Chapter 16
Is the Three-Factor Better Than Single-Factor Capital Asset Pricing Model? Case of Polish Capital Market

Dorota Witkowska

Abstract The three-factor model was developed by Fama and French as a response to the poor performance of the single-factor capital asset pricing model (CAPM) in explaining realized returns. However, the evidence from different markets does not give clear conclusions regarding the appropriateness of this model, and CAPM is still most commonly used by practitioners. The study aims to find out which model better explains returns from portfolios containing selected companies listed on the Warsaw Stock Exchange in the years 2007–2017. In our investigation, four portfolios including: (1) big, (2) medium size, (3) small and (4) all considered companies are concerned. We also distinguish seven sub-periods which are characterized by different situation on the Polish capital market. The results show that the three-factor model better explains rates of returns from portfolios than CAPM, although the improvement is mostly visible for the portfolios of small and medium size companies. The risk factors concerning capitalization of companies and book-to-market value rates are statistically significant in about half of estimated models whereas risk premium significantly affects returns in all models.

Keywords Capital asset pricing model · Fama-French three-factor model · Polish capital market

16.1 Introduction

Capital asset pricing model (CAPM) was developed independently by William Sharpe [1], John Lintner [2] and Jan Mossin [3] twelve years after Harry Markowitz had laid down the foundation of modern portfolio management [4]. This model became a useful instrument to estimate the systematic risk of individual financial instruments or portfolio of securities, and its parameter—beta became one of the most frequently used risk measures. CAPM is also the capital cost model, which is

D. Witkowska (✉)
University of Lodz, ul. Matejki 22/26, 90-237 Łódź, Poland
e-mail: dorota.witkowska@uni.lodz.pl

W. Tarczyński and K. Nermend (eds.), *Effective Investments on Capital Markets*, Springer Proceedings in Business and Economics,
https://doi.org/10.1007/978-3-030-21274-2_16

most often used in practice, thanks to its simple form and easy application as well as clear interpretation (refer to [5–9]).

It should be noted that the classic capital asset pricing model has had both supporters and opponents since it was developed. Among the former, one should mention [10–12]. The latter have criticized CAPM mostly because of unrealistic assumptions that underlie the model and because it is a single-factor model. Roll's critique [13] refers to the model construction itself and concerns the lack of possibility of its empirical verification since it is impossible to create or observe a truly diversified market portfolio. While Fama and French in series of their works [14–16] prove that CAPM model fails to apply in capital estimation because beta coefficient does not provide a correct explanation for the expected return rates. At the same, they proved that good results are given by supplementing model with additional factors, i.e., price to book value ratio and measures of company size (see Fama and French [17]). In [18], it was found that most errors in cost of stock capital estimation using CAPM model are also caused by wrong assessment of risk premiums, while Pástor and Stambaugh in [19] presented that capital estimations may be corrected by Bayesian approach. However, Gibbson [20] who proposed a methodology to avoid errors in the measurement of variables and increase of appropriateness of estimates of model parameters proposes to reject CAPM. Whereas authors of [21] were not able to come to clear conclusions regarding appropriateness of CAPM and beta coefficient estimates. As they found by themselves, decades may pass by until additionally collected data allow for rejection of CAPM for a reasonable significance level.

Despite the criticism, the classic capital asset pricing model is still widely used amongst practitioners. According to a study on European firms (discussed in [22]), about 45% of chief financial officers (CFOs) rely on the CAPM and 73.5% of interviewed US CFOs "always or almost always" use the CAPM to estimate the cost of equity (see Graham and Harvey [5]).

Here, a question arises why Fama–French three-factor model, which seems to be the improved version of the capital asset pricing model, has not been used in practice and research as often as CAPM. In fact, the research on application three-factor model to the Polish capital market has been provided rather rarely. Therefore, the study aims to find out which model is more appropriate to explain rates of return of portfolios containing selected companies listed on the Warsaw Stock Exchange. Investigation is provided for the years 2007–2017.

16.2 Fama–French Three-Factor Model

The three-factor model was developed as a response to the poor performance of the CAPM in explaining realized returns. Its authors claim in [17] that anomalies relating to the CAPM are captured by the three-factor asset pricing model. These three risk factors defined in the Fama–French model are:

1. risk premium, i.e., excess market portfolio return;

2. the difference between the excess return on a portfolio of stocks with small capitalization and the excess return on a portfolio of stocks with big capitalization;
3. the difference between the excess return on a portfolio of stocks which is characterized by the high value of the book-to-market value (BV/MV) and the excess return on a portfolio of stocks which is characterized by low book-to-market value.

The three-factor model is formulated as following [15]:

$$R_i - R_f = \alpha + \beta_M\left(R_M - R_f\right) + \beta_{\mathrm{SMB}}\mathrm{SMB} + \beta_{\mathrm{HML}}\mathrm{HML} + \varepsilon \tag{16.1}$$

where, R_i—rate of return from the portfolio, R_f—risk-free rate of return; R_M—rate of return from the market portfolio; $(R_M - R_f)$—risk premium; SMB—the difference between the excess return on a portfolio of small stocks and the excess return on a portfolio of big stocks (SMB, small minus big); HML—the difference between the excess return on a portfolio of high-book-to-market stocks and the excess return on a portfolio of low-book-to-market stocks (HML, high minus low); α—an intercept; β_M, β_{SMB}, β_{HML}—model parameters describing the effect of each risk factor; ε—residual.

One should note that the classical capital asset pricing model—CAPM, as a single-factor model, is a simplified version of the Fama–French model, i.e., it can be formulated as (16.1) for $\beta_{\mathrm{SMB}} = \beta_{\mathrm{HML}} = 0$.

Empirical tests of the Fama–French three-factor model have been provided for different markets and time spans. For instance, in the studies [15, 17, 23] Fama–French model is applied to the US market, in [24]—to seven developed markets (the US, Canadian, Australian, Japanese, German, British and French), in [25]—to Australian market. The author of [26] considers the Brazilian market and in [27] five Asian markets are considered. The authors of above-mentioned research confirm good performance of the Fama–French model. Although Blanco [23] and Lam [28] for the US market point out that the results depend on the portfolio construction. Also, the research provided for Australian in [29], British [30] and Turkish [31] markets shows that the three-factor model has limited abilities to explain rates of return, and it is hard to conclude that it performs better than CAPM.

There are also some studies on single-factor and three-factor capital asset pricing models dedicated for the Polish capital market, which were carried out for different stocks, periods and return intervals. Application of CAPM to evaluate returns from portfolios and companies listed on Warsaw Stock Exchange is described in [9, 32–37], to mention some of the research. One should notice that the Fama–French model is not used too often. Although, research presented in [38–42] confirm better performance of the Fama–French model in comparison to CAPM. However, [43] prove that the Fama–French model is adequate to describe bull market, but it is useless in explanation of returns in the bear market. Also [44] reports wrong valuation of stock returns.

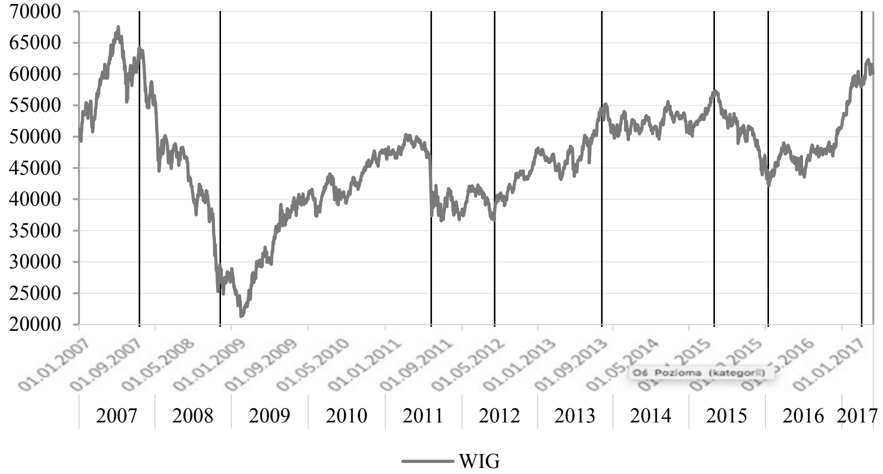

Fig. 16.1 Warsaw stock exchange index WIG quotations in the years 2007–2017. *Source* Own elaboration on the basis of [46, p. 49]

16.3 Assumptions and Data

Capital asset pricing model seems to be simple and elegant; however, there are some issues which must be determined before the model is estimated and applied. For instance, it is necessary to define [37, p. 45]: interval range for rates of return, market portfolio, risk-free instrument, estimation period and methods of model estimation.

In our study, the investigation is provided using daily logarithmic rates of return evaluated for closing prices. This approach is similar to [45] although in the above-mentioned literature monthly returns are usually used. The market portfolio is represented by WIG—the main index of Warsaw Stock Exchange and WIBOR 1Y—Warsaw Interbank Offered Rate (reference rate set for deposits for the 12 months maturities) is used as a proxy of the risk-free rate of return. All data concerning quotations, book values and capitalization of stocks are available on www.stooq.pl.

The time span of analysis is from October 15, 2007, to March 31, 2017. This period is characterized by the changing situation on the Polish capital market. Therefore, seven sub-periods of increasing, decreasing or stable tendency of the Warsaw Stock Exchange index are distinguished (see Fig. 16.1; Table 16.1). Selection of sub-periods results from the instability of beta which should be estimated for shorter periods, especially when less developed capital markets are concerned what is pointed out in [37 pp. 50–51, 81, 137–176, 45]. Also [43] prove different performance of the Fama–French model in bull and bear market.

In the study, two criteria of stocks selection are determined. Firstly, the company has been quoted incessantly in the whole horizon of investigation. Secondly, the company has been comprised in the portfolio of a one among three Warsaw Stock Exchange indexes: WIG20, mWIG40 or sWIG80. These indexes base on the value

Table 16.1 Selected periods of investigation

No.	Symbol	Dates		No. of observations
1	Bear1	15.10.2007	31.10.2008	262
2	Bull1	3.11.2008	5.08.2011	693
3	Stable1	8.08.2011	5.06.2012	207
4	Bull2	6.06.2012	31.10.2013	351
5	Stable2	4.11.2013	30.04.2015	367
6	Bear2	4.05.2015	15.01.2016	177
7	Bull3	18.01.2016	31.03.2017	306

of portfolios which are composed from shares of 20 big and most liquid companies, 40 medium size companies and 80 smaller companies listed at WSE Main List, respectively.

It is worth mentioning that in the years 2006–2017 only seven companies were incessantly comprised in the index WI20, six in mWIG40, and none in sWIG80. However, 35 companies belonged to the portfolio of any index during the period of analysis what is connected with periodical revisions of the index portfolio.[1]

Table 16.2 contains the list of companies selected for further investigation with information about the index portfolio which they belong to. These companies are used to construct four portfolios denoted as:

PB portfolio containing ten big companies belonging to the index WIG20,
PM portfolio containing ten medium size companies belonging to the index mWIG40,
PS portfolio containing ten small size companies belonging to the index sWIG80,
PT portfolio containing all (i.e. 30) selected companies.

The composition of these four portfolios is stable for the whole analyzed time span and all distinguished sub-periods.

Table 16.2 List of selected companies

Index WIG20		Index mWIG40		Index sWIG80	
KGHM	PKNORLEN	AMREST	ORBIS	DEBICA	COMP
MBANK	PKOBP	BUDIMEX	CIECH	JWCONSTR	DOMDEV
ORANGEPL	LOTOS	ECHO	EMPERIA	LENTEX	FAMUR
PEKAO	ASSECOPOL	INGBSK	KETY	RAFAKO	PELION
PGNIG	BZWBK	MILLENNIUM	NETIA	SNIEZKA	POLICE

[1]The WIG20, mWIG40, sWIG80 index participants are selected based on data following the last session in January (annual revision) and April, July and October (quarterly adjustments).

16.4 Analysis of Rates of Return and Risk from Portfolios

In our study, we consider rates of return evaluated for all portfolios constructed from selected shares of companies which are classified as big (PB), medium (PM) and small (PS), together with a portfolio comprised from all 30 distinguished equities (PT). Analysis consists of verification of following hypotheses concerning returns and risk.

$$H_0 : E(R_{\text{PB}}) = 0;\ H_0 : E(R_{\text{PM}}) = 0 \text{ and } H_0 : E(R_{\text{PS}}) = 0,\ E(R_{\text{PT}}) = 0 \tag{16.2}$$

using normally distributed test statistics:

$$u = \frac{R_k}{S_k}\sqrt{T_k} \tag{16.3}$$

$$\begin{aligned} &H_0 : E(R_{\text{PB}}) = E(R_{\text{PM}});\ H_0 : E(R_{\text{PM}}) = E(R_{\text{PS}});\\ &H_0 : E(R_{\text{PS}}) = E(R_{\text{PB}}), \text{ and for each portfolio}\\ &H_0 : E(R_{t1}) = E(R_{t2}), \end{aligned} \tag{16.4}$$

applying Cochran-Cox test:

$$u = \frac{R_1 - R_2}{\sqrt{\frac{S_1^2}{T_1} + \frac{S_2^2}{T_2}}} \tag{16.5}$$

$$\begin{aligned} &H_0 : D^2(R_{\text{PB}}) = D^2(R_{\text{PM}});\ H_0 : D^2(R_{\text{PM}}) = D^2(R_{\text{PS}});\\ &H_0 : D^2(R_{\text{PS}}) = D^2(R_{\text{PB}}), \text{ and for each portfolio}\\ &H_0 : D^2(R_{t1}) = D^2(R_{t2}) \end{aligned} \tag{16.6}$$

using Fisher statistics:

$$F = \frac{S_{\text{max}}^2}{S_{\text{min}}^2} \tag{16.7}$$

where $E(R)$—expected returns, $D^2(R)$—variance of returns, R_{PB}, R_{PM}, R_{PS} and R_{PT}—returns from the portfolio: PB, PM, PS and PT, respectively, R_k—the average rate of return observed in the k-th sample (i.e., the k-th period or portfolio), S_k^2—the variance of rates of return from the k-th sample, T_k—count of observations in the k-th sample, $S_{\text{max}}^2 = \max\{S_1^2, S_2^2\}$, $S_{\text{min}}^2 = \min\{S_1^2, S_2^2\}$, $t1$, $t2$—two neighboring periods of analysis.

The results of rates of return analysis are presented in Tables 16.3, 16.4, 16.5, 16.6 and 16.7. Null hypotheses (16.2), (16.4) and (16.6) are rejected for the significance level 0.05 what is marked in Tables by bold letters. In Tables 16.3, 16.4 and 16.6, values of test statistics (16.3) and (16.5) are positive for bigger values of returns

Table 16.3 Values of test statistics (16.3) and standard deviations of constructed portfolios

Period	H_0: E($R_{portfolio}$) = 0 for portfolios				Standard deviations of portfolios			
	PB	PM	PS	PT	PB (%)	PM (%)	PS (%)	PT (%)
Bear1	**−2.0460**	**−2.4947**	−1.5644	**−2.0313**	2.87	3.11	2.83	2.93
Bull1	0.5933	0.8331	0.7495	0.7304	2.35	2.54	2.49	2.46
Stable1	−0.0061	−0.5181	−0.3645	−0.3089	2.39	2.91	2.48	2.61
Bull2	1.5141	1.1520	0.9892	1.2239	1.98	2.50	1.91	2.13
Stable2	0.7656	−0.2584	0.2051	0.2171	1.75	2.10	1.66	1.84
Bear2	0.0555	−0.1903	−1.2281	−0.4335	1.83	2.11	2.08	2.00
Bull3	0.9483	0.8349	0.8827	0.8897	1.98	1.89	1.93	1.93

Table 16.4 Values of test statistics (16.5) comparing returns from constructed portfolios

Period	Null hypothesis (16.4) H_0		
	$E(R_{PB}) = E(R_{PM})$	$E(R_{PM}) = E(R_{PS})$	$E(R_{PS}) = E(R_{PB})$
Bear1	0.4446	−0.7896	0.3570
Bull1	−0.2077	0.0706	0.1367
Stable1	0.3966	−0.1585	−0.2581
Bull2	0.0371	0.3142	−0.4022
Stable2	0.6889	−0.3299	−0.4150
Bear2	0.1803	0.7274	−0.9604
Bull3	0.1067	−0.0465	−0.0601

Table 16.5 Values of test statistics (16.7) comparing the risk of portfolios

Period	Null hypothesis (16.6) H_0		
	$D^2(R_{PB}) = D^2(R_{PM})$	$D^2(R_{PM}) = D^2(R_{PS})$	$D^2(R_{PS}) = D^2(R_{PB})$
Bear1	*1.1725*	1.2032	*1.0262*
Bull1	***1.1643***	**1.0421**	1.1172
Stable1	***1.4838***	**1.3822**	1.0735
Bull2	***1.5938***	**1.7098**	*1.0728*
Stable2	*1.4357*	**1.6025**	*1.1161*
Bear2	*1.3370*	1.0262	**1.3029**
Bull3	1.0880	*1.0430*	*1.0432*

from the portfolio defined on the left-hand side of hypotheses (16.2) and (16.4). In Tables 16.5 and 16.7, cells containing statistics (16.7) are italicized when the bigger variance concerns portfolio from the right-hand side of hypotheses presented in (16.6).

Table 16.6 Values of test statistics (16.5) comparing returns from portfolios in distinguished periods

Comparing periods	Null hypothesis (16.4) H_0: $E(R_{t1}) = E(R_{t2})$			
	PB	PM	PS	PT
Bear1: Bull1	**−2.0939**	**−2.6031**	**−1.7326**	**−2.1398**
Bull1: Stable1	0.2906	0.8300	0.6840	0.6134
Stable1: Bull2	−0.8240	−1.0700	−0.8211	−0.9158
Bull2: Stable2	0.6542	1.0577	0.6268	0.7993
Stable2: Bear2	0.3629	0.0173	1.1826	0.4832
Bear2: Bull3	−0.5462	−0.6180	−1.5119	−0.8679

Table 16.7 Values of test statistics (16.7) comparing the risk of portfolios in distinguished periods

Comparing periods	Null hypothesis (16.4) H_0: $D^2(R_{t1}) = D^2(R_{t2})$			
	PB	PM	PS	PT
Bear1: Bull1	**1.4904**	**1.5009**	**1.3000**	**1.4194**
Bull1: Stable1	*1.0325*	*1.3159*	**1.0079**	*1.1214*
Stable1: Bull2	**1.4514**	**1.3513**	**1.6717**	**1.4955**
Bull2: Stable2	**1.2857**	**1.4272**	**1.3376**	**1.3390**
Stable2: Bear2	*1.0897*	*1.0148*	***1.5848***	*1.1851*
Bear2: Bull3	*1.1708*	1.2425	1.1609	1.0738

Table 16.3 contains information about rates of returns and risk generated by each portfolio in the distinguished sub-periods. It is visible that the performance of all portfolios in all periods is poor although significantly negative returns are observed only in the first bear market period for all portfolios except the one comprising small companies. Risk, measured by standard deviation, seems to be of the same range in all portfolios and time spans.

Comparing returns generated by pairs of portfolios in different sub-periods, no significant differences are observed (Table 16.4). Whereas the risk of the portfolio PM (Table 16.5) is significantly bigger than the risk of portfolios

– PB in all periods except the ones denoted as the first bear market and the last bull market periods and
– PS when the market was stable and during two first bull market periods.

Taking into consideration distinguished periods of analysis, one may notice that returns do not differ significantly except the first bear market period (Table 16.6). Although risk (Table 16.7) is significantly bigger in the first bear market period and the first stable period in comparison to the two first bull market periods for all portfolios. Also, the risk of each portfolio in the second bull market period is bigger than the one in the second stable market period. Whereas risk in the first stable market period (denoted by stable1) is significantly higher than the one in the first bear market period for the portfolio of medium size companies and significantly smaller for the portfolio of small size companies. The last-mentioned portfolio additionally generates a bigger risk in the second bear market period than in the second stable market period.

To sum up this stage of investigation, we notice that the performance of constructed portfolios does not differ significantly between each other and in distinguished periods (except the first bear market period when returns were significantly smaller) than in the neighbouring time span. However, significant differences are observed for risk generated by considered portfolios (when risk is measured by standard deviation).

16.5 Fama–French Three-Factor Model Construction

To construct the Fama–French model, it is necessary to distinguish (additionally in comparison to CAPM) risk factors SMB and HML. The former (small minus big) is calculated as the difference in returns from a portfolio of stocks characterized by small market value (MV) and from a portfolio of stocks with big MV.[2] The latter (high minus low) represents the difference in returns on a portfolio of high book-to-market value (BV/MV) stocks and on a portfolio of low BV/MV stocks. Therefore, companies are classified according to their capitalization, i.e., big or small value of MV and high, medium and low value of BV/MV rate. Split into small and big companies is made using a median of capitalization. Classification into three groups let us distinguish 30% of companies with the highest and the lowest book-to-market value ratios, and 40% of the rest companies belong to the group of medium BV/MV rate values.

In other words, six portfolios combining both risk factors are defined for each year of analysis. Table 16.8 contains information about composition of each portfolio, denoted as: SL (small and low), SM (small and medium), SH (small and high), BL (big and low), BM (big and medium) and BH (big and high), in every year of analysis.

Daily logarithmic rates of return are calculated for each portfolio assuming an equal share of each company in the portfolio. Then values of risk factors SMB and HML are evaluated, according to formulas:

$$\mathrm{SMB} = \frac{R_{\mathrm{SL}} + R_{\mathrm{SM}} + R_{\mathrm{SH}}}{3} - \frac{R_{\mathrm{BL}} + R_{\mathrm{BM}} + R_{\mathrm{BH}}}{3} \tag{16.8}$$

$$\mathrm{HML} = \frac{R_{\mathrm{SH}} + R_{\mathrm{BH}}}{2} - \frac{R_{\mathrm{SL}} + R_{\mathrm{BL}}}{2} \tag{16.9}$$

where R_{SL}, R_{SM}, R_{SH}, R_{BL}, R_{BM}, R_{BH}—rates of returns from the portfolios: SL, SM, SH, BL, BM, BH, respectively.

Arithmetic means of all three risk factors evaluated in each period of analysis are presented in Table 16.9. It is visible that HML average is always negative. It means that in average, returns from the companies, characterized by high values of

[2]Market value means capitalization and it is the multiplication of the share price and the number of shares.

Table 16.8 Number of companies which are comprised in each portfolio

Year	Type of portfolio					
	SL	SM	SH	BL	BM	BH
2007	5	4	5	5	8	3
2008	4	7	4	6	5	4
2009	4	6	5	5	6	4
2010	5	6	4	5	6	4
2011	3	6	5	6	6	4
2012	3	7	5	7	5	3
2013	4	6	5	6	6	3
2014	4	5	6	5	7	3
2015	4	6	5	6	6	3
2016	3	7	5	6	5	4
2017	3	6	6	6	6	3

Table 16.9 Table captions should be placed above the tables

Period	$R_M - R_f$	SMB	HML
Bear1	−0.3283%	−0.1328%	−0.1224%
Bull1	0.0437%	0.0057%	−0.0798%
Stable1	−0.0792%	−0.0478%	−0.0434%
Bull2	0.0976%	0.0626%	−0.1316%
Stable2	0.0076%	−0.0467%	−0.0414%
Bear2	−0.1488%	0.1381%	−0.1864%
Bull3	0.0869%	−0.0048%	−0.0827%
Whole	−0.0138%	−0.0063%	−0.0907%

BV/MV rate, are lower than returns generated by low book-to-market stocks. This conclusion is in line with Fama and French [15] findings. It is also visible that average risk premium in the bull market periods is positive, whereas excess market portfolio return in the bear market periods is negative.

16.6 Estimation Results

CAPM and Fama–French three-factor models are estimated using the OLS method. Parameter estimates and determination coefficients of the single-factor and three-factor capital asset pricing models obtained for four constructed portfolios and all distinguished sub-periods are presented in Tables 16.10 and 16.11.

It is worth mentioning that the risk premium is statistically significant in all estimated models. It is also visible that portfolio PB, containing the biggest and the most liquid companies, is an aggressive one in the majority of periods. While the reaction

Table 16.10 Results of Fama–French three-factor model estimation

Portfolio	Period	Parameter estimates			
		$(R_M - R_f)$	SMB	HML	R^2
PB	Bear1	1.0560	−0.2923	0.0649	0.5733
	Bull1	1.1220	−0.2667	0.0269	0.5474
	Stable1	0.9947	−0.1723	−0.0007	0.4779
	Bull2	1.0369	−0.1576	0.0265	0.3600
	Stable2	1.0005	−0.2520	0.1027	0.3673
	Bear2	0.9066	−0.3783	0.0553	0.3959
	Bull3	1.0219	−0.2178	0.0590	0.3710
PM	Bear1	0.8557	0.2758	−0.0384	0.3134
	Bull1	0.7749	0.2741	0.0232	0.2304
	Stable1	0.8452	0.2497	0.3046	0.3300
	Bull2	0.7695	0.2262	0.0543	0.1643
	Stable2	0.7995	0.1918	−0.0367	0.1901
	Bear2	0.7688	0.1680	−0.0018	0.2178
	Bull3	0.8079	0.1483	0.1124	0.1937
PS	Bear1	0.9917	0.8121	0.0613	0.3686
	Bull1	0.9584	0.8139	−0.0138	0.2326
	Stable1	0.9347	0.8570	0.1612	0.3183
	Bull2	0.8742	0.7422	−0.0312	0.1796
	Stable2	0.9666	0.8386	0.0849	0.1809
	Bear2	0.8884	0.7559	0.0703	0.1811
	Bull3	0.8546	0.1819	0.0412	0.2650
PT	Bear1	0.9678	0.2652	0.0293	0.4180
	Bull1	0.9518	0.2738	0.0121	0.3370
	Stable1	0.9249	0.3115	0.1550	0.3750
	Bull2	0.8935	0.2703	0.0165	0.2350
	Stable2	0.9222	0.2595	0.0503	0.2460
	Bear2	0.8258	0.6744	0.0525	0.1619
	Bull3	0.8852	0.2016	0.0746	0.2420

of returns to risk premium for portfolios PM and PS is similar, and the parameter estimates are below one. All risk factors present in Fama–French models are statistically significant in ten models (among 21)—in four models estimated for the portfolio PS and in three models estimated for big companies PB and medium size companies PM. The three-factor models explain returns better than the single-factor models although the differences in determination coefficients are not very big, except the models estimated for the portfolio PS in the last four sub-periods. In both types

Table 16.11 Results of CAPM estimation

Period	Portfolio PB		Portfolio PM		Portfolio PS		Portfolio PT	
	$(R_M - R_f)$	R^2	$(R_M - R_f)$	R^2	$(R_M - R_f)$	R^2	$(R_M - R_f)$	R^2
Bear1	1.1203	0.5237	0.7962	0.2655	0.8258	0.2308	0.9141	0.3400
Bull1	1.2261	0.5108	0.6637	0.1751	0.6351	0.1336	0.8416	0.2730
Stable1	1.0331	0.4565	0.8003	0.2734	0.7492	0.1738	0.8609	0.3010
Bull2	1.0946	0.3312	0.6899	0.1148	0.6055	0.0581	0.7967	0.1680
Stable2	1.0779	0.3157	0.7322	0.1353	0.6232	0.0716	0.8111	0.1740
Bear2	1.1152	0.3350	0.6814	0.1649	0.5131	0.0722	0.7699	0.1910
Bull3	1.1817	0.3427	0.6937	0.1342	0.3226	0.0403	0.7327	0.1720

of models, the best performance (measured by R^2) is observed for portfolio PB in two first sub-periods.

16.7 Conclusion

The results of the presented research let us formulate the following conclusions concerning the application of the Fama–French three-factor model to the constructed portfolios.

1. Risk premium is the most important factor affecting rates of return, and it is statistically significant in all estimated capital asset pricing models. Whereas two other risk factors (which appear in the three-factor models only) are significant in about half of models.
2. Presence of risk factors concerning capitalization and book-to-market value rate of companies improve the performance of the capital asset pricing models. However, this improvement is visible mostly for portfolios constructed from small and medium size companies.

Answering the question asked in introduction, why CAPM has been still in use much more often than Fama–French model, one should realize that the latter is much more complicated than the former. Evaluation of two additional (in three-factor in comparison to single-factor model) risk factors requires much more data and work connecting with data processing. Whereas the improvement of performance seems not to be essential. Therefore, results obtained from the three-factor model might not cover "the costs" of its construction and estimation.

References

1. Sharpe, W.F.: Capital asset prices: a theory of market equilibrium under conditions of risk. J. Finance **19**, 425–442 (1964)
2. Lintner, J.: The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets. Rev. Econ. Statist. **47**(1), 13–37 (1965)
3. Mossin, J.: Equilibrium in a capital asset market. Econometrica **34**(4), 768–783 (1966)
4. Markowitz, H.: Portfolio selection. J. Finance **7**(1), 77–91 (1952)
5. Graham, J.R., Harvey, C.R.: The Theory and practice of corporate finance: evidence from the field. J. Financ. Econ. **60**, 187–243 (2001)
6. Bartholdy, J., Peare, P.: Unbiased estimation of expected return using CAPM. Int. Rev. Financ. Anal. **12**(1), 69–81 (2003)
7. Da, Z., Guo, R. Jagannathan, R.: CAPM for estimating the cost of equity capital: interpreting the empirical evidence. NBER Working Papers 14889, National Bureau of Economic Research Inc (2009)
8. Tashfeen, H., Chakraborty, L.: Is the cost of capital an important determinant of market performance of private commercial banks in Bangladesh? Proc. ASBBS **17**(1), 389–399 (2010)
9. Cwynar, W.: Zmienność—dobra, czy zła? Analiza polskiego rynku kapitałowego. Finansowy Kwartalnik Internetowy e-Finanse **6**(2), 16–24 (2010)
10. Sharpe, W.F., Cooper, G.M.: Risk—return class of New York stock exchange common stocks 1931–1967. Financ. Anal. J. **28**(2), 46–56 (1972)
11. Black, F., Jensen, M.C., Scholes, M.S.: The capital asset pricing model: some empirical tests. In: Jensen, M.C. (ed.) Studies in the Theory of Capital Markets, pp. 79–121. Praeger Publishers, New York (1972)
12. Fama, E.F., MacBeath, J.D.: Risk, return and equilibrium: empirical tests. J. Polit. Econ. **81**, 607–636 (1973)
13. Roll, R.: A Critique of the asset pricing theory's tests: part I: on past and potential testability of the theory. J. Financ. Econ. **4**, 129–176 (1977)
14. Fama, E., French, K.: The cross-section of expected stock returns. J. Finance **47**, 427–465 (1992)
15. Fama, E., French, K.: Multifactor explanations of asset pricing anomalies. J. Finance **53**, 55–84 (1996)
16. Fama, E.F., French, K.R.: The capital asset pricing model: theory and evidence. J. Econ. Perspect. Am. Econ. Assoc. **18**(3), 25–46 (2004)
17. Fama, E., French, K.: Common risk factors in the returns on stocks and bonds. J. Financ. Econ. **3**, 3–56 (1993)
18. Ferson, W.E., Locke, D.H.: Estimating the cost of capital through time: an analysis of the sources of error. Manag. Sci. **44**, 485–500 (1998)
19. Pástor, L., Stambaugh, R.F.: Costs of equity capital and model mispricing. J. Finance, Am. Finance Assoc. **54**(1), 67–121 (1999)
20. Gibson, M.R.: Multivariate tests of financial models: a new approach. J. Financ. Econ. **10**, 3–27 (1982)
21. Chan, L.K., Lakonishok, J.: Are the reports of beta's death premature? J. Portfolio Manag. **19**(4), 51–62 (1993)
22. Brounen, D., De Jong, A., Koedijk, K.: Corporate finance in Europe confronting theory with practice. Financ. Manage. **33**, 71–101 (2004)
23. Blanco, B.: The use of CAPM and Fama and French three factor model: portfolios selection. Public Municipal Finance **1**(2), 61–70 (2012)
24. Maroney, N., Protopapadakis, A.: The book-to-market and size effects in a general asset pricing model: evidence from seven national markets. Eur. Finance Rev. **6**(2), 189–221 (2002)
25. Gaunt, C.: Size and book to market effects and the Fama French three factor asset pricing model: evidence from the Australian stock market. Acc. Finance **44**(1), 27–44 (2004)
26. Da Silva, A.C.: Modeling and estimating a higher systematic co-moment asset pricing model in the brazilian stock market. Latin Am. Bus. Rev. **6**(4), 85–101 (2006)

27. Chui, A.C.W., Wei, K.C.J.: Book-to-market, firm size, and the turn-of-the-year-effect: evidence from pacific—basin emerging markets. Pac.—Basin Finance J. **6**(3), 275–293 (1998)
28. Lam, K.: Is the Fama–French three factor model better than the CAPM?, In: M.A. Thesis, Simon Fraser University, Department of Economics, Burnaby (2005)
29. Kassimatis, K.: Size, book to market and momentum effects in the Australian stock market. Aust. J. Manag. **33**(1), 145–167 (2008)
30. Gregory, A., Michou, M.: Industry cost of equity capital: UK evidence. J. Bus. Finance Acc. **36**, 69–704 (2009)
31. Eraslan, V.: Fama and French three-factor model: evidence from istanbul stock exchange. Bus. Econ. Res. J. **4**(2), 11–22 (2013)
32. Wolski, R.: Badanie liniowego charakteru zależności opisanych klasycznym CAPM, technika Famy i MacBetha. In: Tarczyński (ed.) Rynek kapitałowy—skuteczne inwestowanie, Zeszyty Naukowe nr 389, Finanse. Rynki Finansowe. Ubezpieczenia nr 2, Uniwersytet Szczeciński, Szczecin, pp. 527–539 (2004)
33. Gajdka, J., Brzeszczyński, J.: Estymacja parametru β przy użyciu modeli klasy ARCH. In: Tarczyński (ed.) Rynek kapitałowy. Skuteczne inwestowanie. Część I, Wydawnictwo Naukowe Uniwersytetu Szczecińskiego, Szczecin, pp. 73–82 (2007)
34. Witkowska, D.: Badanie stabilności współczynnika beta oszacowanego na podstawie prób o różnej długości. In: Tarczyński (ed.) Rynek Kapitałowy. Skuteczne inwestowanie, Studia i prace Wydziału Nauk Ekonomicznych i Zarządzania, Uniwersytet Szczeciński, Nr 9, Szczecin, pp. 143–154, (2008)
35. Witkowska, D.: Badanie wrażliwości współczynnika beta na metodę estymacji. In: Barczak, A., Iskry, D. (eds.) Metody matematyczne, ekonometryczne i komputerowe w finansach i ubezpieczeniach 2010, Prace Naukowe UE w Katowicach, Katowice, pp. 395–419 (2012)
36. Byrka-Kita, K., Rozkrut, D.: Test CAPM w warunkach polskiego rynku kapitałowego wzorowany na technice Pettengilla, Sundarama oraz Mathura. In: Zarzecki, D. (ed.) Zarzadzanie finansami. Wycena przedsiębiorstw i zarządzanie wartością, Uniwersytet Szczeciński, Szczecin, pp. 685–697 (2009)
37. Tarczyński, W., Witkowska, D., Kompa, K.: Współczynnik beta. Teoria i praktyka, Pielaszek Research, Warszawa (2013)
38. Czapkiewicz, A., Skalna, I.: The CAPM and the Fama–French models in Warsaw stock exchange. Przegląd Statystyczny **57**(4), 128–141 (2010)
39. Kowerski, M.: The analysis of an investment risk within emerging capital markets. Case Warsaw Stock Exchange, e-Finance **6**(4), 1–23 (2010)
40. Zaremba, A.: Cross-sectional asset pricing models for the polish market, SSRN working paper http://dx.doi.org/10.2139/ssrn.2396884 (2014)
41. Urbański, S.: Comparison of a modified and classic Fama–French model for the polish market. Folia Oeconomica Stetinensia **17**, 80–96 (2017)
42. Redlicki, M., Borowski, K.: Wykorzystanie trzyczynnikowego modelu Famy–Frencha na GPW. Studia i Prace Kolegium Zarządzania i Finansów, Zeszyt Naukowy **153**, 81–102 (2017)
43. Czapkiewicz, A., Skalna, I.: Użyteczność stosowania modelu Famy i Frencha w okresach hossy i bessy na rynku akcji GPW w Warszawie. Bank i Kredyt **42**(3), 61–80 (2011)
44. Czapiewski, L.: Model CAPM i trójczynnikowy model Famy-Frencha w analizie zdarzeń na polskim rynku kapitałowym. Zeszyty Naukowe Uniwersytetu Szczecińskiego **854**, 609–620 (2015)
45. Bartholdy, J., Peare, P.: Estimation of expected return: CAPM versus Fama and French. Int. Rev. Financ. Anal. **14**(4), 407–427 (2005)
46. Rogowicz, T.: Model Famy-Frencha na Giełdzie Papierów Wartościowych w Warszawie, praca magisterska przygotowana pod kierunkiem K. Kompy, SGGW, Warszawa (2017)