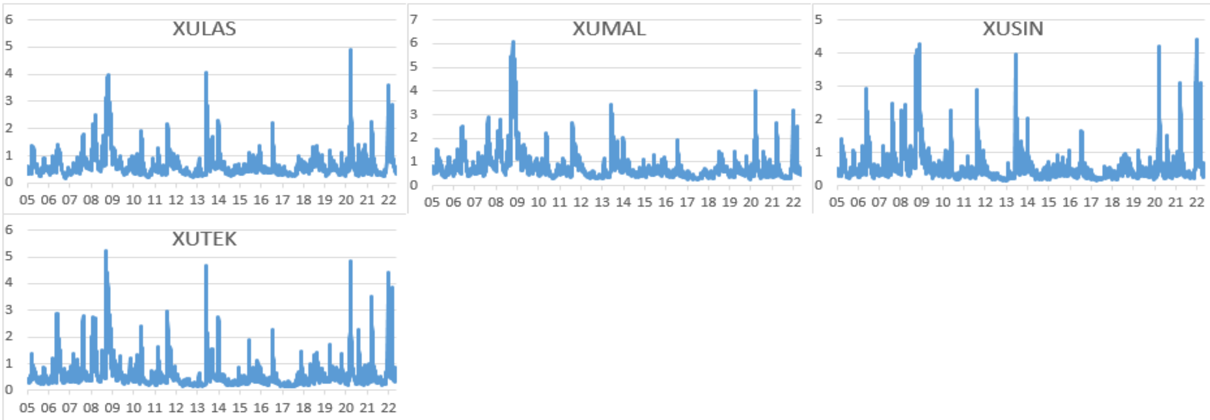


Fig. 1. Time-varying Beta Coefficients Of Sector Indices

6. ROBUSTNESS CHECK

The robustness of the findings obtained from the DCC-GARCH(1,1) model is checked using the constant conditional correlation (CCC)-GARCH(1,1) model. Table 7[1] presents the descriptive statistics of the beta coefficients of BIST sector indices obtained using the CCC-GARCH(1,1) model, which change over time.

Table 7 shows that the XSPOR index has the lowest mean beta coefficient, while the XBANK index has the highest mean beta coefficient. These results support our previous findings. Again in parallel with our previous findings, the lowest beta coefficient in the median belongs to the XSPOR index and the highest beta coefficient belongs to the XBANK index. The most volatile beta coefficient belongs to the XUMAL index, and the least volatile beta coefficient belongs to the XSPOR index. The fact that the XSPOR index has the least volatile beta coefficient supports our previous findings. However, as seen in Table 4, the XUMAL index is the fourth most volatile index with 0.802.

According to Bai and Perron (2003) test results in Table 7, beta coefficients were determined to have a time-varying structure. In addition, it has been determined that all the calculated beta coefficients tend to return to the mean. These results support our main findings from the DCC-GARCH(1,1) model. In summary, all our results are consistent with previous findings and demonstrate the results' robustness.

7. CONCLUSION

The aim of this study is to calculate the time-varying beta coefficients of 21 sector indices in BIST by using the daily closing data for the period between January 03, 2005 and May 25, 2022. In addition, in the study, the beta coefficients of the sectors were compared with each other and the tendency of the time-varying beta coefficients to the mean reversion was investigated. In the study, the beta coefficients of the sector indices were examined using the DCC-GARCH model. In addition, following the study of Ciner (2015), Bai and Perron (2003) structural break test was applied to the beta coefficients obtained from the DCC-GARCH model.

[1] Table 7 is reported in the appendix.

As a result of the analysis, it has been determined that the beta coefficients of 21 sector indices have a structure that changes over time. This result supports the findings of Büberkökü and Şahmaroğlu (2016) and Gümrah and Konuk (2018), who found that the betas of banks changed over time, Aksoy et al. (2019), who found that the betas of the BIST BANK index changed over time and Güçlü (2019), who found that the betas of the Participation 30 index changed over time. At the same time, it has been determined that all sector time-varying betas tend to the mean reversion. This result supports the studies of İskenderoğlu (2012) and Alp et al. (2013).

Excessive beta volatility can be detrimental to the investor. The excessive volatility and low stability of the beta may cause distrust among investors. In the study, it was determined that the most volatile beta coefficient belongs to the XFINK index, while the least volatile beta coefficient belongs to the XSPOR index. In addition, the lowest mean beta coefficient belongs to the XSPOR index with 0.490, while the highest mean beta coefficient belongs to the XBANK index with 1.248. In the study, it was found that the beta of sector indices, has similar changes over time. In general, the betas of BIST sector indices reached the high levels in the 2008 global financial crisis, in the Gezi Park events that started on May 28, 2013, in the attempted coup on July 15, 2016, in the first coronavirus case on March 11, 2020, in the sacking of Naci Ağbal, the President of the Central Bank of the Republic of Turkey, on March 23, 2021, in the announcement of the deposit system with currency protection on December 21, 2021, and in the Russian-Ukrainian conflict on February 25, 2022.

The results of the study provide useful information for investors and policymakers. Considering the tendency of betas to the mean reversion, in the long run, investors are advised to buy indices with below-average betas and sell indices with above-average betas in their investments with a long investment horizon. Finally, developing countries like Turkey need foreign investments more than developed countries. Foreign portfolio investors are uncomfortable with high levels of uncertainty. For example, on 23.03.2021, when the central bank president was dismissed, betas increased at a rate varying between 428.43% and 1669.57%. Given such situations, policymakers should develop policies that will minimize such situations and reduce uncertainties.

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APPENDIX

Table 7. Descriptive statistics of time-varying beta coefficients from the CCC-GARCH model

	Mean	Minimum	Maximum	Median	Standard Deviation	ADF	Bai-Perron	
							UDMax	WDMax
XBANK	1.239	0.515	8.455	1.006	0.785	-10.155***	390.247	392.302
XBLSM	0.744	0.285	7.063	0.578	0.558	-15.710***	133.533	170.876
XELKT	0.792	0.298	8.168	0.589	0.644	-13.664***	402.052	402.052
XFINK	0.758	0.264	7.234	0.539	0.654	-13.650***	267.424	317.797
XGIDA	0.627	0.263	4.183	0.496	0.430	-11.009***	497.036	497.036
XILTM	0.763	0.279	4.115	0.618	0.475	-8.210***	1145.549	1145.549
XKAGT	0.747	0.285	6.524	0.582	0.566	-14.788***	259.343	259.343
XKMYA	0.776	0.324	6.675	0.614	0.541	-10.089***	339.107	339.107
XMANA	0.855	0.339	6.736	0.679	0.601	-10.046***	457.416	457.416
XMESY	0.808	0.299	6.857	0.605	0.657	-12.716***	202.932	230.663
XSGRT	0.679	0.167	5.981	0.470	0.637	-7.672***	1432.772	1432.772
XSPOR	0.479	0.166	6.348	0.372	0.397	-13.597***	213.525	213.525
XTAST	0.681	0.241	5.860	0.517	0.541	-13.467***	165.374	196.525
XTCRT	0.609	0.271	7.501	0.491	0.451	-9.938***	270.276	270.276
XTEKS	0.671	0.276	6.932	0.509	0.536	-15.999***	115.496	139.281
XTRZM	0.770	0.290	6.269	0.590	0.573	-12.105***	403.740	403.740
XUHIZ	0.737	0.293	5.724	0.575	0.541	-12.100***	382.250	382.250
XULAS	0.929	0.425	5.732	0.766	0.539	-10.751***	204.836	229.493
XUMAL	1.135	0.447	8.210	0.902	0.792	-8.673***	494.107	494.107
XUSIN	0.780	0.303	6.214	0.588	0.639	-12.542***	251.299	251.299
XUTEK	0.772	0.296	6.658	0.598	0.574	-14.724***	145.428	145.428

Note: Bai-Perron (2003) states "H_0: there is no structural break in the series". The hypothesis is tested with the UDMax and WDMax test statistics. The critical table values of UDmax and WDmax test statistics at the 5% significance level are 8.88 and 9.91, respectively.