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Research Article

Testing the Augmented Fama–French Six-Factor Asset Pricing Model with Momentum Factor for Borsa Istanbul

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This study aims to test the validity of the Fama–French Asset Pricing Model, which has become a six-factor along with the inclusion of the momentum factor, in terms of Borsa Istanbul. In this context, nested asset pricing models were assessed, and different estimators were developed to determine which of the models explains the stock returns more strongly. The returns (more than the risk-free interest rate) of 24 different portfolios and a total of 9,504 portfolios for 396 weeks, throughout October 2013–May 2021, are utilized based on the BV/MV, profitability, investment, and momentum factors. The results obtained from the research study indicate the Fama–French Six-Factor Asset Pricing Model (FF6F) as the most effective model in explaining stock returns for Borsa Istanbul. For investors, the momentum factor is the one that needs to be regarded and allows higher returns to be obtained, and the necessity of considering it before making investment decisions is one of the practical contributions of the research study. Determining the momentum factor as a factor that should be considered upon making investment decisions would constitute the contribution of the research study to the literature.

1. Introduction

Until the publication of Markowitz's article entitled "Portfolio Selection" in 1952, the comprehension that risk could be reduced by increasing the number of assets in portfolios was predominant in the markets. Nonetheless, in his related study, Markowitz [1] determined that even if the number of assets in the portfolio was increased with the modern portfolio approach, the portfolio risk would not have decreased if there was a high level of correlation among the assets. According to Markowitz [1], if the correlation among assets was low and negative, the portfolio risk would have been decreased. Following Markowitz's related study, Modigliani and Miller [2] made crucial contributions to the occurrence of normative literature regarding the development of corporate finance by investigating the relationships between firm value and capital structure. Besides these studies in the field of modern finance theory, Sharpe [3], Lintner [4], Mossin [5], and Black et al. [6] investigating the relationship between risk and return, as well as the SLM model, have constituted the landmarks in terms of finance literature.

The Capital Asset Pricing Model (CAPM) has been built on modern portfolio theory (MPT). The assumptions of the model regarding risk and returns are based on the assumptions of MPT, and the investor of the model is Markowitz's rational efficient investor. Various aspects of basic assumptions of the CAPM have been discussed, and criticism has been made that it is not possible to encounter the ideal market structure that it reveals. Criticism of the model has caused the assumptions to be altered. Following this situation, Ross [7] developed the arbitrage pricing model as an alternative to the CAPM. In the arbitrage pricing model, unlike the CAPM, evidence has been presented on the extent to which more than one variable would affect asset returns. Notwithstanding, the arbitrage pricing model, which was put forth as a critique of the CAPM, could not fully determine the factors affecting asset returns. In the following years, the factors affecting asset prices began to be discussed frequently, and in recent years, the relevant literature has transformed the CAPM into multifactor models to explain the shift in asset prices.

Fama and French [8] were able to explain stock market anomalies in the 1980s employing the three-factor asset pricing model (FF3F) they developed, and the CAPM has become the basic model to explain the change in the cross-sectional asset returns [9].

The FF3F associates the cross-sectional change in stock returns with three elements as follows:

(i) The market return in excess of the risk-free interest rate

(ii) The difference between the portfolios of small and large companies in terms of returns

(iii) The difference between the portfolios of companies with high and low BV/MV ratios in terms of returns

In this context, the FF3F reveals that, unlike the CAPM, stock returns are affected not only by the market risk premium but also by the firm size as well as the BV/MV ratio. The shortcoming of the FF3F in explaining the changes in stock returns over time, the lack of the three factors of the model in fully capturing the variance of the average returns, and especially Titman et al. [10] and Novy [11] are the main motivation sources underlying the development of a brand new five-factor asset pricing model by Fama and French in 2015 [9, 12]. In this respect, Fama and French [12] developed the five-factor model (FF5F) by including profitability and investment variables in the three-factor model. There are various studies in the literature indicating that the FF5F performs better than the FF3F and the CAPM in explaining the variance in asset returns.

Nevertheless, the main problem of the FF5F involves the fact that small stocks, which tend to act as companies with high investment levels despite low profitability, cannot achieve average returns. Besides, the performance of the model is not sensitive to how the factors are described.

A remarkable FF5F study by Kubota and Takehara [13] suggested that the betas of the factors such as RMW (difference between stock returns of diversified stock portfolios with strong and weak profitabilities) and CMA (the difference between the returns of firms' diversified stock portfolios of companies with low and high investment levels, which are defined as conservative and aggressive), which are included in the FF5F for Japan, had weak relationships with the cross-section variances of the stock returns and yielded different results than the USA. In this respect, the results of the model tend to differ by country.

Fama and French [14] redeveloped the model by including the momentum factor into the FF5F to rank the asset pricing models and to maintain predictions regarding the maximum Sharpe ratio (Sh^2). The momentum factor (UMD, Up Minus Down) indicates the difference between the returns of the portfolio with higher market gearing and the returns of the portfolio with lower market gearing.

In this framework, the main motivation of the research is to test the validity of the Fama–French Six-Factor Asset Pricing Model (FF6F), which is one of the asset pricing models that developed in the historical process and became multifactor models along with the contributions of Fama and French for Turkey. Although FF3F and FF5F have been tested in Turkey so far, the absence of a study on the FF6F constitutes the original aspect of the research. In this context, the main purpose of the research is to investigate whether or not the momentum factor, which is newly added to the model, increases the power of explaining stock returns in Borsa Istanbul and to test the efficiency of the model within the Turkish market. The study contributes to the literature regarding the validity of the FF6F. Moreover, the results of the research study also contribute to investors, portfolio managers, portfolio management companies, and financial institutions, as they reveal the factors affecting portfolio selection on a country basis and test their efficiency.

In the next part of the research study, the literature review on multifactor asset pricing models is presented. The third part introduces the research methodology, the fourth part includes the findings, and the fifth part presents the conclusion and discussion part.

2. Literature Review

Over the last three decades, Sharpe's [3] and Lintner's [4] Capital Asset Pricing Model (CAPM) has been subjected to crucial criticism. Fama and French [8] expanded the CAPM along with size and value factors to render it more explanatory, and then a four-factor Carhart [15] model, including the momentum factor, was developed. Although both models have been frequently used in asset pricing studies on developed markets, it was observed that there were patterns such as profitability, asset growth impact, and accrual impact that these models could not grasp in stock returns [11, 16, 17]. In the next step, Fama and French [12] developed a five-factor model explaining the change in returns by including profitability and investment factors. A five-factor model that adds profitability and investment factors to the three-factor model of Fama and French [8] largely absorbs the patterns in average returns [18]. The five-factor model was tested for countries with developed stock markets, including North America, Europe, Japan, and the Asia Pacific, and it was concluded that the model was more successful in explaining the change in average returns. For instance, Lin [9] concluded that the five-factor model outperformed the three-factor model in the Chinese market over the period 1997 to 2015, whereas the important investment factor was redundant. Huang [19], in compliance with the results of Lin [9], determined that the five-factor model was superior to other asset pricing models in the Chinese market over the period 1994–2016. Leite et al. [20] investigated the Fama–French three-factor, four-factor, and five-factor models for developing countries. The results of the research study indicated that the four-factor and five-factor models outperformed the three-factor model. The value factor seemed unnecessary in the presence of profitability and investment factors, and the size factor was effective in average stock returns. In his research study on 18 different developing countries, Foye

[21] concluded that the five-factor model outperformed the three-factor model. Nonetheless, profitability and investment premiums were not distinguishing enough for Asia. Cox and Britten [22] asserted that the five-factor model best explained the cross-sectional returns in the Johannesburg stock market, and the profitability factor was more consistent than the investment factor. Ali et al. [23] tested the Fama and French three-factor, five-factor, and six-factor and Carhart's four-factor models for the Pakistan stock market over the period 2003–2016 and concluded that the Fama and French five-factor model explained the abnormal change in returns better than other models. At the same time, according to the research study, the profitability factor was effective in explaining the average returns. According to Mosoeu and Kodongo [24], the profitability factor was effective in explaining stock returns in countries such as Australia, China, and South Africa; however, research studies conducted in the American and Japanese markets differed. Guo et al. [25] detected that the factors of size, value, and profitability had strong impacts in explaining the average returns for the Chinese stock market; however, they concluded that the investment factor had a weak impact. Zaremba et al. [26] tested the Capital Asset Pricing Model, Fama and French three-factor asset pricing model, Carhart's four-factor asset pricing model, and Fama and French five-factor asset pricing model over the period 2000–2018 for Poland, which was categorized as a developing country. According to the results of the research study, the four-factor model performed better than the other models. In their research study, conducted on the Japanese market over the period 1978–2014 employing the GMM method, Kubota and Takehara [13] concluded that the Fama and French five-factor asset pricing model was not the best pricing model. Azimli [27] tested the five-factor model and three other models for Borsa Istanbul. The results indicated that only beta and book/market impacts were significant, whereas later included profitability and investment factors did not increase pricing or economic performance. The results asserted that different models yielded better results in different markets. Horváth and Wang [28] investigated Fama and French's five-factor model during COVID-19. The results revealed that the Dotcom bubble has a statistically significant impact on the R^2 of the growth model. Furthermore, in 2008, R^2 of growth portfolios was shown to be lower. Additionally, R^2 increased significantly due to the recent COVID-19. Furthermore, in the GMM model, beta model parameters were shown to be insignificant.

Subsequently, Fama and French [14] extended the five-factor asset pricing model by including the momentum factor. The momentum factor was denoted by UMD_t (up minus down) in the model. In the extended model with the momentum factor, the UMD was defined the same as the HML; however, it had been updated monthly instead of annually. UMD denoted the average value of UMD_s and UMD_b. The results indicated that the six-factor model outperformed the nested models, such as CAPM, three-factor, and five-factor models. Besides, it was concluded that the momentum factor could better explain Sh^2 (f). On the other hand, Ali and Ülkü [29] and Fama and French [14] determined that the expected returns in the six-factor model could not explain the mispricing factor, undervalued minus overvalued (UMO), and quality minus junk (QMJ) premiums. Procedures that were suggested by various factor spanning tests as well as Barillas and Shanken [30] and Barillas et al. [31], which comprise the market, UMO, and momentum factors, often outperform the six-factor model. Ali [32] tested the UMO (undervalued minus overvalued) proposed by Hirsleifer and Jiang [33] in the Pakistan stock market for the first time. The results determined that the UMO factor was significant for the long-term low-priced and short-term high-priced stocks, and it gained risk-adjusted returns. Moreover, upon analyzing the UMO factor with other asset pricing models (CAPM, Carhart's four-factor, and Fama and French three-, five-, and six-factor models), it revealed information that could not be identified by other factors in the Pakistani stock market. Ali [32] concluded that the four-factor model comprising UMO, size, and profitability factors would have performed better in his study using factor spanning regression, Barillas and Shanken's [30] maximum Sharpe square ratio, and GRS test metrics over the period 2003–2018.

In another striking study, Dirkx and Peter [34] conducted a research on the German market employing the Fama–French six-factor model obtained by including the momentum factor to the Fama–French three-and five-factor asset pricing models. The monthly data obtained over the period 2002–2019 were used in the empirical research. The number of factors used in the study, as used in the Fama–French five-factor asset pricing model, became six by including the momentum factor besides market factor, size factor, value factor, profitability factor, and investment factor. According to the preliminary analysis results of the research study, no significant finding was obtained in terms of profitability and investment factors. Upon comparing the results of the six-factor model with the results of the three-factor model, the included factors do not make a significant contribution to the analysis in terms of explanatory power. As a result of the research, it was concluded that the use of profitability and investment factors in the context of international asset pricing studies did not have a statistically significant contribution to explaining the stock returns in the German stock market.

3. Methodology

The main purpose of the research study is to test the validity of the FF6F in terms of Borsa Istanbul. Within the scope of the study, the returns of 24 different portfolios exceeding the risk-free interest rate are utilized along with the weekly obtained data (396 weeks) over the period October 2013–May 2021 based on value, investment, profitability, and momentum factors. A total of 9,504 portfolios (24 portfolios $*$ 396 weeks) are generated in the study. In the study, estimators are developed by employing the FF3F, the FF4F, the FF5F, and the FF6F separately to determine which of these models would better explain stock returns in Borsa Istanbul. Although the monthly or annual data are usually used in asset pricing models, the weekly data are used in this research study. Black [35] stated that many asset pricing models utilized the realized returns that did not accurately reflect expected returns to test the hypotheses. Nevertheless, Liu et al. [36] asserted that assets should have acted together in an efficient market, and therefore, expected returns in shorter prediction intervals were closer to the actual returns. It was the main reason why the weekly data were preferred in the research study.

The weekly returns of the Borsa Istanbul National 100 Index are taken as the basis for market returns. For the weekly returns, the closing data obtained over the period 2013–2021 are utilized. The rate of return of the market factor at week t is calculated by dividing the market's weekend t value by the previous weekend's value and by taking its natural logarithm. The data of the "Average Cost of Domestic Borrowing" table were converted into weekly data and used as the risk-free interest rate. The relevant data are obtained from the official website of the Turkish Republic Ministry of Treasury and Finance (https://www.hmb.gov.tr/). The weekly return of the stock and the weekly return of the BIST National-100 index used in the study is obtained from the Finnet Electronic software.

In the study, Fama–French's [12] sampling criteria are used. They include all companies (except for financial sector companies) which traded in Borsa Istanbul over the period between October 2013 and May 2021. Besides, companies with high leverage and negative equity are excluded from the sample.

The market values of the firms are used for the size factor. The companies are ranked separately for each year t according to their market values as Fama and French [12] did in their study. In the study, the value factor companies, which are categorized into two groups as small and big, considering the size of the company, are independently ranked from small to large according to the book value/market value ratio and are divided into 3 groups, and this process is repeated for each year t by the methodology of Fama and French [12]. The profitability factor is considered the operating profitability ratio and is calculated by dividing the operating profit of the company by the book value of equity. Following the methodology of Fama and French [12], companies that are divided into two groups, small and big, are divided into three groups, R, M, and W, according to their profitability ratios. The investment rate is calculated by dividing the difference between the total value of assets in years $t-1$ and $t-2$ by the total value of assets in year $t-2$ and is similarly classified into three groups. It is determined as 30% for the group with low-level cut-offs in all factors, 40% for the group with intermediate level, and 30% for the group with a high level.

Employing the FF3F, the β coefficient related to the market sensitivity in the CAPM is excluded from the model, and instead, the value and size factors are included in the model with the assumption that it better handles the cross-sectional change. Fama and French developed the current model by including the investment and profitability factors into the FF3F in 2015 since the FF3F was insufficient to explain some anomalies and cross-sectional variation in expected returns associated with investment and profitability. As such, the new model is known in the literature as the FF5F [13]. The FF5F, which was developed since the FF3F was insufficient to explain the expected return, would be formulated as follows [37]:

$$R_{it} - R_f = a_i + \left(R_{Mt} - R_{ft}\right) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + \varepsilon_i. \tag{1}$$

In the FF5F, besides the stock return, the systematic risk premium β_i (RM-RF), market factor, value factor (HML), size factor (SMB), investment factor (CMA), and profitability factor (RMW) variables are utilized. Fama and French [14] tested the validity of the obtained six-factor model by including the momentum variable into the FF5F in terms of the US stock markets. Following this study, Dirkx and Peter [34] conducted a similar research study in terms of the German stock market. In this respect, the validity of the FF6F would be employed in terms of Borsa Istanbul by taking the aforementioned research studies as a reference. The momentum variable is utilized as the sixth factor in this research study, similar to the studies of Fama and French [14] and Dirkx and Peter [34]. In the study, the impacts of the 6 explanatory variables shown below on the return of 24 portfolios are examined.

$$R_{it} - R_{ft} = \alpha_i + b_i\left[R_{mt} - R_{ft}\right] + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + m_i MOM_t + \varepsilon_i. \tag{2}$$

The factors used in the research study express the changes in the returns of the companies and the change in the price of the stocks in each portfolio concerning the previous periods.

$[R_{mt} - R_{ft}]$ is the market risk premium return change.

SMB_t is the change in returns of portfolios generated according to firm size.

HML_t is the change in returns of portfolios generated according to book/market values ratio.

CMA_t is the change in returns of portfolios generated according to investment changes.

$RMW_t$is the change in returns of portfolios generated according to the operational profitability of the company.

MOM_t is the momentum factor referring to winners and losers. Therefore, momentum factor is based on past winners (W), neutral performers (N), and losers (L) [34].

(i) Market risk premium is the market return (BIST100) − risk-free interest rate.

(ii) $SMB$is the difference between returns on small and large-cap stocks

$$= \frac{(SL + SM + SH)}{3} - \frac{(BL + BM + BH)}{3}. \tag{3}$$

(iii) $HML$is the difference between returns on stocks with high and low BV/MV ratios

$$= \frac{(SH + BH)}{2} - \frac{(SL + BL)}{2}. \tag{4}$$

(iv) RMW is the difference between returns on stocks with high and low profitabilities

Table 1: Portfolios used in the study.

Portfolio	Firm size	Value effect	
SL[2]	Small	Low	Book value/market value
SN	Small	Neutral	
SH	Small	High	
BL	Big	Low	
BN	Big	Neutral	
BH	Big	High	
SC	Small	Conservative	Investment
SM	Small	Medium	
SA	Small	Aggressive	
BC	Big	Conservative	
BM	Big	Medium	
BA	Big	Aggressive	
SW	Small	Weak	Profitability
SM-	Small	Medium	
SR	Small	Robust	
BW	Big	Weak	
BM-	Big	Medium	
BR	Big	Robust	
SC	Small	Conservative	Momentum
SN	Small	Neutral	
SA	Small	Aggressive	
BW	Big	Past winners	
BN	Big	Neutral performers	
BL	Big	Losers	

[2]It denotes the return on a portfolio of stocks with small company size and low book value/market ratio.

$$= \frac{(SR + BR)}{2} - \frac{(SW + BW)}{2}. \quad (5)$$

(v) *CMA* is the difference between returns on stocks with high and low investments

$$= \frac{(SC + BC)}{2} - \frac{(SA + BA)}{2}. \quad (6)$$

(vi) *MOM* is the based on past winners (W), neutral performers (N), and losers (L), MOM_t is derived as

$$= \frac{(SW + BW)}{2} - \frac{(SL + BL)}{2}. \quad (7)$$

Since there are fewer financial assets in Borsa Istanbul compared to the US market, a correction is made by calculating 24 weighted portfolios instead of 25 (5×5). A similar correction was also made regarding the portfolio diversification in the research study conducted by Dirkx and Peter [34] on the German Stock Exchange.

Table 1 presents the portfolios utilized in the study. After the companies are categorized into 2 groups, such as large and small scale, while creating portfolios, portfolios are categorized into 4 groups, namely, "market value/book value," "investment," "profitability," and "momentum." Two distinct portfolios, such as "small (Small-S)" and "large (Big-B)," are generated regarding the size effect. Three distinct portfolios, such as "high (Big-B)," "neutral (Neutral-N)," and "Low-L," are selected according to market value/book value regarding the value effect. Then, 6 value-weighted portfolios are generated (2×3) with the intersections of portfolio composition according to size and market value/book value. Within the scope of the study, consistent with Fama and French [14], the following models are developed to cover the aim of the study and the generated portfolios:

$$\begin{aligned}
R_{it} - R_{ft} &= \alpha_i + \beta_i\left(R_{mt} - R_{ft}\right) + \varepsilon_i, \\
R_{it} - R_{ft} &= \alpha_i + \beta_i\left(R_{mt} - R_{ft}\right) + s_i\left(SMB_t\right) \\
&\quad + h_i\left(HML_t\right) + \varepsilon_i, \\
R_{it} - R_{ft} &= \alpha_i + \beta_i\left(R_{mt} - R_{ft}\right) + s_i\left(SMB_t\right) \\
&\quad + h_i\left(HML_t\right) + r_i\left(RMW_t\right) + \varepsilon_i, \\
R_{it} - R_{ft} &= \alpha_i + \beta_i\left(R_{mt} - R_{ft}\right) + s_i\left(SMB_t\right) \\
&\quad + h_i\left(HML_t\right) + r_i\left(RMW_t\right) + c_i\left(CMA_t\right) + \varepsilon_i, \\
R_{it} - R_{ft} &= \alpha_i + \beta_i\left(R_{mt} - R_{ft}\right) + s_i\left(SMB_t\right) \\
&\quad + h_i\left(HML_t\right) + r_i\left(RMW_t\right) \\
&\quad + c_i\left(CMA_t\right) + m_i\left(MOM_t\right) + \varepsilon_i.
\end{aligned} \quad (8)$$

In this context, the hypotheses of the GRS-F test are as follows [38]:

H_0: all alpha coefficients obtained from the CAPM, Fama–French three-, four-, five-, and six-factor models are equal to zero ($\alpha_i = 0$).

Table 2: Descriptive statistics for intersection portfolios exceeding the risk-free interest rate.

	N (weeks)	Mean	Std. dev
SL	396	0.0021	0.03356
SN	396	0.0025	0.02977
SH	396	0.0015	0.02922
BL	396	0.0016	0.02431
BN	396	0.0032	0.02370
BH	396	0.0011	0.02695
SC	396	0.0025	0.03067
SM	396	0.0021	0.03019
SA	396	0.0007	0.03003
BC	396	0.0022	0.02701
BM	396	0.0020	0.02460
BA	396	0.0026	0.02695
SW	396	0.0007	0.02978
SM-	396	0.0019	0.02877
SR	396	0.0042	0.03169
BW	396	−0.0008	0.02836
BM-	396	0.0025	0.02419
BR	396	0.0034	0.02342
SC-	396	0.0018	0.02752
SN-	396	0.0024	0.03195
SA-	396	0.0016	0.03454
BW-	396	0.0019	0.02754
BN-	396	0.0033	0.02532
BL-	396	0.0012	0.02432

H_1: all alpha coefficients obtained from the CAPM, Fama–French three-, four-, five-, and six-factor models are not equal to zero ($\alpha_i \neq 0$).

It is a statistic proposed by Gibbons et al. [38] to test the future effectiveness of the asset portfolio under examination. It is designed to test the effectiveness of the CAPM model and the portfolio on a mean-variance basis. With the GRS test, it can be tested whether or not the fixed terms calculated as a result of the regression equation in the asset pricing model are equal to zero for all stocks or portfolios. The null hypothesis of the test implies that the constant term of the entire stock or portfolio examined by the model is equal to zero (39). Gibbons et al. [38] expressed the statistics with different parameters as follows:

$$GRS = \left(\frac{T}{N}\right)\left(\frac{T}{T} \frac{-N-L}{-L-1}\right)\left[\frac{\widehat{\alpha}'\widehat{\Sigma}^{-1}\widehat{\alpha}}{1+\overline{\mu}\prime\widehat{\Omega}^{-1}\overline{\mu}}\right] \sim F(N, T-N-L),$$

$$\widehat{\alpha} = Nx1 \text{ estimated constant term vector,} \tag{9}$$

$$\widehat{\Sigma} = \text{error terms unbiased covariance matrix,}$$

$$\overline{\mu} = Lx1 \text{ factor portfolio mean matrix,}$$

$$\widehat{\Omega} = \text{Factor portfolio unbiased covariance matrix.}$$

T is the denotes the number of observations, N denotes the number of regression equations, and L denotes the number of factors in the regression.

Table 3: Unit root test results.

Variables	LLC test		PP Fisher test	
	t-test	Probability (p)	Statistic	Probability (p)
SL	−8.45	0.000	42.43	0.000
SN	−9.45	0.000	65.64	0.000
SH	−14.84	0.000	67.50	0.000
BL	−9.75	0.000	55.82	0.000
BN	−23.95	0.000	81.73	0.000
BH	−12.50	0.000	75.78	0.000
SC	−8.55	0.000	53.71	0.000
SM	−9.85	0.000	97.53	0.000
SA	−12.64	0.000	107.27	0.000
BC	−12.64	0.000	53.29	0.000
BM	−13.54	0.000	88.38	0.000
BA	−22.63	0.000	76.34	0.000
SW	−14.63	0.000	69.61	0.000
SM-	−12.44	0.000	123.45	0.000
SR	−14.97	0.000	53.93	0.000
BW	−16.64	0.000	87.30	0.000
BM-	−9.64	0.000	75.38	0.000
BR	−16.02	0.000	87.38	0.000
SC-	−7.63	0.000	56.88	0.000
SN-	−9.53	0.000	89.32	0.000
SA-	−12.73	0.000	98.54	0.000
BW-	−19.42	0.000	43.50	0.000
BN-	−13.63	0.000	68.39	0.000
BL-	−14.32	0.000	64.22	0.000
RM-RF	−15.89	0.000	77.52	0.000
SMB	−12.34	0.000	87.65	0.000
HML	−15.34	0.000	87.54	0.000
CMA	−20.33	0.000	93.34	0.000
RMW	−9.54	0.000	33.43	0.000

$H_0: \alpha_i = 0$ i: 1,2,3, . . ., N.
$H_1: \alpha_i \neq 0$ i: 1,2,3, . . ., N.

4. Findings

In this part of the study, the validity of the FF6F is tested for Turkey.

Descriptive statistics regarding the generated portfolios in the research study are presented in Table 2. The BN portfolio, which is comprised of stocks with a small to medium BV/MV ratio in terms of value-weighted weekly return and firm size, has the highest mean value. The SR portfolio with small firm size and high-yielding stocks has the highest weekly return.

The hypotheses regarding the unit root tests of the variables are as follows:

H_0: an overall unit root exists in the series (H_0: $p_i = p = 1$).

H_1: no overall unit root exists in the series ($H_0 = p_i = p < 1$).

The ability to perform econometric analyses on the variables used in the study depends solely on the fact that the series is stationary; in other words, they do not contain unit roots. If the variables exhibit a trend, the relationship involves a spurious regression rather than an actual one [40].

Table 4: Correlation analysis of factor premiums.

	RM-RF	SMB	HML	CMA	RMW	MOM
RM-RF	1					
SMB	0.097	1				
HML	0.095	−0.264	1			
CMA	0.136	0.017	0.179	1		
RMW	0.012	0.139	−0.075	−0.036	1	
MOM	0.041	−0.162	0.297	0.014	0.027	1

Table 5: Estimator results.

$R_i - R_f$	A	β	S	H	R	c	M	GRS-F	DW	F-statistic	Adj. R^2
CAPM	0.026 (0.276)	0.304 (3.102)**	—	—	—	—	—	1.68 (0.11)	2.093	27.53 (0.000)	0.321
FF3F	0.012 (0.183)	0.298 (3.041)**	0.565 (4.343)**	0.164 (1.856)*	—	—	—	1.54 (0.19)	1.753	29.32 (0.000)	0.362
FF4F	0.002 (0.143)	0.322 (3.264)**	0.464 (3.974)**	0.175 (1.904)*	.545 (4.565)**	—	—	1.29 (0.28)	2.031	31.76 (0.000)	0.385
FF5F	0.017 (0.206)	0.215 (2.343)**	0.653 (5.623)**	.202 (2.005)*	.492 (3.875)**	.503 (3.943)**	—	1.12 (0.38)	2.129	35.97 (0.000)	0.402
FF6F	0.021 (0.232)	0.301 (3.094)**	0.527 (4.242)**	0.194 (1.988)*	.405 (3.215)**	.551 (4.640)**	.364 (3.574)**	1.10 (0.39)	1.875	38.01 (0.000)	0.427

Table 6: Testing equality of squared Sharpe ratios for competing models.

	Differences in sample squared Sharpe ratios			
Models	2	3	4	5
1	0.094**	0.098**	0.105**	0.126**
2		0.084*	0.091**	0.119**
3			0.082*	0.112**
4				0.103*

* and ** indicate significance at the 5% and 1% levels, respectively.

Table 3 presents the unit root test results calculated by the LLC and PP Fisher tests. Both test results indicate that the variables are stationary and do not contain unit roots. Since the series are stationary, the null hypothesis (H_0), which implies that the variables contain unit roots, is statistically rejected.

Table 4 presents the correlation analysis results regarding factor premiums. Analysis results indicate that a positive relationship exists between the change in the return of RM-RF market risk premium and SMB, HML, and CMA variables. Similarly, although statistically weak, RM-RF is positively correlated with RMW and MOM variables. Upon examining the relationship between independent variables, it is understood that an inverse relationship exists between SMB and HML factors, whereas CMA and HML factors are positively related. It is seen that there are quite low correlations among the independent variables utilized in the study. It can be claimed that this situation may mitigate multicollinearity problems and spurious regression results that may arise in the model.

Table 5 indicates the regression results for all related models. Upon examining the analysis results, it is understood that the 5 models developed with 24 portfolios are significant, and there is no autocorrelation. The R^2 values of the CAPM, FF3F, FF4F, FF5F, and FF6F are 32.1%, 36.2%, 38.5%, 40.2%, and 42.7%, respectively. It indicates that the FF6F has the highest explanatory power in explaining stock returns.

Nevertheless, the alpha coefficients are equal to zero, and no pricing error exists in the developed models. Besides, the market factor β coefficients are positive and significant in the models. The value factor "h" coefficient is statistically significant. Similarly, the profitability factor "r" coefficient is positive and significant. Consequently, the coefficient of investment factor "c" is statistically significant. The momentum variable "m" is seen to be statistically significant in the FF6F regression model.

As a result, the H_0 hypothesis is accepted for the CAPM, FF3F, FF4F, FF5F, and FF6F according to the GRS-F test results. In other words, it is determined that the CAPM, FF3F, FF4F, FF5F, and FF6F are valid for Borsa Istanbul since there are no pricing errors in the models.

Table 6 presents the pairwise tests of equality of the squared Sharpe ratios of the 5 models within the framework of Barillas et al. [31]. This table expresses the difference between the $\theta2_i - \theta2_j$ sample square Sharpe ratios indicated in column i and row j of the models developed in the research study. Barillas et al. [31] metric and covering nonnested models are used for generalization. These models express a superior model of higher $\theta2$ in comparison. According to the analysis results, it is understood that, at the 1% significance level, Model 1 performs lower than all other models ($p < 0.05$). Nonetheless, Model 4 outperforms Model 3, Model 2, and Model 1. Also, Model 3 performs higher than Model 2 and Model 1 ($p < 0.01$). Model 5, however, statistically significantly performs higher than all other models. Consequently, it is understood that the best model developed in the research study is the 5-factor momentum model ($R_m - R_{ft}$, *SMB, HML, RMW, CMA,* and MOM_t).

5. Conclusion

The main objective of this research study is to test the validity of the Fama and French six-factor model for Borsa Istanbul. Turkey is categorized as a developing country, and the importance of emerging markets is increasing day by day. However, there is a limited number of studies that explain the change in returns in emerging stock markets employing multifactor asset pricing models. To fill this gap, the CAPM, Fama and French [8] three-factor model, Fama and French four-factor model, Fama and French [12] five-factor model, and Fama and French [14] six-factor models are tested using 396-week data obtained over the period October 2013–May 2021 by creating 24 different portfolios in Borsa Istanbul. To increase the reliability of the models, the GRS-F test is also performed with the adjusted resistive estimator employing the Newey-West method.

The empirical results of the research study indicate that the Fama and French [14] six-factor model outperforms other multifactor asset pricing models for Borsa Istanbul. There is no pricing error in the models developed in the research study. Accordingly, the results are similar to those of Fama and French [14] in terms of US stock markets. Fama and French [14] concluded that the six-factor model could better explain stock returns in the US market. Nonetheless, multifactor models do not yield similar results for all countries and financial markets. Although the obtained results of this research study for Borsa Istanbul indicate that the Fama and French [8] three-factor model, the Fama and French four-factor model, the Fama and French [12] five-factor model, and the Fama and French [14] six-factor model explain the variation of stock returns more strongly, Dirkx and Peter [34] concluded that became a five-factor model by the inclusion of the investment and profitability variables in the three-factor model for the German Stock Exchange and lastly included that the momentum factor did not increase the explanatory power of the model. The specific differences that financial markets exhibit by country may account for different results obtained from the German Stock Exchange. Moreover, the fact that the results of the research study do not comply with the results of Ali and Ülkü [29] accounts for the validity of the six-factor model varying by country in terms of its power to explain different factor premiums. Ali and Ülkü [29], contrary to our research findings, stated that the three-factor model, which consists of the market, UMO, and momentum factors, often outperformed the six-factor model.

The β coefficient is found to be positive and significant in the models tested in the study. At the same time, book-to-market value is considered an important factor. In this context, the results comply with the results of Azimli [27], which tested the five-factor model for Borsa Istanbul. Accordingly, in studies that tested asset pricing models for emerging markets, it is seen that, in general, new factors included in the model are more successful in explaining the change in stock returns [9, 19–21]. Nevertheless, since countries have financial markets with different characteristics, it should not be overlooked that all of the newly included factors in the model may not always explain the change in returns to the same degree.

At this point, Fama and French [14] attract attention to a crucial point. Accordingly, the increasing demand for the inclusion of empirically sound factors lacking theoretical motivation to the model, as well as the accompanying parsimonious models, may hamper the entire model.

The results of this research study are crucial for academics, investors, portfolio managers, and policymakers. The research study is the first to test the Fama and French [14] six-factor model for Borsa Istanbul. Within the scope of Borsa Istanbul, portfolio managers should take into account the momentum factor to ensure a stronger portfolio performance, whereas policymakers should consider the momentum factor to make effective decisions regarding risk and return factors.

The number of empirical studies on the six-factor model is still limited. Future studies to be conducted on different country groups and their probable findings would help us to have a clearer view of multifactor asset pricing models.

Data Availability

The data used to support the findings of this study are obtained from the Borsa Istanbul Databank.

Disclosure

This research was presented as a paper at the 24th Finance Symposium held in Sakarya, Turkey, on October 20–23, 2021, and was later developed and expanded.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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