Theoretical and Applied Economics
Volume XXX (2023), No. 1(634), Spring, pp. 115-136

Validity of asset pricing models in Istanbul Stock Exchange (ISE) information technology index*

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Abstract. *Statistical models have been created to understand capital assets' return and risk. In the empirical studies in which these developed models were tested, it was concluded that the models were valid in some periods and some samples, but not in others. In this study, it is aimed to test whether the developed asset pricing models are valid for the stocks in the Borsa Istanbul (Istanbul Stock Exchange – ISE) Information Technology Index. Model tests were carried out with panel data analysis. The data set consists of the monthly returns of 13 companies traded in the ISE Information Technology Index for the period 2013/January-2019/December. Model tests were performed on both portfolio and stock basis.*
As a result of the tests, it was concluded that CAPM is valid in firm-based studies in the ISE Information Technology Index, and both CAPM and C4F are valid in portfolio-based studies.

Keywords: Capital Asset Pricing Model (CAPM), Fama French Pricing Models, ISE Technology Index, panel data.

JEL Classification: G12, C33.

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* This study is derived from the master's thesis named "Alternative models of expected stock return and risk Istanbul Stock Exchange(ISE) application", prepared by Akin Arda.

Introduction

There are various definitions of the terms investment and investor. However, the capital market definition of these words is important because the subject of the research is the stocks/portfolios in ISE. In capital markets, investors are defined as real or legal persons who have savings and invest their savings in capital market instruments. The motivation of the investors is to generate income through their investments (SPL, 2019).

Although it is claimed that risk-free or relatively risk-free earnings can be made through various investment tools, there are risk factors in every transaction. The risk can be defined as the situation of deviating from the targeted results while operating. As a result of deviation from the results, additional benefit or loss may be obtained and can be interpreted as an opportunity or a danger, depending on the direction of the deviation from the results with the effect of risk (ISO, 2018). Although the term risk generally brings negative connotations to people, it can be considered as uncertainty because it contains not only loss but also gains. The perspective on risk varies from person to person. Actions to be taken by legal entities and people vary according to their risk perspectives. People can be grouped as risk seekers, risk-neutral, and risk-averse (Basoglu et al., 2001).

Like people do, companies identify risks in their operations and try to reduce those risks. Risk management is also related to efforts to reduce these risks. Identifying risks, taking measures for them, controlling the measures taken afterward, and making updates, if necessary, are the basic steps of risk management that can be applied to individuals or institutions. Thanks to this cycle, the effects of the risks encountered are reduced. In many studies, the relationship between risk and return has been tried to be explained scientifically. As a result of the related studies, asset pricing models were designed. In this study, we used some of the most referenced related models, which follow each other and include similar factors. The Capital Asset Pricing Model (CAPM), Fama-French 3-Factor Asset Pricing Model (FF3F), Carhart 4-Factor Asset Pricing Model (C4F), Fama-French 5-Factor (FF5F), and the 6 Factor Model (6F), created by adding the momentum factor from the C4F to the FF5F, are tested by using the stocks'/portfolios' values in ISE Information Technology Index and tried to determine which model is more explanatory for the relevant stocks/portfolios.

1. Conceptual – theoretical framework

1.1. Risk and risk management

The term risk is a concept that has existed for all kinds of financial mechanisms. However, risk has been defined in different ways. In 1921, Frank Knight mentioned the concepts of measurable uncertainty and unmeasurable uncertainty in his work. The concept of measurable uncertainty is a reflection of antecedent and statistical probabilities, and unmeasurable uncertainty is expressed as the uncertainty of subjective probabilities. In 1952, Harry Markowitz, in his study titled "Portfolio Selection", stated that the expected return is desired by the investor, but the variance of the expected return is undesirable for the investor. Harry Markowitz expressed risk as to the standard deviation of expected returns. With this expression, the expected return variance is accepted as a numerical measure of risk (Holton, 2004).

Risk types can be classified according to their sources, results, and many more different ways. In this paper, classification is related to risk reduction. Some of the risks can be reduced by asset diversification. If the risks decrease as a result of asset diversification, the relevant risks are called unsystematic risks. If asset diversification does not affect the risk reduction, the related risks are called systematic risks. Systematic risks occur due to macroeconomic factors. Total risk consists of systematic risk and unsystematic risk (Reilly and Brown, 2002).

The system that determines the risk to be reached to achieve the company target which maximizes the company value and tries to achieve the target is called risk management. On the other hand, enterprise risk management is the systematic process that is created to define the potential issues that may have an impact on firms, manage the risks according to the risk appetite of the companies and give reasonable assurance to achieve the goals of the companies. The risk management process consists of defining, analyzing, prioritizing risks, identifying solutions, monitoring the process, and communication steps (TÜSİAD, 2008).

1.2. Portfolio theory, portfolio selection and capital assets pricing models

Portfolio theory is discussed under two main headings as traditional portfolio theory and modern portfolio theory. The most important distinction between traditional and modern portfolio theory is the consideration of the relationship between financial assets. In the traditional portfolio theory, the relationship between the financial assets in the portfolio is not taken into account. It has been concluded that the risk can be reduced by increasing the number of financial assets in the portfolio, diversifying their maturities, and incorporating financial assets from different sectors into the portfolio. In the modern portfolio theory, it is stated that the main aim of the investors is profit maximization, and for this, the concepts of expected return and risk are important. In addition, the low covariance of the assets included in the portfolio indicates correct diversification.

In portfolio selection, the investor can first choose how many risky and risk-free assets to invest, as well as the selection of risky assets according to the effective limit in the Mean-Variance Model (MVM). MVM states that portfolios with the highest average return but the lowest variance will be selected when creating the portfolio, and the line formed by the portfolios that show the highest return at a certain risk level is called the effective limit. In addition, while determining the optimal portfolio, the utility function of the investor outside the effective limit is also taken into account. Indifference curves are formed depending on the utility function. Investors want to reach the highest indifference curve. The optimal portfolio is formed at the point where the efficient frontier and the indifference curve of investors are tangent (SPL, 2020).

When the literature on asset pricing models is reviewed, it is seen that many models have been developed to use them in the return and risk estimations of financial assets. In this study, the CAPM, FF3F, C4F, FF5F, and the 6F model were used.

The model in the studies of Sharpe (1964), Lintner (1965), and Black (1972) are stated in the studies of Fama and French as the CAPM. In CAPM, the relationship between the expected return of the financial asset and the degree of risk is shown (Ceylan and Korkmaz, 1998). CAPM took the capital market line a step forward by allowing it to assess the link between risk and expected return for individual risky assets. In CAPM, the risk is specified as the systematic component of total risk rather than total risk. Also, the systematic risk of a financial asset or portfolio is indicated by the beta (β) coefficient, which indicates the sensitivity of the asset's return to changes in the return of the hypothetical market portfolio, in CAPM. Regardless of the individual asset or portfolio, since the return consists of the return of the risk-free asset and the expected risk premium, a risk-expected return relationship can also be established for individual assets other than portfolios.

Although the CAPM model has many assumptions, many criticisms have been brought to these assumptions. These criticisms are related to issues such as unlimited borrowing and lending at risk-free interest rates, the adequacy of beta being a risk measure, whether the market portfolio represents the market, and the linear relationship between risk and return. As a result of these criticisms, the FF3F model has emerged. Since CAPM is criticized for trying to predict the expected returns of financial assets on a single factor, in the study conducted by Fama and French in 1992, factors such as the size of the firms, leverage ratio, price/earnings ratio, cash cycle, book value, past sales growth, and long and short-term historical returns were added to the model (Yolsal, 2005).

Fama and French stated that factors such as firm size, price/earnings ratio, and book value/market value are effective factors in explaining stock returns. In the "3-Factor Asset Pricing Model" developed by Fama and French in 1993, "portfolio size" and "book value/market value" factors were added to the CAPM (Guzeldere and Sarıoğlu, 2012). The model is built on the assumption that rational pricing and optimal portfolios are designed following the multi-factor minimum variance criterion (Yücel, 2013).

In 1997, Carhart built the "Four-Factor Asset Pricing Model" by adding the momentum factor (Winner minus loser-WML) to the related model, with the criticism that the momentum returns could not be explained by the FF3F. The model assumes that the markets are in equilibrium. In his study, Carhart calculated the momentum factor according to the high and low returns in the previous 11 months, from 1 year before the portfolio creation period to 1 month before. Then, by sorting the returns of the companies from the largest to the smallest, Carhart came to the conclusion by subtracting the returns of the companies in the last 30% from the returns of the companies in the first 30% (Carhart, 1997).

Profitability and investment variables were added to the 3-factor model in the study conducted by Fama and French and published in 2015. It is stated that the reason for adding the related variables to the model is that the related variables affect the average returns of the stocks. In the related study, data of companies traded in NYSE, AMEX, and NASDAQ markets between July/1963-December/2013 were used. As a result of the study, it was concluded that FF5F performed better than FF3F (Fama and French, 2015).

2. Literature review

There are many studies on financial models in the literature. Studies on the models tested in the study were examined under two main headings, abroad and domestically.

Table 1. *Studies – Abroad*

Author/s	Publishing Year	Study Market	Study Period	Study Models	Brief Summary
Harshita, Singh and Yadav	2015	India	1999-2014	CAPM, FF3F and FF5F	- FF3F is more successful than CAPM - FF5F is more successful model in portfolios created according to the investment factor.
Chiah, Chai, Zong and Li	2016	Australia	1982-2013	FF3F, C4F and FF5F	- FF5F is more successful model
Taha and Elgiziry	2016	Egypt	2005-2013	FF3F and 5 Factor	- Momentum factor has no effect - The model which has factors of market risk premium, firm size, book to market ratio, P/E ratio and liquidity is more successful model
Jiao and Lilti	2017	China	2010-2015	FF3F and FF5F	- Profitability and investment factors have not much descriptive power - There is no significant distinction between FF3F and FF5F
Machado, Faff and Silva	2017	Brazil	1997-2014	FF5F and 5 Factors	- Book to market ratio, momentum and liquidity factors are helpful to predict returns - Investment and profitability factors are not significant - Keene and Peterson's 5 factors model is more successful than others
Kubota and Takehara	2017	Japan	1978-2014	FF5F	- FF5F is not significant
Foye	2018	Asia, East Europe, and Latin America	1996-2016	FF3F and FF5F	- FF5F is more successful than FF3F in East Europe and Latin America - Investment and profitability factors are not significant in Asia market
Musawa, Kapena and Shikaputo	2018	Lusaka (Zambia)	2008-2014	FF3F and FF5F	- FF5F is more successful than FF3F
Dash	2019	India	2008-2016	FF3F	- HML factor has negative effect - ß&SMB factors are insignificant
Nilsson and Ljungström	2019	Sweden	1998-2018	CAPM, FF3F and FF5F	- Related models are not significant regarding explanation of average earnings
Sonubi	2019	Ireland	2011-2015	CAPM and FF3F	- FF3F is more successful model - ß&HML factors are significant, but SMB is not significant
Jansen	2019	Holland	2000-2017	CAPM, FF3F and FF5F	- FF5F is not significant and, CAPM and FF3F are more successful models regarding explanation of change in returns

Table 2. *Studies – Domestic*

Author/s	Publishing Year	Study Market	Study Period	Study Models	Brief Summary
Yolsal	2005	Türkiye	1999-2004	CAPM and FF3F	- FF3F is more successful than CAPM
Sultanov	2010	Türkiye (Real Estate Investment Companies and Securities Investment Trusts)	1997-2009	CAPM, FF3F and C4F	- FF3F is more successful - Momentum factor is not significant
Aydemir	2012	USA	2005-2011	CAPM, FF3F and C4F	- Real Estate Investment Companies have positive correlation with SMB and HML but they have negative correlation with momentum
Çakır	2012	Türkiye (12 Sectors)	2000-2009	APT	- APT is significant
Yücel	2013	Türkiye (4 Sectors)	2009-2011	CAPM and FF3F	- Both models are significant
Kakilli Acaravcı and Karaömer	2017	Türkiye	2005-2016	FF5F	- FF5F is significant
Karaömer	2017	Türkiye (4 Sectors)	2005-2016	CAPM, FF3F, FF4F and FF5F	- CAPM is not significant - FF3F, FF4F and FF5F are significant - The most successful model is FF5F
Sondemir	2018	Türkiye (Participation Banks 30)	2011-2017	FF3F	- FF3F is not significant
Karabay	2018	Türkiye	2008-2018	CAPM, FF3F and FF5F	- FF5F is not significant - Model with 2 factors is more successful than CAPM
Çömlekçi and Genç	2018	Türkiye (ISE Corporate Governance Index)	2010-2017	FF3F	- FF3F is not significant
Zeren, Yılmaz and Belke	2018	Türkiye (ISE Sustainability Index)	1995-2017	FF5F	- FF5F is not significant
Kirman Başpehlivan	2019	Czechia, Hungary, Russia, Polond and Türkiye	2007-2017	CAPM, FF3F and C4F	- CAPM is not significant - FF3F and C4F are significant
Aras, Çam, Zavalsız and Keskin	2019	Türkiye	2005-2017	CAPM, FF3F and FF5F	- FF5F is more successful
Yayıkçı	2019	Türkiye	2011-2015	CAPM	- CAPM is not significant
Kartal	2019	Türkiye (Participation Banks 30)	2011-2018	FF5F	- FF5F is significant
Arı	2020	Türkiye	2006-2018	FF5F	- There is not adequate proof about significance of FF5F model

When we look at the these studies, it is seen that the results differ considerably according to the sample and period studied. According to this result, it has been observed that there is not a single model valid for every period and every sample.

3. Research

The purpose of the study, the methodology used, and the analysis part are discussed in this chapter.

3.1. Purpose of the research

This study, it is aimed to test the CAPM, FF3F, C4F, and FF5F models with panel regression using monthly data of stocks traded in ISE Information Technology Index between 2013/January-2019/December periods.

3.2. Methodology of the research

The models in the study were tested with panel data analysis methods. The methods of estimating economic relations with the help of models created using panel data are called panel data analysis (Yerdelen Tatoğlu, 2013).

In panel data analysis, firstly, hypothesis tests are performed based on variables to determine the model estimator. The most basic assumption about variables is the stationarity assumption. For this, first of all, the existence of a correlation between units in the variables is tested with the Pesaran CD (PCD) test. If the variables are not correlated between units, the I. generation unit root tests are performed, and if there is an inter-unit correlation, the II. generation unit root tests are used to test the assumptions of the variables. If the variables are stationary, then the existence of the multicollinearity problem related to the model is tested with the VIF test. Variables with a VIF value above 10 should be excluded from the model. Afterward, the panel data is subjected to some tests to determine the model estimator. Many tests can be done to decide whether the model is a classical model or a model with fixed effects. These tests are F test, the likelihood ratio test, Breusch-Pagan Lagrange multiplier, and adjusted Lagrange multiplier test, Score test, and Wooldridge's test. In this study, this control was carried out with the F test, the Breusch-Pagan Lagrange multiplier, and the corrected Lagrange multiplier test. The F test helps to understand whether the data differs according to the units. If the data does not differ by units, the classical model is suitable. To test the suitability of the pooled least squares model against the random-effects model, the Breusch Pagan LM test based on the residuals of the pooled least squares model was developed. In this test, the hypothesis that the variance of the random unit effects is zero (H_0: $\sigma_{\mu^2} = 0$) is tested. If the H_0 hypothesis cannot be rejected, it can be said that the classical model is suitable. After testing whether the model is classical, heteroscedasticity, autocorrelation, and correlation between units, which are the basic assumptions about the model, are tested. Hypothetical tests differ depending on whether the model is classical, or unit rooted. In this study, since the model is a classical model, the autocorrelation assumption was tested with Wooldridge's test. In this test, the H_0 hypothesis is established as "There is no first-order autocorrelation.". Heteroskedasticity assumption was tested with the Breusch-Pagan/Cook-Weiesberg test. The H_0 hypothesis of the test is established as "There is no heteroskedasticity.". In the absence of autocorrelation in the model but heteroscedasticity, the model can be estimated with the Beck-Katz (BK) estimator.

3.3. Data set and theoretical model

In the regression analysis, the pooled ordinary least squares method was used. The relevant models were tested on both stock and portfolio basis, and the results were evaluated within the 95% confidence interval. Financial statements, stocks' daily prices, and 2-year government bond yield which were used for risk-free interest rate were used, in this study.

Financial statements were obtained from Public Disclosure Platform's (PDP) website, stock prices were obtained from İş Yatırım and bond yields were obtained from tr.investing.com. The government bond yield was used by converting it on monthly basis. There are 13 stocks operating continuously in the BIST during the relevant periods. Stata17, Gretl, and Microsoft Excel programs were used for data analysis.

In the data set, the average of the most recent returns has been taken instead of the missing returns since they coincide with the holidays. In the event that the financial statements are given comparatively by years in the PDP and there is inconsistency in the data in the financial statements published on different dates, the most up-to-date published data is used for the data found to be inconsistent. Since the provided data have been corrected, no additional calculations have been made regarding dividends and/or splits.

After the portfolios were created, the factors were calculated thanks to the relevant portfolios, and then models were created by using the portfolios and factors. Models were analyzed separately on both stock and portfolio basis.

Due to the small number of stocks, portfolios were formed with the 2x2 method. The stocks are named according to the 50% tranches based on the median value, annually factors are arranged from largest to smallest according to their status, and portfolios are formed from the overlapping stocks. The details of the portfolio formation method are given below. For the January rankings of the year "t", the December financial data of the year "t - 1" were used. Although studies are using approximately 6-month intervals in the literature, there was no need to use historical data since the financial data of the companies are published quarterly. The research was carried out under the precondition that the difference would not affect the results.

Table 3. *Portfolio formation method*

		Value Ratio		Momentum		Operational Profit		Investment	
		L	**H**	**K**	**D**	**W**	**R**	**C**	**A**
Size	**S**	SL	SH	SK	SD	SW	SR	SC	SA
	B	BL	BH	BK	BD	BW	BR	BC	BA

Source: Fama and French: A five-factor asset pricing model, 2015.

SL: It refers to the portfolio consisting of small size (S) stocks and low value ratio (L) stocks.

SH: It refers to the portfolio consisting of S stocks and high value ratio (H) stocks.

BL: It refers to the portfolio consisting of big size (B) stocks and L stocks.

BH: It refers to the portfolio consisting of B stocks and H stocks.

SK: It refers to the portfolio consisting of S stocks and low momentum (K) stocks.

SD: It refers to the portfolio consisting of S stocks and high momentum (D) stocks.

BK: It refers to the portfolio consisting of B stocks and K stocks.

BD: It refers to the portfolio consisting of B stocks and D stocks.

SW: It refers to the portfolio consisting of S stocks and weak operational profitability (W) stocks.

SR: It refers to the portfolio consisting of S stocks and robust operational profitability (R) stocks.

BW: It refers to the portfolio consisting of B stocks and W stocks.

BR: It refers to the portfolio consisting of B stocks and R stocks.

SC: It refers to the portfolio consisting of S stocks and conservative investment (C) stocks.

SA: It refers to the portfolio consisting of S stocks and aggressive investment (A) stocks.

BC: It refers to the portfolio consisting of B stocks and C stocks.

BA: It refers to the portfolio consisting of B stocks and A stocks.

The list of companies in the portfolios formed as a result of the studies carried out as stated above, by years is given below.

Table 4. *Stocks in portfolios*

	2013	2014	2015	2016	2017	2018	2019
SL	KRONT, LINK	KRONT	LINK, PKART	KRONT, LINK, PKART	KRONT, LINK	LINK	DESPC, DGATE, KRONT, LINK, PKART
SH	ARMDA, DESPC, DGATE, PKART	ARMDA, DESPC, DGATE, ESCOM, LINK	DESPC, ESCOM, KAREL, KRONT	DESPC, ESCOM, KAREL,	DESPC, ESCOM, KAREL, PKART,	ARENA, ARMDA, DESPC, ESCOM, PKART	ESCOM
SK	KRONT, LINK, PKART	DESPC, DGATE, ESCOM, LINK	ESCOM, KAREL, KRONT, PKART	ESCOM, KAREL, LINK, PKART	KAREL, KRONT, PKART	ARENA, ARMDA, ESCOM, PKART	DGATE, ESCOM, KRONT
SD	ARMDA, DESPC, DGATE	ARMDA, KRONT	DESPC, LINK	DESPC, KRONT	DESPC, ESCOM, LINK	DESPC, LINK	DESPC, LINK, PKART
SW	DESPC, DGATE, KRONT, LINK, PKART	DGATE, ESCOM, KRONT, LINK	DESPC, ESCOM, KRONT, LINK, PKART	DESPC, ESCOM, KRONT, LINK, PKART	DESPC, ESCOM, KAREL, LINK, PKART	ARENA, DESPC, ESCOM, LINK, PKART	DESPC, ESCOM, KRONT, LINK, PKART
SR	ARMDA	ARMDA, DESPC	KAREL	KAREL	KRONT	ARMDA	DGATE
SC	ARMDA, DESPC, DGATE, KRONT, LINK	ARMDA, DGATE	DESPC, ESCOM, KAREL, LINK, PKART	DESPC, ESCOM, KRONT, PKART	DESPC, ESCOM, LINK	ARENA, ESCOM	DESPC, DGATE, ESCOM, PKART
SA	PKART	ARMDA, DESPC, ESCOM, KRONT	KRONT	KAREL, LINK	KAREL, KRONT, PKART	ARMDA, DESPC, LINK, PKART	KRONT, LINK
BL	ALCTL, INDES, LOGO, NETAS	ALCTL, INDES, LOGO, NETAS, PKART	ALCTL, DGATE, INDES, LOGO	ALCTL, DGATE, LOGO	ALCTL, DGATE, INDES, LOGO	DGATE, INDES, KAREL, KRONT, LOGO	LOGO
BH	ARENA, ESCOM, KAREL	ARENA, KAREL	ARENA, ARMDA, NETAS	ARENA, ARMDA, INDES, NETAS	ARENA, ARMDA, NETAS	ALCTL, NETAS	ALCTL, ARENA, ARMDA, INDES, KAREL, NETAS
BK	ESCOM, KAREL, NETAS	ALCTL, NETAS	ALCTL, NETAS	ARENA, INDES	ARMDA, DGATE, NETAS	ALCTL, LOGO	INDES, LOGO, NETAS

	2013	2014	2015	2016	2017	2018	2019
BD	ALCTL, ARENA, INDES, LOGO	ARENA, INDES, KAREL, LOGO, PKART	ARENA, ARMDA, DGATE, INDES, LOGO	ALCTL, ARMDA, DGATE, LOGO, NETAS	ALCTL, ARENA, INDES, LOGO	DGATE, INDES, KAREL, NETAS, KRONT	ALCTL, ARENA, ARMDA, KAREL
BW	ESCOM	ALCTL, PKART	ALCTL	ARMDA	ARMDA	KRONT	ARENA
BR	ALCTL, ARENA, INDES, KAREL, LOGO, NETAS	ARENA, INDES, KAREL, LOGO, NETAS	ARENA, ARMDA, DGATE, INDES, LOGO, NETAS	ALCTL, ARENA, DGATE, INDES, LOGO, NETAS	ALCTL, ARENA, DGATE, INDES, LOGO, NETAS	ALCTL, DGATE, INDES, KAREL, LOGO, NETAS	ALCTL, ARMDA, INDES, KAREL, LOGO, NETAS
BC	ALCTL	ARENA, INDES, KAREL, PKART	NETAS	ALCTL, ARENA	DGATE, INDES, NETAS	KAREL, KRONT, LOGO, NETAS	ARENA, INDES
BA	ARENA, ESCOM, INDES, KAREL, LOGO, NETAS	ARENA, LOGO, NETAS	ALCTL, ARENA, ARMDA, DGATE, INDES, LOGO	ARMDA, DGATE, INDES, LOGO, NETAS	ALCTL, ARENA, ARMDA, LOGO	ALCTL, DGATE, INDES	ALCTL, ARMDA, KAREL, LOGO, NETAS

The factors were created as follows (Fama and French, 2015).

SMBT: [(SL+SH+SK+SD+SW+SR+SC+SA)/8]-[(BL+BH+BK+BD+BW+BR+BC+BA)/8]

SMB5: [(SL + SH + SW + SR + SC + SA) / 6] - [(BL + BH + BW + BR + BC + BA) / 6]

SMB4: [(SL + SH + SK + SD) / 4] - [(BL + BH + BK + BD) / 4]

SMB3: [(SL + SH) / 2] - [(BL + BH) / 2]

HML: [(SH + BH) / 2] - [(SL + BL) / 2]

WML: [(SK + BK) / 2] - [(SD + BD) / 2]

RMW: [(SR + BR) / 2] - [(SW + BW) / 2]

CMA: [(SC + BC) / 2] - [(SA + BA) / 2]

3.4. Research model

The panel data regression analysis performed in this study, it is aimed to estimate the mean value of the dependent variable over the known or unchanged values of the independent variables by examining the dependence of the excess return of stocks or portfolios, which are the dependent variables, on one or more explanatory variables (such as SMB, HML). (Gujarati and Porter, 2009)

The models in which the hypotheses are tested in the study are as follows:

Model 1 – FVFM : $R_{i,} - R_{f,} = \alpha_{i,} + \beta_{i,}(R_{m,t} - R_{f,t}) + \varepsilon_{i,t}$

Model 2 – FF3F : $R_{i,t} - R_{f,t} = \alpha_{i,t} + \beta_{i,t}(R_{m,t} - R_{f,t}) + s_i(SMB3)_t + h_i(HML)_t + \varepsilon_{i,t}$

Model 3 – C4F : $R_{i,t} - R_{f,t} = \alpha_{i,t} + \beta_{i,t}(R_{m,t} - R_{f,t}) + s_i(SMB4)_t + h_i(HML)_t + w_i(\mathrm{WML})_t + \varepsilon_{i,t}$

Model 4 – FF5F : $R_{i,t}$ - $R_{f,t}$ = $\alpha_{i,t}$ + $\beta_{i,t}(R_{m,t} - R_{f,t})$ + $s_i(SMB5)_t$ + $h_i(HML)_t$ + $r_i(RMW)_t$ + $+ci(CMA)_t$ + $\varepsilon_{i,t}$

Model 5 – 6F : $R_{i,t}$ - $R_{f,t}$=$\alpha_{i,t}$+$\beta_{i,t}(R_{m,t}-R_{f,t})$+$s_i(SMB\text{T})_t$+$h_i(HML)_t$+$w_i(\text{WML})_t$+ $+r_i(RMW)_t$+$ci(CMA)_t$+$\varepsilon_{i,t}$

: It represents time.

$SMB3$: It represents the returns of the SMB portfolio formed for FF3F.

$SMB4$: It represents the returns of the SMB portfolio formed for C4F.

$SMB5$: It represents the returns of the SMB portfolio formed for FF5F.

SMBT: It represents the returns of the SMB portfolio formed for 6F.

: It represents the margin of error.

The hypotheses tested with the relevant models are as follows:

H_1: CAPM is valid for stocks in ISE IT Index.

H_2: FF3F is valid for stocks in ISE IT Index.

H_3: C4F is valid for stocks in ISE IT Index.

H_4: FF5F is valid for stocks in ISE IT Index.

H_5: 6F is valid for stocks in ISE IT Index.

H_6: CAPM is valid for portfolios formed from stocks in the BIST IT Index.

H_7: FF3F is valid for portfolios formed from stocks in the BIST IT Index.

H_8: C4F is valid for portfolios formed from stocks in the BIST IT Index.

H_9: FF5F is valid for portfolios formed from stocks in the BIST IT Index.

H_{10}: 6F is valid for portfolios formed from stocks in the BIST IT Index.

3.5. Analysis

After the research model and hypothesis were created, the analysis part was started. The descriptive statistics of the stocks included in the model are as follows:

Table 5. *Descriptive statistics-stocks*

	Mean	Med.	Min.	Maks.	S.D.	Skew.	Kurt.	n
ALCTL	0.0168	0.0019	-0.2659	0.8304	0.1707	2.0208	6.7944	84
ARENA	0.0127	0.0002	-0.1860	0.4000	0.1160	0.9159	1.3808	84
ARMDA	0.0243	0.0136	-0.2309	0.3371	0.1115	0.5843	0.3260	84
DGATE	0.0358	0.0149	-0.3612	0.7673	0.1873	0.8467	2.1110	84
ESCOM	-0.0041	-0.0225	-0.3972	0.4714	0.1389	0.6332	1.9250	84
INDES	0.0121	0.0222	-0.2774	0.3568	0.1134	0.1405	0.9602	84
KAREL	0.0251	0.0037	-0.3287	0.3610	0.1364	0.3531	-0.1202	84
LINK	0.0295	-0.0157	-0.2294	1.4057	0.2295	3.3498	15.2851	84
LOGO	0.0366	-0.0011	-0.1864	0.8791	0.1715	2.1337	6.7288	84
NETAS	0.0032	-0.0128	-0.2587	0.5162	0.1428	1.3566	2.7615	84
PKART	0.0137	-0.0072	-0.1990	0.4701	0.1119	1.6972	4.3152	84
DESPC	0.0106	0.0058	-0.1908	0.2802	0.1004	0.4039	-0.1119	84
KRONT	0.0292	0.0027	-0.2715	0.7383	0.1549	1.3015	3.8494	84

Looking at the average returns of the stocks, it is seen that only ESCOM stock has negative returns (-0.4%), while the others have positive returns for their investors. DGATE (3.6%) and LOGO (3.7%) are the stocks with the highest average returns.

Looking at the median returns, it is understood that LINK's (-1.6%), LOGO's (-0.1%), NETAS's (-1.2%) and PKART's (-0.7%) shares accompany ESCOM (-2.3%) in terms of negative returns. Stock of LINK also has the highest standard deviation (0.23), while DESPC has the lowest (0.1).

Descriptive statistics of the portfolios are presented in Table 6.

Table 6. *Descriptive statistics-portfolios*

	Mean	Med.	Min.	Maks.	S.D.	Skew.	Kurt.	N
SL	0.0114	-0.0116	-0.2326	0.3959	0.1233	0.8298	0.6511	84
SH	0.0275	0.0145	-0.1798	0.6027	0.1131	2.0117	7.4555	84
SK	0.0323	0.0085	-0.1975	0.7571	0.1398	2.0576	7.3916	84
SD	0.0192	0.0189	-0.2167	0.4390	0.1116	1.0056	2.8392	84
SW	0.0217	-0.0055	-0.2005	0.7661	0.1322	2.5708	11.0693	84
SR	0.0415	0.0093	-0.2710	0.7673	0.1612	2.0341	7.0864	84
SC	0.0263	0.0116	-0.1880	0.4249	0.1145	0.7940	1.4098	84
SA	0.0440	0.0163	-0.1568	0.5599	0.1313	1.3324	2.6866	84
BL	0.0161	0.0032	-0.1716	0.5346	0.1203	1.2512	2.9829	84
BH	0.0051	0.0030	-0.2061	0.3120	0.0988	0.7242	1.3841	84
BK	0.0100	-0.0085	-0.2419	0.4389	0.1228	1.0477	1.3816	84
BD	0.0179	0.0154	-0.2375	0.5320	0.1146	1.1901	4.2061	84
BW	0.0012	-0.0259	-0.3972	0.8305	0.1705	2.0140	7.5129	84
BR	0.0154	0.0064	-0.1696	0.4311	0.1077	1.0124	1.9801	84
BC	0.0066	-0.0023	-0.2659	0.5163	0.1291	1.3419	3.3449	84
BA	0.0192	0.0077	-0.2729	0.4496	0.1208	0.6213	1.4265	84

Looking at the average return of the portfolios, it is seen that there is no negative return, and the SR and SA portfolios provide the highest return to their investors with a return of about 4.4%. Although there is no negative average return, 5 portfolios have a negative median value. The highest standard deviation of 0.14 belongs to the SK portfolio, while the lowest standard deviation of 0.1 belongs to the BH portfolio.

Descriptive statistics of the factors are presented in Table 7.

Table 7. *Descriptive statistics-factors*

	Mean	Med.	Min.	Maks.	S.D.	Skew.	Kurt.	N
SMBT	0.0166	0.0275	-0.2121	0.2109	0.0850	-0.2110	-0.0530	84
SMB5	0.0182	0.0309	-0.2188	0.2147	0.0857	-0.2600	-0.0653	84
SMB4	0.0103	0.0192	-0.1462	0.2614	0.0808	0.0725	0.0623	84
SMB3	0.0089	0.0208	-0.1492	0.2272	0.0800	-0.0734	-0.4839	84
HML	0.0026	0.0030	-0.2809	0.2191	0.0843	-0.2222	0.9049	84
WML	-0.0071	-0.0054	-0.2992	0.4125	0.0988	0.8361	4.0630	84
RMW	0.0170	0.0114	-0.3877	0.4210	0.1263	0.1145	2.1849	84
CMA	-0.0152	-0.0057	-0.3833	0.2702	0.0977	-0.2733	1.6192	84
mf	-0.0030	-0.0013	-0.1188	0.1267	0.0608	-0.0156	-0.7916	84

On the other hand, it is seen that the factors do not have a negative mean value or median except for WML, CMA and mf. The highest standard deviation of 0.13 belongs to RMW and the lowest standard deviation of 0.6 belongs to mf.

Table 8. *Variance Inflation Factor (VIF) test*

	Firm					Portfolio				
	CAPM	**FF3F**	**C4F**	**FF5F**	**6F**	**CAPM**	**FF3F**	**C4F**	**FF5F**	**6F**
mf	1.00	1.01	1.02	1.05	1.05	1.00	1.01	1.02	1.05	1.05
SMB3		1.01					1.01			
SMB4			1.02					1.02		
SMB5				1.21					1.21	
SMBT					1.21					1.21
HML		1.03	1.22	1.35	1.41		1.03	1.22	1.35	1.41
WML			1.22		2.24			1.22		2.24
RMW				1.25	2.25				1.25	2.25
CMA				1.30					1.30	
Mean VIF	1.00	1.02	1.12	1.23	1.58	1.00		1.12	1.23	1.58

It was seen that there is no multicollinearity problem according to the test results.

Before the model analysis, the stationarity of the variables was tested. Since the variables are panel data, before performing the unit root test, whether the variables are correlated between units was tested with the PCD test. If the variables are not correlated between units, the I. generation unit root tests are performed, and if they are inter-unit correlated, the II. generation unit root tests are used to test for stationarity. The hypothesis of PCD test is as follows:
H_0: There is no interdependence between the units.
H_1: There is interdependence between units.

Table 9. *CD test's results*

Variable	**Stock**	**Portfolio**
Dependent Variable	23.311 (0.0000)	49.529 (0.0000)
Mf	(80.944) 0.0000	100.399 (0.0000)
SMB3	(80.944) 0.0000	100.399 (0.0000)
SMB4	(80.944) 0.0000	100.399 (0.0000)
SMB5	(80.944) 0.0000	100.399 (0.0000)
SMBT	(80.944) 0.0000	100.399 (0.0000)
HML	(80.944) 0.0000	100.399 (0.0000)
WML	(80.944) 0.0000	100.399 (0.0000)
RMW	(80.944) 0.0000	100.399 (0.0000)
CMA	(80.944) 0.0000	100.399 (0.0000)

According to the PCD test results for stocks and portfolios separately in Table 9, the null hypothesis suggesting cross-sectional independence is rejected. Since there is no independence between the cross-section units of the variables, the stationarity test of the variables can be performed with the I. generation unit root tests. In this study, the variables' stationarity test was done with the Im Pesaran Shin (IPS) unit root test.

Table 10. *IPS unit root test's results*

Variable	Stock	Portfolio
Dependent Variable	-8.4046 (0.0000)	-8.2770 (0.0000)
Mf	-9.1461 (0.0000)	-9.1461 (0.0000)
SMB3	-10.3283 (0.0000)	-9.6977 (0.0000)
SMB4	-10.5089 (0.0000)	-10.5089 (0.0000)
SMB5	-9.6838 (0.0000)	-9.6838 (0.0000)
SMBT	-9.6977 (0.0000)	-9.6977 (0.0000)
HML	-8.4986 (0.0000)	-8.4986 (0.0000)
WML	-8.6707 (0.0000)	-8.6707 (0.0000)
RMW	-8.0130 (0.0000)	-8.0130 (0.0000)
CMA	-8.8993 (0.0000)	-8.8993 (0.0000)

According to the IPS unit root test results, which are stated separately for stocks and portfolios in Table 10, H_0 is rejected because the p value of all the variables is less than 0.05, and according to this result, it is concluded that the factors are stationary at the level.

Regarding the model, existence of unit effect, autocorrelation and heteroscedasticity tests were performed, and the appropriate estimator was selected according to the results. Testing the existence of autocorrelation related to the model was done with Wooldridge test. P values of Wooldridge autocorrelation tests and hypotheses regarding the test are as follows:

H_0: There is no autocorrelation.
H_1: There is autocorrelation.

Table 11. *Autocorrelation test*

	Stock	Portfolio
Model	Test Statistics' Value	Test Statistics' Value
CAPM	0.000 (0.9909)	0.272 (0.6097)
FF3F	0.005 (0.9470)	0.039 (0.8466)
C4F	0.003 (0.9562)	0.005 (0.9431)
FF5F	0.015 (0.9036)	0.033 (0.8573)
6F	0.000 (0.9988)	0.153 (0.7009)

Looking at the autocorrelation test results, H_0 is rejected because the p values for both stocks and portfolios are higher than 0.05, and it is concluded that there is no autocorrelation problem.

Breusch-Pagan/Cook Weisberg test was used for heteroscedasticity test. P values of Breusch-Pagan/Cook Weisberg test results and hypotheses related to the test are given below.

H_0: There is no heteroscedasticity.
H_1: There is heteroscedasticity.

Table 12. *Heteroscedasticity test*

	Stock	Portfolio
Model	**Test Statistics' Value**	**Test Statistics' Value**
CAPM	8.66 (0.0032)	12.19 (0.0005)
FF3F	13.09 (0.0003)	29.46 (0.0000)
C4F	16.58 (0.000)	32.50 (0.0000)
FF5F	15.65 (0.0001)	27.51 (0.0000)
6F	16.40 (0.0001)	35.68 (0.0000)

When the test results of the models for stocks and portfolios are examined, it is understood that the null hypothesis is rejected and there is heteroscedasticity in the models because the p values for the related tests are less than 0.05 significance level.

According to the test results, it was seen that the model did not have autocorrelation but heteroskedacity. Therefore, models were estimated using the BK estimator, which is a heteroscedasticity resistant estimator.

Table 13. *Model results-firms*

		α	β	s	h	w	r	c	R^2	Chi² (*p*)
CAPM	**Value**	0.0215	0.8783						0.1312	164.95 *0.0000*
	σ	0.0042	0.0683							
	Test Value	5.12***	12.84***							
FF3F	**Value**	0.0216	0.8603	0.0206	-0.1144				0.1353	170.85 *0.0000*
	σ	0.0042	0.0687	0.0532	0.0506					
	Test Value	5.12***	12.52***	0.39	-2.26**					
C4F	**Value**	0.0219	0.8554	0.0425	-0.1425	0.0572			0.1371	173.43 *0.0000*
	σ	0.0042	0.0688	0.0524	0.0553	0.0474				
	Test Value	5.15***	12.43***	0.81	-2.58**	1.20				
FF5F	**Value**	0.0219	0.8614	0.0335	-0.1297		-0.0653	-0.0332	0.1384	175.38 *0.0000*
	σ	0.0043	0.0695	0.0539	0.0577		0.0371	0.0488		
	Test Value	5.06***	12.39***	0.62	-2.25**		-1.76*	-0.68		
6F	**Value**	0.0218	0.8607	0.0403	-0.1328	0.0904	-0.0607	-0.0318	0.1386	175.67 *0.0000*
	σ	0.0043	0.0695	0.0542	0.0591	0.0639	0.0498	0.0488		
	Test Value	5.04***	12.38***	0.74	-2.25**	0.15	-1.22	-0.65		

* states that the relevant factor is significant in the 90% confidence interval.
** states that the relevant factor is significant in the 95% confidence interval.
*** states that the relevant factor is significant in the 99% confidence interval.

According to the results of the regression analysis of the CAPM model performed with firm-based data, it is understood that the relationship between the excess returns of the stocks and the excess returns of the fixed term and market risk premium (MF, β) variable in the model is significant at the 95% confidence interval. So, a one-unit change in the market risk premium variable changes the excess returns of stocks by 0.88 units in the same direction as the change.

In the Wald test results of the model, it is stated that the p value is significant at the 95% confidence level and the R2 value, which expresses the explanatory power of the model, is 0.13.

In the results of the FF3F model, it is understood that the only market value (SMB, s) factor's p value showing the relationship between the excess returns of the stocks and the excess returns of the other variables in the model is not less than 0.05 significance level, this means that there is a significant relationship between the other variables and the excess returns of the stocks. When the coefficients of the variables that are significant are examined, it is seen that there is a negative relationship between the excess returns of stocks and the book-to-market ratio (HML, h), while the MF has a positive relationship. So, in a one-unit change in MF and HML, the excess returns of stocks change by 0.86 and -0.11 units, respectively.

In the Wald test results of this model, similar to the results of the CAPM model, it is seen that the p value is significant at the 95% confidence level and the R2 value is 0.13.

In the results of the C4F model, it is stated that the market value factor is not as significant as in the FF3F model, and there is no significant relationship between the variable regarding the return in the last 1 year (WML, w) and the excess returns of the stocks at the 95% confidence interval. When the relationship between the other variables and the excess returns of the stocks is examined, it is stated that there is a significant relationship between the factors and the excess returns of the stocks. When the coefficients of the factors that have a significant relationship are examined, it is seen that only the HML has a negative relationship with the excess returns of the stocks, while the others have a positive relationship. So, the excess returns of stocks change by 0.85 and -0.14 units in a one-unit change in MF and HML, respectively.

In the Wald test results of this model, like the results in other models, the p value is significant at the 95% confidence level and the R2 value is 0.14.

According to the results of the FF5F model given in Table 13, it is seen that the relationship between the excess returns of the stocks and the fixed term, the market risk premium and the HML is significant at the 95% confidence interval. However, it was understood that the factor related to operational profitability (RMW, r) was significant only in the 90% confidence interval, while other factors did not have a significant relationship. When the coefficients of the variables that are significant at the 95% confidence interval are examined, it is seen that the HML is negative, and the others are positive. So, the excess returns of stocks change by 0.86 and -0.13 in a one-unit change in MF and HML, respectively.

In the Wald test results of the model, it is stated that the p value is significant at the 95% confidence level and the R2 value, which expresses the explanatory power of the model, is 0.14.

In the 6F model, it is seen that the significant relationship between the excess returns of stocks and the excess returns of other variables is only in the fixed term, MF and HML, and this situation is similar in other models. It is understood that there is no significant relationship between other factors and the excess returns of stocks. When the coefficients of the variables that are significant are examined, it is seen that HML has a negative relationship and MF has a positive relationship in parallel with the results in other models. So, the excess returns of the stocks show a change of 0.86 and -0.13 units in a one-unit change in MF and HML, respectively.

As in other models, it is stated that the p value of this model is significant at the 95% confidence level in the Wald test results and the R2 value of the model is 0.14.

Table 14. *Model results-Portfolios*

		α	β	s	h	w	r	c	R^2	Chi² (*p*)
CAPM	**Value**	0.0222	0.8530						0.1708	276.85 *0.0000*
	σ	0.0031	0.0513							
	Test Value	7.05***	16.64***							
FF3F	**Value**	0.0222	0.8199	0.0580	-0.2070				0.1895	314.19 *0.0000*
	σ	0.0031	0.0510	0.0395	0.0376					
	Test Value	7.08***	16.07***	1.47	-5.50***					
C4F	**Value**	0.0223	0.8151	0.0827	-0.2427	0.0775			0.1946	324.68 *0.0000*
	σ	0.0031	0.0510	0.0389	0.0410	0.0352				
	Test Value	7.17***	15.98***	2.13**	-5.92***	2.20**				
FF5F	**Value**	0.0218	0.8265	0.0758	-0.2064		-0.0351	-0.0147	0.1914	318.07 *0.0000*
	σ	0.0032	0.0517	0.0401	0.0429		0.0276	0.0363		
	Test Value	6.78***	16.00***	1.89*	-4.81***		-1.27	-0.40		
6F	**Value**	0.0218	0.8221	0.0707	-0.2298	0.1069	0.0214	-0.0185	0.1952	325.97 *0.0000*
	σ	0.0032	0.0516	0.0402	0.0439	0.0474	0.0369	0.0362		
	Test Value	6.80***	15.94***	1.76*	-5.24***	2.26**	0.58	-0.51		

According to the results of the regression analysis of the CAPM model performed with portfolio-based data, it is understood that the relationship between the excess returns of portfolios and the excess returns of the fixed term and market risk premium variable in the model is significant at the 95% confidence interval. So, a one-unit change in the market risk premium variable changes the excess returns of the portfolios by 0.85 units, in the same direction as the change. Although there is variation in values, the relevant results are consistent with the results in the firm-based study.

In the Wald test results of the model, it is stated that the p value is significant at the 95% confidence level and the R2 value is 0.17. Although there were differences in the values, it was seen that the results were compatible with the stock-based study.

In the results of the FF3F model, it is understood that the only market value factor's p value showing the relationship between the excess returns of the portfolios and the returns of the other variables in the model is not less than 0.05 significance level. When the coefficients of the variables that are significant are examined, it is seen that the excess returns of the portfolios have a negative relationship with HML and a positive relationship with MF. So, the excess returns of the portfolios change by 0.82 and -0.21 units in a one-unit change in MF and HML, respectively. The relevant results are similar with the results in the firm-based study.

In the Wald test results of this model, similar to the results of the CAPM model, it is seen that the p value is significant at the 95% confidence level and the R2 value is 0.19. Although there are differences in the values in this model, as in the CAPM, it has been concluded that the results are compatible with the stock-based study.

In the results of the C4F model given in Table 14, it is stated that all factors in the model have a significant relationship with the excess returns of the portfolios at the 95% confidence interval. This situation differs from the stock-based study. When the coefficients of the factors that have a significant relationship are examined, it is seen that only the HML has a negative relationship with the excess returns of the portfolios and the others have a positive relationship. So, in a one-unit change in MF, SMB, HML and WML, the excess returns of portfolios change by 0.81, 0.08, -0.24 and 0.08 units, respectively.

In the Wald test results of this model, like the results in other models, the p value is significant at 95% confidence level and the R2 value is 0.19. In the firm-based study, the relevant model was also significant.

According to the results of the FF5F model given in Table 14, it is seen that the relationship between the excess returns of the portfolios and the fixed term, the market risk premium and the HML is significant at the 95% confidence interval. However, it was understood that the SMB was significant only in the 90% confidence interval, while other factors did not have a significant relationship. When the coefficients of the variables that are significant at the 95% confidence interval are examined, it is seen that the HML is negative, and the others are positive. So, the excess returns of portfolios change by 0.83 and -0.21 in a one-unit change in MF and HML, respectively.

In the Wald test results of the model, it is stated that the p value is significant at the 95% confidence level and the R2 value, which expresses the explanatory power of the model, is 0.19. It is understood that the relevant results are compatible with the results of the firm-based study.

Looking at Table 14, which contains the data for the last model, it is seen that only the fixed term, MF, HML and WML have a significant relationship with the excess returns of the portfolios, and this situation is not similar to the 6F model in the firm-based study. In the related model, it is understood that the WML factor is significant in accordance with the results in the C4F model, and unlike the C4F model, the SMB factor is not significant at the 95% confidence interval, but only at the 90% confidence interval. It is concluded that there is no significant relationship between the other factors and the excess returns of the portfolios. When the coefficients of the variables that are significant at the 95% confidence interval are examined, it is seen that HML has a negative relationship, and the others have a positive relationship in parallel with the results in other models. Accordingly, with a one unit change in MF, HML and WML, the excess returns of the portfolios change by 0.82, -0.23 and 0.10 units, respectively.

As in other models, it is stated that the p value of this model is significant at the 95% confidence level in the Wald test results and the R2 value of the model is 0.19. These results are also compatible with the firm-based study.

Table 15. *Summary results of the research*

	Model\Variable	F.T.	MF	SMB	HML	WML	RMW	CMA
Firm	CAPM	+	+					
	FF3F	+	+		-			
	C4F	+	+		-			
	FF5F	+	+		-			
	6F	+	+		-			
Portfolio	CAPM	+	+					
	FF3F	+	+		-			
	C4F	+	+	+	-	+		
	FF5F	+	+		-			
	6F	+	+		-	+		

+/- expresses the factors that are significant in the 95% confidence interval and have a positive/negative coefficient in the model it contains.

Looking at the table above, it is seen that although the models are valid, not every factor may be valid in every model. It is understood that the fixed term, MF and HML factors are significant in all models, regardless of firm-based or portfolio-based work, and the relationship aspects of the excess returns of stocks and portfolios do not change on the basis of model-based and dependent variable.

The SMB factor has a significant relationship only in the C4F model of portfolio-based work. Although there is no model in which the WML factor is significant in the firm-based study, it was found to be significant in both models in the portfolio-based study and its relationship with the portfolio returns was found to be positive.

4. Conclusion

Studies have been carried out for years on the return and risk of financial assets and models have been created. Today, these studies continue without losing their importance and interest. Although models with a single index/factor were developed at first, multi-factor models were created over time with the influence of the criticisms brought to the relevant models. The purpose of developing the relevant models is to predict the risks and returns of financial assets, valid under all conditions. For this reason, the models created so far are tested for various conditions and periods.

The aim of this study is to test the CAPM, FF3F, C4F, FF5F and 6F Model whether they are valid for stocks in BIST IT Index by panel data regression analysis method. Testing was carried out with portfolios created and stocks included in the scope. 13 companies traded in the BIST IT Index in the 2013/January-2019/December period formed the scope of the study. Due to the scarcity of stocks, portfolios were created with the 2×2 method.

Although there was no autocorrelation problem in the models, regression analyzes were performed using the BK estimator, which is resistant to varying variance, because of the varying variance problem. Accordingly, although all models are valid, it has been observed that there are models where all factors are not valid and the explanatory power of the models is limited.

Although all the variables of the CAPM gave significant results both in the firm-based study and in the portfolio-based study, all the variables of the C4F model gave significant results only in the portfolio-based study. Although these models are valid like other models, they differ from other models because the factors they include in the above-mentioned studies are significant in the model. Although the variables included by CAPM and C4F are significant in the above-mentioned conditions, the fact that the explanatory value of the models, R2, does not change significantly between the other models and themselves is another important result of the study. When viewed on a factor basis, it was understood that the MF and HML factors, together with the fixed term, were significant in all models, and the relationship aspects with excess returns did not show a model-based change. Apart from this, although the SMB factor is significant only in the C4F model in the portfolio-based study, and the WML factor in the C4F and 6F models in the portfolio-based study, it is not significant in the other models they include.

As a result, with the increase of companies participating in the BIST Informatics Index over time, it is concluded that the studies that can be carried out with the data of more companies in a wider date range may have clearer and healthier results, and it is hoped that this study will shed light on the present. Although it is considered that the CAPM can be used for the relevant index in firm-based studies, and the CAPM and C4F models in portfolio-based studies, the low explanatory value of the models is an important issue to consider.

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