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The Comparative Performance Evaluation of the Fama-French Five Factor Model in Turkey[1]

Songul KAKILLI ACARAVCI
Hatay Mustafa Kemal Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, İşletme Bölümü, Hatay.
Email: sacaravci@mku.edu.tr, https://orcid.org/0000-0002-1359-5483

Yunus KARAOMER
Hatay Mustafa Kemal Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, İşletme Bölümü, Hatay.
Email: yunuskaraomer@mku.edu.tr, https://orcid.org/0000-0002-6377-1326

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ABSTRACT: The aim of this study is to test the performance of the Capital Asset Pricing Model (CAPM) and Fama-French Factor Models in Borsa Istanbul (BIST) during period covering July 2005-June 2016. Thus, it is tested by using the adjustments (Adj.) R^2, Gibbons, Ross, and Shanken (1989) GRS-F test and p-probability values and it is aimed to find out which model (s) can explain the variation in portfolio returns better and which model (s) can be used to explain portfolio returns in BIST. The results in this article indicate that there is no pricing error as regards result of GRS-F test of Fama-French Factor Models excluding CAPM. Hence, Fama-French Factor Models appeared to be valid in the case of BIST. Moreover, Fama-French Factor Models appear to explain variations in excess portfolio returns and Fama-French Five Factor Model has the most explanatory power in variations regarding portfolio returns.
Keywords: CAPM, Fama-French Factor Models, Regression Analysis.
JEL Code: C22, G11, G12.

Türkiye'de Fama-French Beş Faktörlü Modelin Karşılaştırmalı Performans Değelendirmesi

ÖZ: Bu çalışmanın amacı, Temmuz 2005 ile Haziran 2016 yılları arası dönemin Borsa İstanbul'da (BİST) Sermaye Varlıkları Fiyatlama Modeli (SVFM) ve Fama-French Faktör Modellerinin performansını test etmektir. Böylece hangi model veya modellerin portföy getirilerindeki değişimi daha iyi açıklayabildiğini ve hangisinin BİST'deki portföy getirilerini açıklamada kullanılabildiğini p–olasılık değeri, düzeltilmiş R2 ve GRS-F testi kullanılarak test edilmiştir. Çalışmanın sonuçları, GRS-F testi sonucuna göre CAPM hariç Fama-French Faktör Modellerinde fiyatlama hatası olmadığını göstermektedir. Böylece, Fama-French Faktör Modellerinin BİST'de geçerli olduğu görülmektedir. Ayrıca, Fama-French Faktör Modelleri portföy getirilerindeki değişimi açıklamaktadır ve Fama-French Beş Faktör Modeli portföy getirilerini açıklamada en yüksek açıklayıcı güce sahip modeldir.
Anahtar Kelimeler: SVFM, Fama-French Faktör Modelleri, Regresyon Analizi.
JEL Kodu: C22, G11, G12.

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1. Introduction

The foundations of the portfolio theory were built by Markowitz in 1952. Before Modern Portfolio Theory, the relationship between risk and return in portfolio management was not evaluated numerically and portfolio diversification is intended to take into account average returns. Markowitz introduced a systematic approach that consider the risk factors in selecting the optimal portfolio. In the finance literature, the models which are indeed the continuation of Markowitz's Modern Portfolio Theory have emerged as general equilibrium models. This equilibrium model is followed by many models such as CAPM, Arbitrage Pricing Model (APM), Carhart Factor Model, Fama-French 3 Factor Model (FF3F), Fama-French 4 Factor Model (FF4F), and Fama-French 5 Factor Model (FF5F) introduced by Fama-French. In this context, in line with the financial developments in recent years in both developed countries and developing countries, it is seen that there are many researches on the factors affecting share prices expressive of firm value. There are many national and international articles which will be the main sources of this paper. The table 1 below is a summary of some of these articles.

Table 1: Articles on Asset Pricing Models

Author (s) / Year	Sampling	Model (s)	Result
Ajili (2002)	1976-2001, in France.	-Two models are tested: 1) CAPM, 2) FF3F Model.	- FF3F Model explains better the common variation in stock returns than the CAPM.
Charitou and Constantinidis (2003)	1992–2000, in Japan.	-Two models are tested: 1) CAPM, 2) FF3F Model.	- FF3F Model explains better the common variation in stock returns than the CAPM.
Messis, Blanas and Iatrides (2006)	2002–2006, in Greece .	-Two models are tested: 1) APM, 2) FF3F Model.	- FF3F Model explains better the common variation in stock returns than the APM.
Gokgoz (2008)	2001–2006, in Turkey.	-Two models are tested: 1) CAPM, 2) FF3F Model.	- FF3F Model explains better the common variation in stock returns than the CAPM and CAPM is not valid in Turkey.
Yalcin (2012)	2003–2010, in Turkey.	-Two models are tested: 1) CAPM, 2) FF3F Model.	- FF3F Model explains better the common variation in stock returns than the CAPM.
Czapkiewicz and Wójtowicz (2014)	2003–2012, in Poland.	-Two models are tested: 1) Carhart 4 Factor Model, 2) FF3F Model.	- Carhart 4 Factor Model explains better the common variation in stock returns than the FF3F Model.
Clarice and William (2015)	2002–2014, in Brasil.	- Two models are tested: 1) FF3F Model, 2) FF5F Model.	- FF5F Model explains better the common variation in stock returns than the FF3F Model.
Nguyen, Ulku and Zhang (2015)	2008–2015, in Vietnam.	Three models are tested: 1) CAPM, 2) FF3F Model, 3) FF5F Model.	- FF5F Model explains better the common variation in stock returns than the FF3F Model and CAPM.
Chiah, Chai, Zhang and Li (2016)	1982–2013 in Australia.	- Two models are tested: 1) FF3F Model, 2) FF5F Model.	- FF5F Model explains better the common variation in stock returns than the FF3F Model.
François and William (2016)	January 1968 - December 2014, 12 sec.	FF5F Model.	- FF5F Model explains common variation in stock returns.
Foye (2017)	October 1989 - September 2016, in UK.	- Two models are tested: 1) FF3F Model, 2) FF5F Model.	- FF3F and FF5F Model do not explains common variation in stock returns.
Wijaya, Murhadi and Utami (2017)	July 2010-June 2015, in Indonesia.	- Two models are tested: 1) FF3F Model, 2) FF5F Model.	- FF5F Model explains better the common variation in stock returns than the FF3F Model.

As shown in Table 1, The CAPM, APT, Carhart Factor Model, Fama-French Factor Models, which is very important and remarkable for academic circles in the financial world, has been used in order to determine factors affecting share price and the explanatory power and direction of these factors. Thus, due to the limited number of studies on the FF5F Model, it is thought that this study will have a unique character, be useful for new studies and fill a gap in terms of the empirical finance literature.

The paper proceeds as follows: In Section 2, we describe the data preparation and research methodos; in Section 3, we present the empirical result for CAPM, FF3F, FF4F, and FF5F Models and in Section 4, concludes.

2. Data Sources and Research Methods

In analysis of this study, we use all companies (excluded financial companies) ordinary shares traded on the BIST. Our sample period is the period at the monthly from July 2005 to June 2016. For the accounting information, we collect from company annual reports from 2005 to 2016 due to the change in accounting standards in 2004 in Turkey. Our sample increase in number from 2005 (306 companies) to 2016 (414 companies). We collect data from FINNET Information News Network for publicly listed on BIST through financial statements submitted to BIST by the publicly listed firms. BIST National-100 indices are used as the market return. Treasury bill rates are used as a risk-free interest rate and obtained from Republic of Turkey Prime Ministry Undersecretariat of Treasury.

To generate the SMB (small minus big), HML (high minus low), RMW (robust minus weak), CMA (conservative minus aggressive), we formed 6 pcs portfolios from the intersections of 2 pcs size effect (Small or Big; S or B) and 3 pcs market-to-book (high, middle or low; H, M, or L), operating profit, (robust, middle or weak; R, M, W), investment portfolios (conservative, middle or aggressive; C, M, A). Portfolio creation periods have calculated between at the end of each “t” year's July and at the end each “t+1” year's June. Thereby, for portfolio creation, in the calendar year “t-1” are matched with the returns from “t” year's July to “t+1” year's June. Five factors were illustrated to disclose portfolio constructions (see Table 2):

Table 2: Construction of SMB, RMA and CMA factors

Sort	Breakpoints		Factors and their components
			$SMB_{ME/BE}$= [(S/H + S/M + S/L)– (B/H + B/M + B/L]
2×3 sort on;	-Size; median value	/3	
-Size-ME/BE,			$SMB_{Op.}$= [(S/R + S/M + S/W) – (B/R + B/M + B/W)
-Size-Invs,		]/3	
Size-Op.	ME/BE, Invs, Op.;		$SMB_{Invs.}$= [(S/C + S/M + S/A) – (B/C + B/M + B/A)
	30%; 40%; 30%.	]/3	
			-SMB= [($SMB_{ME/BE}$ + $SMB_{Op.}$ + $SMB_{Invs.}$)]/3
			-HML= [(S/H – S/L) + (B/H – B/L)/2
			-RMW= [(S/R – S/W) + (B/R – B/W)]/2
			-CMA= [(S/C – S/A) + (B/C – B/A)]/2

Source: Fama and French, 2015: 6.

Table 2 shows intersection portfolios constructed on the basis of size, ME/BE ratio, profitability and investment ratio. To ensure that the factors and the monthly returns, we create portfolio and factors criteria using Fama-French (1993) and Fama-French (2015) methodologies. They are used as dependent *(S/H, S/M, S/L, B/H, B/M, B/L, S/R, S/W, B/R, B/W, S/C, S/A, B/C, B/A)* in time series regression following Fama and French (1993, 2015). The regression equations for CAPM, FF3F, FF4F, and FF5F Models are shown as follows:

CAPM: $R_{it} - R_{ft} = \alpha_i + \beta_i (R_{mt} - R_{ft}) + \varepsilon_{it}$

FF3F Model: $R_{it} - R_{ft} = \alpha_i + \beta_i (R_{mt} - R_{ft}) + s_i (SMB_t) + h_i (HML_t) + \varepsilon_{it}$

FF4F Model: $R_{it} - R_{ft} = \alpha_i + \beta_i (R_{mt} - R_{ft}) + s_i(SMB_t) + h_i(HML_t) + r_i(RMW_t) + \varepsilon_{it}$

FF5F Model: $R_{it} - R_{ft} = \alpha_i + \beta_i(R_{mt} - R_{ft}) + s_i(SMB_t) + h_i(HML_t) + r_i(RMW_t) + c_i(CMA_t) + \varepsilon_{it}$

Where;

- $R_{it} - R_{ft}$ is the return of the share i over the risk free rate at time t,
- $R_{mt} - R_{ft}$ is the return of the market portfolio i over the risk free interest rate at time t,

- SMB_t is the difference between the returns on portfolios of big and small shares at time t,
- HML_t is the difference between the returns on portfolios of low and high ME/BE ratio at time t,
- RMW_t is the difference between the returns on portfolios of robust and weak profitability ratio at time t,
- CMA_t is the difference between the returns on portfolios of low and high investment ratio at time t,
- ε_{it} is a zero-mean residual at time t,

The beta coefficients (β_i, s_i, h_i, r_i, c_i) are the risk factor of respectively $R_m - R_f$, SMB, HML, RMW, and CMA. If an asset pricing model completely captures expected returns, the coefficient estimate for alpha (α_i) is indistinguishable from zero (Fama and French, 2015: 9).

This paper investigates the performance of the CAPM, FF3F, FF4F, FF5F Models in BIST covering period from July 2005 to June 2016. For the measure of Asset Pricing Model's comperative performance, it is used on adjustments (Adj.) R^2, Gibbons et al. (1989) GRS-F test and p-probability values. Thus it is aimed to determine which model (s) can explained the variation in portfolio returns better and which model (s) can be used to explain portfolio returns in BIST. Hypotheses tested for BIST is shown in Table 3.

Table 3: Hypotheses Tested for Borsa Istanbul

Hypothesıs 1: CAPM explains the variation in portfolio returns better than the FF3F, FF4F and FF5F Model.
Hypothesıs 2: FF3F Model explains the variation in portfolio returns better than the FF4F and FF5F Model.
Hypothesıs 3: FF4F Model explains the variation in portfolio returns better than the FF5F Model.
Hypothesıs 4: FF3F, FF4F, FF5F Model can be used to explain the portfolio returns in the BIST.

3. Empirical Results

Before the empirical analysis, it is essential to examine whether the variables used are stationary in order to obtain econometrically significant relations between the variables. Therefore, the Augmented Dickey Fuller (ADF) (1979) and the Phillips-Perron (PP) (1988) unit root tests are employed for the stationarity analysis. The hypotheses for these tests are as follows:

- **H_0:** The serial contains unit root and is not stationary.
- **H_1:** The serial does not contain unit root and is stationary.

Table 4 shows stationarity results relating to the variables. Since the MacKinnon critical values are bigger than ADF test statistics and PP test statistics, we reject the null hypotheses (H_0). When the variables are investigated for stationary, they are stationary at any significance level. Besides, When Durbin-Watson values are investigated, there is no autocorrelation.

The results related the portfolios are shown in Table 5. Mean returns for intersection portfolios of S/L, S/M, S/H, B/L, B/M, B/R, S/R, S/W, B/R, B/W, S/C, S/A, B/C, B/A are; (%) 0.0112, 0.0091, 0.0054, 0.0105, 0.0054, 6.11E-05, 0.0052, 0.0056, 0.0058, -0.0029, 0.0071, 0.0057, 0.0031, 0.0046, respectively. When the mean returns are sorted from large to small:

S/L > B/L > S/M > S/C > B/R > S/A > S/W > B/M > S/H > S/R > B/A > B/C > B/H > B/W

Table 4: The Unit Root Tests Results

Variable	ADF (level)		Phillips Perron (level)		Durbin Watson
	Statistics	**Probability**	**Statistics**	**Probability**	
S/L	-9.628	0.000	-9.608	0.000	1.985
S/M	-9.924	0.000	-9.924	0.000	1.997
S/H	-9.771	0.000	-9.703	0.000	1.985
B/L	-9.774	0.000	-9.868	0.000	2.010
B/M	-10.109	0.000	-10.104	0.000	1.988
B/H	-9.844	0.000	-9.856	0.000	2.000
S/R	-10.241	0.000	-10.235	0.000	1.969
S/W	-9.721	0.000	-9.703	0.000	1.979
B/R	-9.991	0.000	-9.991	0.000	1.988
B/W	-11.748	0.000	-11.742	0.000	1.966
S/C	-9.974	0.000	-9.980	0.000	1.979
S/A	-10.380	0.000	-10.440	0.000	2.007
B/C	-10.259	0.000	-10.262	0.000	1.985
B/A	-9.569	0.000	-9.569	0.000	1.987
R_m	-11.115	0.000	-11.118	0.000	2.002
SMB	-11.530	0.000	-11.528	0.000	2.005
HML	-10.142	0.000	-10.078	0.000	1.997
RMW	-12.948	0.000	-12.948	0.000	2.043
CMA	-10.513	0.000	-10.550	0.000	2.017
Critical values 1 % level	-3.435		-3.435		
5 % level	-2.863		-2.863		
10 % level	-2.567		-2.567		

Table 5: Descriptive Statistics Related to Portfolio (July 2005 - June 2016)

Variable	Mean	Median	Maximum	Minimum	SD	Skewness	Kurtosis
S/L	0.0112	0.0021	0.2519	-0.2930	0.0799	-0.3081	4.7140
S/M	0.0091	0.0076	0.2914	-0.2940	0.0834	-0.0873	5.1837
S/H	0.0054	-0.0027	0.5690	-0.2591	0.0997	1.1741	1.0052
B/L	0.0105	0.0122	0.1660	-0.2400	0.0723	-0.5305	3.9689
B/M	0.0054	0.0077	0.1782	-0.2721	0.0728	-0.5670	4.2475
B/H	-0.0000	0.0048	0.1522	-0.2940	0.0691	-0.6755	4.7612
S/R	0.0052	0.0055	0.2261	-0.2593	0.0808	-0.1908	3.9699
S/W	0.0056	0.0121	0.2655	-0.2619	0.0838	-0.2108	4.0220
B/R	0.0058	0.0089	0.1279	-0.2715	0.0646	-0.9130	4.8582
B/W	-0.0029	-0.0066	0.3518	-0.2889	0.0885	0.3083	5.7367
S/C	0.0071	0.0047	0.1999	-0.2423	0.0778	-0.2261	3.5575
S/A	0.0057	0.0042	0.3021	-0.3096	0.0889	-0.2289	4.9104
B/C	0.0031	0.0057	0.1860	-0.2444	0.0761	-0.6336	4.2272
B/A	0.0046	0.0114	0.2095	-0.3230	0.0745	-0.6610	5.4783
Observation number	132	132	132	132	132	132	132

When we investigate intersection portfolio in terms of firm size, it is seen that the small firms portfolio (S/L, S/M, S/H, S/C, S/A, S/W) has a higher return than the large firms (B/L, B/M, B/H, B/C, B/A, B/W). When we investigate intersection portfolio in terms of ME/BE, it is seen that the low ME/BE rate portfolio (S/L, B/L) has a higher return than the high ME/BE rate (S/H, B/H). Thereby, this result indicates that return can be achieved when the portfolio is constructed according to criterion low ME/BE rate in terms of ME/BE rate and small scale in terms of firm size. This result that small firm's return is more than big firm's return and is in line with these papers handled by Banz (1981), Roll (1981), Elfekhani and Zaher (1990), Bildik and Guzhan (2002).

Table 6: Descriptive Statistics Related to SMB, HML, RMW, CMA (July 2005 - June 2016)

Variable	**Mean**	**Median**	**Maximum**	**Minimum**	**SD**	**Skewness**	**Kurtosis**
R_m	0.024	0.019	0.916	-0.437	0.142	2.595	18.022
S	0.016	0.014	0.240	-0.262	0.080	-0.196	4.345
B	0.013	0.016	0.167	-0.255	0.070	-0.611	4.239
SMB	0.003	-0.000	0.124	-0.068	0.032	0.807	4.820
H	0.012	0.010	0.356	-0.260	0.079	0.204	5.789
L	0.020	0.015	0.166	-0.230	0.072	-0.530	4.073
HML	-0.008	-0.011	0.251	-0.106	0.039	1.977	15.496
R	0.014	0.015	0.173	-0.249	0.069	-0.546	4.281
W	0.010	0.008	0.237	-0.259	0.082	-0.152	4.251
RMW	0.004	0.004	0.069	-0.134	0.033	-1.291	6.811
C	0.014	0.013	0.177	-0.227	0.073	-0.513	3.765
A	0.014	0.011	0.195	-0.300	0.078	-0.490	4.843
CMA	0.000	-0.001	0.106	-0.103	0.026	0.086	6.296
Observation number	132	132	132	132	132	132	132

Table 6 indicates descriptive statistics related to SMB, HML, RMW, CMA portfolios. When the mean returns are investigated, these mean returns are R_m (% 0.024), SMB (% 0.003), HML (% −0.008), RMW (% 0.004), CMA (% 0.000), respectively. When the mean returns are sorted from large to small:

$$R_m > RMW > SMB > CMA > HML$$

It is shown that the mean return of the R_m portfolio is greater than the RMW, SMB, CMA, and HML. Thereby, this result indicates that the most return can be gained from the market portfolio (R_m). In the following sections, we will include the results of the CAPM, FF3F, FF4F, and FF5F Models in order to explain portfolio return. Thus, when we compare it with the results of the factor models, it will be possible to base upon sound findings the market factor, SMB, HML, RMW, and CMA factor on the basis of monthly returns.

Table 7 indicates the result of CAPM regression that uses with the help of market factor ($R_{mt} – R_{ft}$) as the explanatory variable. For intersection portfolios, the F values show that all regressions are statistically significant and the regression intercepts (α) values are statistically equal to zero. Thereby, we can say that there is no pricing error in the all regression models. When beta coefficients of market factors in regression models are investigated, beta (β) coefficients for all regression models are positive and all beta coefficients are statistically significant. Moreover, it is seen that the R^2 values of the intersection portfolios in CAPM vary between approximately 0.096 and 0.190 and the average R^2 value is approximately 0.149. When Durbin-Watson values are investigated, there is no autocorrelation.

Table 8 indicates the result of FF3F Model regression that uses with the help of market factor, size factor, value factor as the explanatory variable. For intersection portfolios, the F values show that all regressions are statistically significant and the regression intercepts (α) values are statistically equal to zero. Thereby, we can say that there is no pricing error in the all regression models. Moreover, the R^2 values of regressions for the FF3F Model are higher than CAPM. In the FF3F Model, the R^2 values of the intersection portfolios vary between approximately 0.171 and 0.518 and the average R^2 value is approximately 0.275. We can say that variation in share returns better explain included two factors (SMB, HML) in the regression models. When Durbin-Watson values are investigated, there is no autocorrelation.

Table 7: Regression Results from CAPM

$R_{it} - R_{ft} = \alpha_i + \beta_i (R_{mt} - R_{ft}) + \varepsilon_{it}$					
$R_i - R_f$	**α**	**β**	**DW**	**F-sta.**	**Adj.R^2**
S/L	0.002 (0.238)	0.224 (2.454)**	1.910	15.01 [0.000]	0.096
S/M	0.003 (0.455)	0.217 (2.00)**	1.894	21.80 [0.000]	0.137
S/H	0.008 (1.129)	0.212 (2.198)**	1.801	21.98 [0.000]	0.138
B/L	-0.003 (-0.522)	0.214 (2.497)**	1.801	31.63 [0.000]	0.189
B/M	0.002 (0.350)	0.239 (2.100)**	1.843	31.85 [0.000]	0.190
B/H	0.007 (1.095)	0.192 (1.863)***	1.707	21.98 [0.000]	0.138
S/R	0.002 (0.331)	0.190 (1.819)***	1.883	16.60 [0.000]	0.106
S/W	0.002 (0.341)	0.204 (1.960)**	1.74	17.96 [0.000]	0.114
B/R	0.003 (0.548)	0.192 (2.083)**	1.835	28.85 [0.000]	0.175
B/W	-0.006 (-0.977)	0.263 (2.256)*	1.815	28.73 [0.000]	0.174
S/C	0.004 (0.646)	0.193 (2.029)**	1.797	18.74 [0.000]	0.126
S/A	0.002 (0.275)	0.234 (2.034)**	1.913	21.47 [0.000]	0.135
B/C	-0.000 (-0.064)	0.236 (2.269)**	1.822	31.91 [0.000]	0.190
B/A	0.001 (0.186)	0.226 (2.225)**	1.933	30.28 [0.000]	0.182
Observation number	132	132	132	132	132

-The values in brackets are probability values and values in parentheses are t statistics (***), (**), (*) show significance at 10%, 5%, 1% levels.
-The values in parentheses are the corrected resistive t statistic according to Newey-West method for the heteroscedasticity problem.

Table 9 indicates the result of FF4F Model regression that uses with the help of market factor, size factor, value factor, and profitability factor as the explanatory variable. For intersection portfolios, the F values show that all regressions are statistically significant and the regression intercepts (α) values are statistically equal to zero. Thereby, we can say that there is no pricing error in the all regression models. Moreover, the R^2 values of regressions for the FF4F Model are higher than FF3F Model. Moreover, the R^2 values of regressions for the FF4F Model are higher than the CAPM and FF3F Models. In the FF4F Model, the R^2 values of the intersection portfolios vary between approximately 0.194 and 0.537 and the average R^2 value is approximately 0.315. We can say that variation in share returns better explain included RMW factor in the regression models. When Durbin-Watson values are investigated, there is no autocorrelation.

Table 8: Regression Results from FF3F Model

$R_{it} - R_{ft} = \alpha_i + \beta_i (R_{mt} - R_{ft}) + s_i (SMB_t) + h_i (HML_t) + \varepsilon_{it}$							
$R_i - R_f$	α	**β**	**s**	**h**	**DW**	**F-sta.**	**Adj.R^2**
S/L	0.004 (0.554)	0.221 (2.124)**	1.41 (7.866)*	0.818 (4.238)*	1.821	48.08 [0.000]	0.518
S/M	-0.001 (-0.239)	0.226 (2.081)**	1.157 (7.958)*	-0.087 (-0.680)	1.832	22.41 [0.000]	0.329
S/H	0.000 (0.007)	0.229 (2.421)**	1.271 (7.532)*	-0.435 (-3.544)*	1.736	26.28 [0.000]	0.366
B/L	-0.001 (-0.169)	0.209 (2.333)**	0.172 (1.295)	0.321 (3.122)*	1.706	14.01 [0.000]	0.229
B/M	0.001 (0.174)	0.241 (2.096)**	0.256 (1.321)	-0.211 (-0.174)	1.828	11.19 [0.000]	0.189
B/H	0.002 (0.437)	0.201 (2.025)**	0.316 (2.020)**	-0.424 (-2.983)*	1.779	10.39 [0.000]	0.177
S/R	-0.001 (-0.262)	0.198 (1.886)***	0.978 (5.259)*	-0.083 (-0.607)	1.840	14.93 [0.000]	0.241
S/W	-0.004 (-0.710)	0.218 (2.121)**	1.411 (8.608)*	-0.266 (-2.273)**	1.700	27.33 [0.000]	0.376
B/R	0.003 (0.587)	0.192 (2.036)**	0.112 (0.799)	0.887 (0.957)	1.797	10.01 [0.000]	0.171
B/W	-0.008 (-1.236)	0.267 (2.295)***	0.396 (1.940)***	-0.705 (-0.518)	1.789	10.67 [0.000]	0.181
S/C	-0.001 (-0.235)	0.204 (2.146)**	1.255 (7.769)*	-0.150 (-1.320)	1.753	26.20 [0.000]	0.365
S/A	-0.004 (-0.638)	0.248 (2.180)**	1.341 (6.205)*	-0.258 (-1.532)	1.759	23.68 [0.000]	0.341
B/C	-0.002 (0.315)	0.239 (2.291)**	0.322 (2.245)**	-0.067 (-0.594)	1.841	11.61 [0.000]	0.195
B/A	0.000 (0.140)	0.227 (2.208)**	0.137 (0.769)	0.021 (0.197)	1.754	10.22 [0.000]	0.174
Observation number	132	132	132	132	132	132	132
-The values in brackets are probability values and values in parentheses are t statistics (***), (**), (*) show significance at 10%, 5%, 1% levels. *-The values in parentheses are the corrected resistive t statistic according to Newey-West method for the heteroscedasticity problem.*							

Table 9: Regression Results from FF4F Model

$R_{it} - R_{ft} = \alpha_i + \beta_i (R_{mt} - R_{ft}) + s_i (SMB_t) + h_i (HML_t) + r_i (RMW_t) + \varepsilon_{it}$								
$R_i - R_f$	**α**	**β**	**s**	**h**	**r**	**DW**	**F-sta.**	**A.R^2**
S/L	0.007 (1.028)	0.198 (1.955)***	1.247 (6.273)*	0.897 (4.357)*	-0.497 (-2.765)*	1.88	38.98 [0.00]	0.537
S/M	0.001 (0.238)	0.207 (1.926)***	1.010 (5.667)*	-0.017 (-0.134)	-0.410 (-2.597)*	1.86	18.56 [0.00]	0.349
S/H	0.003 (0.561)	0.206 (2.238)**	1.101 (6.165)*	-0.354 (-2.921)*	-0.472 (-3.785)*	1.80	22.55 [0.00]	0.396
B/L	0.001 (0.266)	0.192 (2.163)**	0.044 (0.296)	0.383 (3.778)*	-0.358 (-2.884)*	1.73	11.95 [0.00]	0.250
B/M	0.003 (0.554)	0.223 (1.963)**	0.124 (0.535)	0.041 (0.326)	-0.367 (-1.931)**	1.89	9.48 [0.00]	0.205
B/H	0.005 (0.823)	0.185 (1.873)***	0.190 (1.130)	-0.364 (-2.373)*	-0.351 (-2.392)*	1.81	8.90 [0.00]	0.194
S/R	-0.002 (-0.293)	0.201 (1.848)***	0.997 (4.603)*	-0.924 (-0.713)	0.516 (0.227)	1.83	11.13 [0.00]	0.236
S/W	0.001 (0.297)	0.178 (1.822)***	1.108 (6.998)*	-0.121 (-1.285)	-0.845 (-7.092)*	1.76	30.54 [0.00]	0.474
B/R	0.005 (0.823)	0.185 (1.873)***	0.190 (1.130)	-0.364 (-2.373)*	-0.351 (-2.392)*	1.81	8.90 [0.000]	0.194

B/W	0.000 (0.062)	0.208 (1.959)***	-0.046 (-0.189)	0.141 (1.030)	-1.236 (-4.564)*	1.90	20.40 [0.00]	0.372
S/C	0.002 (0.399)	0.182 (1.953)***	1.08 (5.928)*	-0.703 (-0.572)	0.468 (-3.084)*	1.81	22.61 [0.00]	0.397
S/A	0.000 (0.002)	0.218 (1.971)**	1.120 (5.348)*	-0.152 (-1.104)	-0.618 (-4.068)*	1.81	21.54 [0.00]	0.385
B/C	0.001 (0.209)	0.217 (2.135)**	0.157 (1.00)	0.010 (0.098)	-0.459 (-2.972)*	1.92	10.56 [0.00]	0.226
B/A	0.004 (0.654)	0.202 (2.00)**	-0.049 (-0.237)	0.111 (0.980)	-0.523 (-2.835)*	1.93	10.11 [0.00]	0.217
Ob.Num.	132	132	132	132	132	132	132	132

-The values in brackets are probability values and values in parentheses are t statistics (***), (**), (*) show significance at 10%, 5%, 1% levels.
-The values in parentheses are the corrected resistive t statistic according to Newey-West method for the heteroscedasticity problem.

Table 10: Regression Results from FF5F Model

$$R_{it} - R_{ft} = \alpha_i + \beta_i (R_{mt} - R_{ft}) + s_i (SMB_t) + h_i (HML_t) + r_i (RMW_t) + c_i (CMA_t) + \varepsilon_{it}$$

$R_i - R_f$	α	β	s	h	r	c	DW	F-sta.	A.R^2
S/L	0.007 (1.10)	0.195 (1.96)**	1.274 (6.26)*	0.894 (4.31)*	-0.432 (-2.52)**	-0.304 (-1.26)	1.91	31.75 [0.00]	0.54
S/M	0.001 (0.22)	0.204 (1.94)***	1.030 (5.75)*	-0.019 (-0.14)	-0.385 (-2.31)**	-0.226 (-0.76)	1.90	15.07 [0.00]	0.35
S/H	0.003 (0.56)	0.202 (2.28)*	1.138 (6.65)*	-0.358 (-3.02)*	-0.427 (-3.37)*	-0.417 (-1.8)***	1.86	19.33 [0.00]	0.41
B/L	0.001 (0.24)	0.189 (2.20)	0.074 (0.50)	0.380 (3.69)*	-0.322 (-2.33)**	-0.340 (-1.30)	1.79	10.30 [0.00]	0.26
B/M	0.003 (0.56)	0.219 (1.99)**	0.159 (0.72)	0.038 (0.29)	-0.324 (-1.8)***	-0.390 (-1.50)	1.94	8.33 [0.00]	0.22
B/H	-0.005 (0.82)	0.182 (1.88)**	0.210 (1.18)	-0.366 (-2.34)**	-0.327 (-2.04)**	-0.227 (-0.85)	1.83	7.35 [0.00]	0.20
S/R	-0.002 (-0.33)	0.198 (1.87)**	1.021 (4.85)*	-0.095 (-0.69)	0.081 (0.38)	-0.278 (-0.91)	1.85	9.22 [0.00]	0.24
S/W	0.001 (0.28)	0.176 (1.84)**	1.127 (6.77)*	-0.123 (-1.28)	-0.823 (-6.10)*	-0.209 (-0.94)	1.80	24.66 [0.00]	0.48
B/R	0.004 (0.76)	0.181 (1.97)**	0.097 (0.62)	0.108 (1.13)	-0.094 (-0.75)	-0.367 (-1.8)***	1.88	6.96 [0.00]	0.19
B/W	0.000 (0.02)	0.203 (1.98)**	-0.008 (-0.04)	0.136 (0.92)	-1.189 (-4.84)*	-0.437 (-1.44)	1.94	17.37 [0.00]	0.38
S/C	0.002 (0.40)	0.184 (1.95)***	1.067 (5.87)*	-0.068 (-0.61)	-0.493 (-3.26)*	0.234 (0.93)	1.75	18.41 [0.00]	0.40
S/A	-0.000 (-0.10)	0.209 (2.03)**	1.200 (7.64)*	-0.160 (-1.55)	-0.519 (-3.54)*	-0.919 (-3.87)*	1.89	23.04 [0.00]	0.46
B/C	0.001 (0.21)	0.218 (2.14)**	0.153 (0.96)	0.011 (0.10)	-0.465 (-2.78)*	0.052 (0.21)	1.91	8.40 [0.00]	0.22
B/A	0.004 (0.69)	0.194 (2.07)**	0.019 (0.10)	0.104 (0.84)	-0.438 (-2.67)*	-0.794 (-2.95)*	1.77	11.83 [0.00]	0.29
Obs.Num.	132	132	132	132	132	132	132	132	132

-The values in brackets are probability values and values in parentheses are t statistics (***), (**), (*) show significance at 10%, 5%, 1% levels.
-The values in parentheses are the corrected resistive t statistic according to Newey-West method for the heteroscedasticity problem.

Table 10 indicates the result of FF5F Model regression that uses with the help of market factor, size factor, value factor, profitability factor, and investment factor as the explanatory variable. For intersection portfolios, the F values show that all regressions are statistically significant and the regression intercepts (α) values are statistically equal to zero. Thereby, we can say that there is no pricing error in the all regression models. Moreover, the R^2 values of regressions for the FF5F Model are higher than the CAPM, FF3F, FF4F Model. Besides, In the FF5F Model, the R^2 values of the intersection portfolios vary between approximately 0.185 and 0.540 and the average R^2 value is approximately 0.330. We can say that variation in share returns better explain included CMA factor in the regression models. When Durbin-Watson values are investigated, there is no autocorrelation.

Furthermore, in order to evaluate whether the alpha coefficient values (the regression intercepts) in CAPM, FF3F, FF4F, and FF5F Models are significantly different from zero, we estimate that regression model allows for using a standart alpha as an alternative to the GRS-F test statistic and p-probability values, as recommended by Gibbons, Ross and Shanken (1989). GRS-F test statistic and p-probability values compute whether the regression intercepts are jointly equal to zero.

- **H_0:** For the CAPM, FF3F, FF4F, FF5F Models; all α_i coefficients obtained from multiple factor models are equivalent to zero.
- **H_1:** For the CAPM, FF3F, FF4F, FF5F Models, not all αi coefficients obtained from multiple factor models are equivalent to zero.

Table 11: Comparative Performance of Models.

Dependent Variable	Model	Average (Adj.) R^2	GRS-F	p–value
S/H, B/H, S/R, B/R, S/C, B/C, S/M, B/M, S/W, B/W, S/A, B/A, S/L, B/L	CAPM	0.14	2.23	0.01
	FF3F Model	0.27	1.50	0.11
	FF4F Model	0.31	1.01	0.44
	FF5F Model	0.33	1.00	0.45

Table 11 indicates the comparative performance of models. It has been tested by using the average adjustments (Adj.) R^2, Gibbons et al. (1989) GRS-F test and p-probability values, in which model (s) can explain the variation in portfolio returns better and which model (s) can be used to explain portfolio returns in BIST. When we investigate average Adj. R^2 of the CAPM, FF3F, FF4F, and FF5F Model, they are as follows; 0.14, 0.27, 0.31, and 0.33, respectively. Thus, this result shows that the FF5F Model has the most explanatory power on variations in excess portfolio returns.

When we compare our GRS-F test and p-values of the CAPM, FF3F, FF4F, and FF5F Model, we result in that the null (H_0) hypothesis is rejected for CAPM (2.23) and the null (H_0) hypothesis is accepted for FF3F Model (1.50), FF4F Model (1.01), FF5F Model (1.00). In this way, we can say that there is pricing error in the CAPM and it is not valid in BIST. This result is in line with papers handled by Gokgoz (2008). For FF3F, FF4F and FF5F Model, we can say that there is no pricing error in the models and they are valid in BIST. This result is in line with these papers handled by Fama and French (2015), Nguyen et al. (2015), Clarice and William (2015), Chiah et al. (2016), François and William (2016), Wijaya, Murhadi and Utami (2017) but not Foye (2017).

Table 12: Hypothesis Results for Borsa Istanbul.

Hypotheses	Accept	Reject
Hypothesis 1: CAPM explains the variation in portfolio returns better than the FF3F, FF4F, and FF5F Model.		X
Hypothesis 2: FF3F Model explains the variation in portfolio returns better than the FF4F and FF5F Model.		X
Hypothesis 3: FF4F Model explains the variation in portfolio returns better than the FF5F Model.		X
Hypothesis 4: FF3F, FF4F, FF5F Model can be used to explain the portfolio returns in the BIST.	X	

Table 12 indicates hypothesis results for BIST. As a result, it is found that all the models except CAPM are valid and the BIST and FF5F Model has the most explanatory variations in excess portfolio returns, then become the FF4F and FF3F Model, respectively. Thus we reject Hypothesis 1, Hypothesis 2, Hypothesis 3, and accept Hypothesis 4.

4. Conclusion

One of the most fundamental problem that analysts or investors face while investing in the capital market are expected return and risk. There are many risk factors such as size factor (SMB), value factor (HML), profitability factor (RMW), and investment factor (CMA) that affects share returns. This paper investigates the relationship between share return and risk factors, which are tested by using Asset Pricing Models in BIST from July 2005 to June 2016. Thus in time series regression, the excess montly returns on the risk-free interest rate of S/H, B/H, S/R, B/R, S/C, B/C, S/M, B/M, S/W, B/W, S/A, B/A, S/L, B/L intersection portfolios created on the basis of size, value factor, investment factor and profitability are used as dependent variable and risk factors are used as the independent variable. In these study, four different asset pricing models are used to explain share returns. Firstly, CAPM is the single factor that includes the market factor. Secondly, the FF3F Model is model which includes market, SMB, HML factors. Thirdly, the FF4F Model is the model which includes market, SMB, HML, RMW factors. Lastly, the FF5F Model is the model which includes market, SMB, HML, RMW and CMA factors.

In this study, When we investigate average Adj. R^2 values related to regression results, the average Adj. R^2 values indicate that Adj. R^2 of CAPM, FF3F, FF4F, and FF5F Models, they are as follows; 0.14, 0.27, 0,31 and 0.33, respectively. Thus, the FF5F Model has the most explanatory power in variations on excess portfolio returns, then FF4F and FF3F Models, respectively.

When we compare our GRS-F test and p-values of the CAPM, FF3F, FF4F, and FF5F Model, we result in that the null (H_0) hypothesis is rejected for CAPM (2.23) and the null (H_0) hypothesis is accepted for FF3F Model (1.50), FF4F Model (1.01), FF5F Model (1.00). In this way, we can say that that there is pricing error in the CAPM and it is not valid in BIST. For FF3F, FF4F and FF5F Model, we can say that there is no pricing error in the models and they are valid in BIST.

Thanks to this work, analysts or investors will be able to examine the relationship between expected risk and return while investing in capital market instruments. Thus, they will be able to carry out their analysis with a more accurate calculation of the expected return and risk. Moreover they will be able to make better speculations with strategies which are presented in the model.

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