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Assessing the performance of mutual funds with multifactor asset pricing models

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Abstract

The subject of the article is assessing the performance of mutual funds. The main goal of the study is to indicate which multifactor asset pricing model fits the performance of the Polish mutual funds the best. Another objective is to examine the impact of risk factors on the excess returns of the Polish mutual funds. In the study, Carhart's model and the three-, five- and six-factor Fama and French models were used. The main outcomes are as follows: (1) the Fama and French six-factor model best explains the performance of Polish equity mutual funds, (2) the size factor and the profitability factor has a positive, significant impact and the investment factor has a negative, significant impact on mutual funds' performance, (3) the momentum factor delivers insignificant alpha and the value factor is associated with an insignificant and negative alpha.

Keywords: effectiveness, mutual funds, multifactor asset pricing model, risk factor

JEL: G11, G14, G23

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1. Introduction

One of the basic measures of performance is a simple rate of return; however, it delivers too little information which is limited to the level of a profit or a loss. New measures of performance and new asset pricing models are introduced to provide more information. Measures to assess the efficiency of mutual funds are developing in two ways. The first one is connected with the one-factor measures which are based on investment risk. The second one embraces factors which have an impact on performance. Among them are mainly multifactor models which emphasise factors influencing the performance of mutual funds. There are also ones related to the CAPM model (Sharpe 1964; Lintner 1965; Mossin 1966).

The first model which delivered more information than the CAPM model was the Fama and French three-factor model (1992, 1993). Here, alongside the market factor, the performance of mutual funds is a function of two additional factors – value and size effects. Some years later, Carhart (1997) extended the Fama and French three-factor model by introducing a fourth factor – momentum. This effect, documented by Jegadeesh and Titman (1993, 2001), refers to the inertia of the price trend to continue either rising or falling for a particular length of time. Carhart (1997) added a momentum effect which was based on a subtract between winners and losers.

Other studies indicate that other factors which are not included in the Fama and French three--factor model or Carhart's four-factor model also have an impact on the performance of mutual funds. The best solution to avoid missing some information is to embrace the influence of other factors in an asset pricing model without making the model less predictable. One of those models which is accounted for an extended number of factors is the Fama and French five-factor model (2015). Not only is this model an expansion of their three-factor model, but it is also an attempt to capture changes which have taken place over 20 years since their first model was introduced. Alongside the market risk factor, the size effect and the value effect, two new factors, the profitability factor and the investment factor, are included in the Fama and French five-factor model. Another model is the result of the amalgamation of two models – the Fama and French five-factor model and Carhart's four-factor model. In 2018 Fama and French introduced a new model, the Fama and French six-factor model (Fama, French 2018), which embraces factors as follows: market return, size effect, value effect, profitability factor, investment factor and momentum.

According to Miziołek and Trzebinski's study (2017) the most popular method to assess the performance of Polish mutual funds is the Sharpe ratio and the classic Jensen alpha. Therefore, the main reason to conduct this study is the lack of analysis of multifactor models as for the performance of Polish mutual funds.

The main goal is to assess the sense of applying multifactor asset pricing models to describe the performance of Polish mutual funds and to determine the most appropriate asset pricing model for them. Therefore, we evaluate and compare the performance of the Fama and French three-factor model (1993), five-factor model (2015), six-factor model (2018) and Carhart's four-factor model (1997). The second goal is to examine whether the performance of mutual funds is related to such factors as size effect, value effect, momentum, profitability factor and investment factor. The outcome can be helpful to give answers to the following questions: Which of the multifactor asset pricing models is the most applicable to the performance of Polish equity mutual funds? What factors have an impact on the performance of the mutual funds, and to what extent?

To answer these questions, we investigate a sample of 104 mutual funds for the period from January 2004 to June 2009. We use four asset pricing models: Carhart's four-factor model and the Fama and French three-, five- and six-factor model. According to the best knowledge of the authors, this is the first study in which the Fama and French five- and six-factor models have been used to describe the performance of Polish equity mutual funds.

The rest of the paper is organised as follows. Section 2 deals with a literature review about the use of multifactor asset pricing models. Section 3 presents descriptions of models and statistical tests adopted. The data used and the methodology are presented in the next section. Section 4 details the results and findings and finally, section 5 concludes the paper.

2. Literature review

As Pástor and Stambaugh (2002) and Fama and French (2015) noticed, factors related to assets which are in mutual funds' portfolios should be represented in asset pricing models. For many years attempts have been made to complete existing asset pricing models for factors which fit the performance of mutual funds the best. Despite introducing about ten new models some years ago (see Hou et al. 2019; Mateus, Mateus, Todorovic 2019) to assess the effectiveness of mutual funds, the Fama and French three-factor model and Carhart's four-factor model are still used predominantly. This model was used by Otten and Bams (2002) in the case of several European markets, Sehgal and Babbar (2017) examined the Indian market and Chen et al. (2017) explored the Chinese market. Perez (2012), Homa and Mościbrodzka (2016), and Filip (2018) were focused on the Polish market. Cuthbertson, Nitzsche and O'Sullivan (2010), Berk and van Binsbergen (2015), Adams, Nishikawa and Rao (2018), and Huang, Pilbeam and Pouliot (2019) assessed the US market, and Matallín-Sáeza et al. (2019) the US, Canadian and European markets.

The Fama and French five-factor model is rarely used, which can be explained by the short lifecycle of this model. It was introduced about six years ago. For example, this model was used by Naqvi et al. (2018) to assess equity mutual funds from China, Thailand and Singapore, Sehgal and Babbar (2017) examined Indian mutual funds, and Jin (2018) explored US mutual funds. The Fama and French six--factor model was used by Kutan et al. (2018) to examine Chinese mutual funds, Hiraki and Liu (2021) for US and global mutual funds and Dirx and Peter (2020) for the German market. The common quality of most studies about the effectiveness of mutual funds is inferencing that mutual funds are not achieving an excess return.

It can be stated focusing merely on Polish studies devoted to the performance of Polish mutual funds and their effectiveness that most studies were conducted with classical methods such as the Sharpe ratio, Treynor ratio and Jensen alpha (Czerwińska, Nowak 2015; Filip 2016; Kozak, Ochnio 2016; Dopierała, Mosionek-Schweda, Ilczuk 2019). This kind of approach limits the analysis because the ratios are adjusted to data with a normal distribution. What is more, they answer whether mutual funds are effective, which means checking if a mutual fund's performance is higher or lower than a benchmark's performance. The Fama and French multifactor models allow to assess the performance of mutual funds to a higher degree. Thanks to these models, factors which may have an impact on the performance of mutual funds can be pointed out. Additionally, it is possible to assess both managerial skills and their usage. The benefits of using the Fama and French three- and four-factor model to describe Polish mutual funds were shown by Bialkowski and Otten (2011), Perez (2012), and Filip (2018).

3. Multifactor asset pricing models

In this study four different multifactor asset pricing models were used. The first one is the Fama and French three-factor model (1992, 1993) (henceforth abbreviated as FF3F):

$$R_{i,t} = \alpha_i + R_{f,t} + \beta_{M,i}\left(R_{M,t} - R_{f,t}\right) + \beta_{SMB,i} SMB_t + \beta_{HML,i} HML_t + \mu_{i,t} \tag{1}$$

where SMB_t is the difference between returns on diversified portfolios of small and large stocks, and HML_t is the difference between returns on diversified portfolios of high book-to-market ratio (BM) and low BM stocks (High Minus Low book-to-market ratio), $\beta_{SMB,i}$ and $\beta_{HML,i}$ are vectors of risk factor sensitivities or loadings.

The second model is Carhart's model (1997), which extends the FF3F model by introducing a momentum factor (henceforth abbreviated as C4F):

$$\begin{aligned} R_{i,t} = \alpha_i + R_{f,t} + \beta_{M,i}\left(R_{M,t} - R_{f,t}\right) + \beta_{SMB,i} SMB_t + \beta_{HML,i} HML_t + \\ + \beta_{WML,i} WML_t + \mu_{i,t} \end{aligned} \tag{2}$$

where WML_t is the return on the Winners Minus Losers portfolio representing a factor of maintaining the rate of return in time and is calculated as the difference between portfolios of stocks with high and low prior rate of returns, $\beta_{WML,i}$ is a vector of risk factor.

The presented classical asset pricing models embrace four risk factors. The market factor was introduced alongside the size factor, which depicts the difference between diversified portfolios of stocks with high and low book-to-market ratios. Investors are expected to receive compensation due to taking the greater risk of buying small companies' stocks which may be less liquid than that of large ones. The value size is connected with the premium for the chosen stocks with high book-to--market ratio to the market value. It is said that stocks with high BM/MV ratio are related to a lower rate of return than undervalued ones (with low BM/MV ratio). The last but not least important factor is a momentum premium based on short-term investing in assets whose prices have risen in previous months.

Further studies about market anomalies contributed to implementing other models. One of the latest ones is the Fama and French five-factor model (2015). It is the FF3F model extended by two new factors (henceforth abbreviated as FF5F):

$$\begin{aligned} R_{i,t} = \alpha_i + R_{f,t} + \beta_{M,i}\left(R_{M,t} - R_{f,t}\right) + \beta_{SMB,i} SMB_t + \beta_{HML,i} HML_t + \\ + \beta_{RMW,i} RMW_t + \beta_{CMA,i} CMA_t + \mu_{i,t} \end{aligned} \tag{3}$$

where RMW_t (Robust Minus Weak) is the difference in returns between diversified portfolios of firms with high and low profitability, and CMA_t (Conservative Minus Aggressive) measures the difference between the return of a portfolio of stocks with low investment and the return of a portfolio consisting of stocks with a high investment, and $\beta_{RMW,i}$, $\beta_{CMA,i}$ are vectors of risk factors.

The next model is the Fama and French six-factor model (2018), which embraces all of the presented factors. In other words, this model includes six risk factors, namely: MKT, SMB, HML, WML, RMW and CMA (henceforth abbreviated as FF6F):

$$R_{i,t} = \alpha_i + R_{f,t} + \beta_{M,i}\left(R_{M,t} - R_{f,t}\right) + \beta_{SMB,i}SMB_t + \beta_{HML,i}HML_t + \\ + \beta_{WML,i}WML_t + \beta_{RMW,i}RMW_t + \beta_{CMA,i}CMA_t + \mu_{i,t} \tag{4}$$

RMW factor is the excess rate of return connected with investing in companies with high ROE and captures the potential profitability premium. The higher ROE, the higher the expected returns. Then CMA premium is linked to the outperformance (underperformance) of the companies of low (high) investment. The lower the investment, the higher the expected returns (Fama, French 2015).

4. Data and methods

In these studies, we use the Polish equity mutual funds which operated on the market from January 2004 to June 2019. The beginning of this period was determined by a lack of sufficient number of mutual funds before January 2004. Additionally, two subperiods can be identified. The first one was from January 2004 to December 2008 and the second was from January 2009 to June 2019. Distinguishing the two subperiods has helped to examine the outcome of managers' activities in the long term and the different market circumstances. During the first subperiod, there was a bull and bear market at the Warsaw Stock Exchange (WSE). The end of the first subperiod is characterised by the lowest value of the main index (the WIG Index). The second one embraces predominantly bull markets with periodical corrections (Figure 1).

We examine 104 mutual funds which existed through the whole period, were established within the studied period and closed at the time too. The search group accounts for Polish mutual funds which are classified as domestic, which means that they invest most of their assets into shares quoted on the WSE. The data is from Notoria, analizy.pl and the websites of TFIs. We use monthly rates of return and the risk-free rate is based on the one-month WIBID rates to catch changes in its value in time. For all the funds the main index of the WSE is taken as a market portfolio. All the six factors (MRK, SMB, HL, WML, RMW and CMA) are calculated based on the data from the WSE according to the Fama and French approach (1993, 2015). Descriptive statistics of mutual funds and factors are presented in Table 1 and Table 2.

All models are estimated using OLS and the statistically significance of parameters is checked using classical tests. To determine the similarity between each model and the data, the GRS test (Gibbons, Ross, Shanken 1989; Barillas, Shanken 2018) is used:

$$GRS = \left(\frac{T}{N}\right)\left(\frac{T-N-L}{T-L-1}\right)\hat{\alpha}'\hat{\Omega}^{-1}\hat{\alpha}\left[1+E_T(f)\hat{\Omega}^{-1}E_T(f)\right]^{-1} \sim F_{N,T-N-L} \tag{5}$$

and $H_0: \alpha = 0$ vs. $H_1: \alpha \neq 0$

where: T is the length of the time series, N is the number of portfolios, L means the number of independent variables (the number of risk factors), $\hat{\alpha}$ is the $N \times 1$ vector of the estimators for the intercepts α_i, $\hat{\Sigma}$ is the $(N \times N)$ unbiased estimator of error covariance matrix, $E_T(f)$ is a $L \times 1$ vector of the sample means of asset pricing factors, while $\hat{\Omega}$ is a $(L \times L)$ factor covariance matrix.

The null hypothesis is rejected when the F-statistic with N and $T - N - L$ degree of freedom given (5) is greater than the critical value at a prescribed level of significance α. The GRS test is widely used in assessing asset pricing models (for instance, Czapiewski 2016; Zaremba 2018).

On the other hand, to check whether factors have an impact on mutual funds' excess returns $(R_{i,t} - R_{f,t})$, and to what extent, various portfolios with mutual funds were created. In the first step, each factor was split into groups with 20, 40, 60 and 80 percentile breakpoints. Next, we checked the average performance of portfolios which were one-way sorted with only one factor. The outcomes of this were five portfolios (5 × 1) for each factor. Further on, based on the approach commonly used in the studies, portfolios were two-way sorted with two specific factors. Owing to that, we were able to examine the excess portfolio returns in relation to two factors. We used the most frequent factors – the size factor, the value factor and momentum. Additionally, we evaluated portfolios sorted by new risk factors – profitability and the investment effect.

5. Results

Alphas from multifactor asset pricing models are significantly negative for the whole period (Table 3). Each model generates negative alpha, which means that other factors not included in these models have an impact on the performance of the mutual funds. The outcome is similar to the results achieved by others for Polish mutual funds (Perez 2012; Filip 2018).

While considering common factors of models which have an influence on the excess returns of mutual funds, some conclusions can be drawn. The market factor (MKT), the size factor (SMB), the profitability effect (RMW) and the investment effect (CMA) all have a significant and positive impact on the performance of mutual funds. However, the value factor and momentum are insignificant, and negative and positive, respectively. It can be stated that the findings confirm the outcome reported by other researchers: the size factor – Borys and Zemcik (2009) and Czapiewski (2016), the value factor – Lischewski and Voronkova (2012), Zaremba (2015), Zaremba et al. (2019), momentum – Szyszka (2006), Zaremba (2018).

The results of the subperiods are similar to those observed for the whole period (Table 4). An accordance between subperiods can be noticed for the market factor. On the other hand, the size factor (SMB) in 2009–2019 generates a significant premium higher than in 2004–2008. The value factor decreases the mutual funds' excess returns regardless of the periods, but only two models confirm that this impact is significant. Momentum delivers a very interesting outcome. In the earlier subperiod (2004–2008) the momentum strategy decreases the mutual funds' excess returns and in the later one (2009–2019) it increases this parameter. Interestingly, Carhart's four-factor model does not confirm the significant momentum effect, but the Fama and French six-factor model does. Different outcomes are noticed for the profitability factor (RMW) and the investment factor (CMA). RMW in 2004–2008 is approximately zero and it is insignificant, but in the later period (2009–2019) it is significant positive.

CMA decreases the mutual funds' performance in both periods. It can be noticed that significant results are obtained only in the Fama and French six-factor model in 2009–2019.

Using the multifactor asset pricing model should be treated as a good choice (Table 5). For all the models, adjusted R^2 is at a similar level for the whole period and subperiods. The average R^2 is 59% for 2004–2019, 67% for 2004–2008 and 56% for 2009–2019. Considering the results for the GRS test, it can be stated that the best fit model to assess the performance of Polish equity mutual funds is the Fama and French six-factor model with the GRS = 24.79. The second one is the Fama and French five-factor model with the GRS = 17.61. The third place is taken by the Fama and French three-factor model with the GRS = 16.00. The least fit model is Carhart's four-factor model with the GRS = 6.17. The obtained sequence can be explained by the differences between the impact of factors on the excess returns of mutual funds.

In the second part of the studies, we check whether factors included in multifactor models have an impact on the performance of mutual funds. The results for one-way sorted portfolios do not meet our expectations (Table 6). For the size factor, the momentum effect and the profitability factor, a reverse effect to the assumed one can be observed. The findings are similar to the expected ones for the value effect and the investment effect. The bigger the companies, the higher the excess returns, and the lesser the investment, the higher the excess returns.

Although the opposite effect is expected, for the whole period the size factor increases alongside the size of the company. The same situation is observed for the first subperiod (2004–2008). In the later subperiod (2009–2019), the value of the size factor for the extreme portfolios is the same as expected. The size factor for the smallest companies is lower than for the biggest ones. The explanation for this can be found in the alternative stock exchange market New Connect, established in 2007, where the smallest companies from the main market were removed. The second reason may be that small companies performed worse than the big ones, which is supported by a comparison of the small companies index (sWIG80) and the biggest companies index (WIG20). WIG20 recorded much higher quotes than sWIG80 in the whole period and 2004–2008 in particular (Figure 2).

The momentum effect should be higher for winners and lower for losers. Moreover, this can also be observed for the earlier subperiod 2004–2008. Additionally, excess returns of the extreme portfolio are higher than for the minimum portfolio, but these two values are negative, which means that the momentum effect is not observed. The excess returns of the middle portfolios are positive, which implies that the momentum effect exists and generates a premium. The findings are unambiguous for the whole studied period and that of 2009–2019. The higher the momentum factor, the lower the excess returns. No tendency to form excess returns of portfolios is observed and none of the vectors of momentum effect is significant. The lack of a momentum strategy used by managers can explain this observation.

The outcome of the profitability sorted portfolios is somewhat of a surprise. The right relation was observed only for the extreme portfolios in 2004–2008. The highest value of the profitability effect is connected with the highest excess returns. The tendency is reversed for the whole studied period and that of 2008–2019. Companies with a low profitability factor are related to the portfolio with higher excess returns more frequently than companies with a high profitability factor.

Excess returns of the value sorted portfolios are the same as expected. Portfolios with the lowest value effect have lower excess returns in comparison to portfolios with the highest value factor. This relation exists during the whole studied period and the subperiods as well. This can be connected with transferring small companies from the GPW's main market to New Connect market, too.

The investment effect as the second factor indicates portfolios with the expected value of excess returns. The highest value is noticed for the portfolios with the lowest investment factor and contrariwise. The low excess returns are connected with a high investment factor. The outcome is not surprising, which stems from the intuitive impact of this factor on performance. The higher expenses, the higher the expected returns.

Very interesting results can be observed for two-way sorted portfolios (Table 7). The average of the size and the excess returns of other factor sorted portfolios occupy the range from -0.55% to 0.001%, regardless of the second factor. The findings can be connected with the fact that the size value is indicated as the factor with the biggest impact on excess returns. However, the differences in excess returns are noticeable for portfolios sorted by momentum, value, profitability and investment factors. The values for the extreme portfolios sorted by value and momentum factors are 0.92% and -1.73%. For the portfolios sorted by value and profitability they are 4.23% and -3.16%, respectively. For the portfolios sorted by value and investment -0.75% and 0.06%, respectively. It should be stated that it is the only situation when the portfolio's excess returns change from negative to positive.

What is more, in this case it is visible how strong the connection between factors and excess returns is. The high value of a company and the low investment generate high average excess returns. The findings are similar for both the investment and the momentum sorted portfolios, as well as the investment and profitability sorted portfolios. For the extreme portfolios, changes in the value of excess returns can be observed. The average excess returns switch from the level above zero (2.66% and 7.10%) to below zero (-6.76% and -1.70%).

Other information is supplied by alphas from the multifactor models estimated for two sorted portfolios (Tables 8–16). In most cases alphas are statistically significant for p-value = 0.01, which means that factors not included in the multifactor models have an impact on the performance of mutual funds. The differences in insignificant alphas from the multifactor models are too small to indicate the best model. However, the total number of statistically insignificant intercepts may be a clue. The most insignificant alphas are generated by the Fama and French five- and six-factor model – 51 and 50, respectively. The alphas generated by Carhart's four-factor model and the Fama and French three--factor model were 41 and 37, respectively. It should be noticed that all models generate a similar number of insignificant alphas for the portfolio sorted by the size factor, the value factor and momentum. Including the profitability effect in the models increases the number of significance alphas. In the case of portfolios sorted by momentum and the investment effect, all alphas from the Fama and French three-factor model are statistically significant. The same observation refers to the portfolios sorted by the profitability and investment factors. However, for the portfolio sorted by the value and investment factors the number of statistically significant alphas is from 20 to 24 (out of 25).

6. Conclusions

The main goal of the study is to indicate which multifactor asset pricing model fits the performance of mutual funds the best. The second objective is to examine whether risk factors included in the multifactor asset pricing models have an impact on the performance of mutual funds. The aims are achieved by means of four multifactor models – the Fama and French three-, five and six-factor models and Carhart's four-factor model. The study uses 104 Polish equity mutual funds which existed from January 2004 to June 2019.

This study resulted in some theoretical and practical remarks. Firstly, the Fama and French five- and six-factor models may be used in assessing the performance of mutual funds because they deliver more information than other models. The Fama and French five-factor model includes two new factors – profitability (RMW) and the investment effect (CMA). The Fama and French six-factor model combines the market factor and four other effects and the momentum to provide additional information. Based on the results of the coefficient of determination and the GRS test, it can be stated that the Fama and French six-factor model fits the performance of the mutual funds the best. The second one in the ranking is the Fama and French five-factor model. Next is the Fama and French three-factor model and lastly, Carhart's four-factor model. The results of the order of the multifactor models were quite predictable.

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Appendix

Table 1
Descriptive statistics

Feature	R	$R - R_f$	MKT	SMB	HML	UMD	RMW	CMA
Average (%)	0.004	-0.252	-0.029	-0.151	0.634	1.010	0.517	0.088
Median (%)	0.014	-0.230	-0.393	-0.547	0.519	1.254	0.854	-0.049
Minimum (%)	-5.041	-5.423	-23.368	-11.756	-5.796	-25.158	-17.242	-13.239
Maximum (%)	3.939	3.810	18.593	12.160	11.080	12.556	9.663	7.604
Standard deviation	0.003	0.003	0.050	0.034	0.028	0.041	0.034	0.027
Skewness	-0.560	-1.538	-0.132	0.213	0.037	-1.850	-0.539	-0.174
Kurtosis	20.789	8.926	2.110	3.468	5.307	9.777	4.910	3.359

Table 2
Correlation between factors

Variable	MKT	SMB	HML	WML	RMW	CMA	R_f
MKT	1.000	-0.081	0.211	-0.152	-0.333	-0.235	-0.066
SMB		1.000	-0.134	0.010	0.190	-0.103	-0.003
HML			1.000	-0.323	-0.309	0.235	0.196
WML				1.000	0.220	0.195	-0.039
RMW					1.000	-0.052	-0.093
CMA						1.000	0.110
R_f							1.000

Table 3
Value of factors from 2004 to 2019

		α	MKT	SMB	HML	WML	RMW	CMA	adj. R^2
	average	-0.0023***	0.0412***						
CAPM	standard error	0.0000	0.0004						0.47
	p-value	0.0000	0.0000						
	average	-0.0023***	0.0432***	0.0112***	-0.0108***				
FF3F	standard error	0.0000	0.0004	0.0006	0.0007				0.50
	p-value	0.0000	0.0000	0.0000	0.0000				
	average	-0.0023***	0.0434***	0.0113***	-0.0103***	0.0012**			
C4F	standard error	0.0000	0.0004	0.0006	0.0007	0.0005			0.50
	p-value	0.0000	0.0000	0.0000	0.0000	0.0186			
	average	-0.0023***	0.0439***	0.0094***	-0.0070***		0.0077***	-0.0046***	
FF5F	standard error	0.0000	0.0004	0.0006	0.0007		0.0006	0.0008	0.50
	p-value	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000	
	average	-0.0023***	0.0440***	0.0095***	-0.0060***	0.0018***	0.0074***	-0.0055***	
FF6F	standard error	0.0000	0.0004	0.0006	0.0008	0.0005	0.0006	0.0008	0.50
	p-value	0.0000	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	

Table 4
Value of factors from 2004 to 2008 and from 2009 to 2019

2004–2008									
		α	**MKT**	**SMB**	**HML**	**WML**	**RMW**	**CMA**	**Adj. R^2**
FF3F	average	-0.0041***	0.0436***	0.0160***	-0.0074***				
	standard error	0.00011	0.0007	0.0011	0.0016				0.66
	p-value	0.0000	0.0000	0.0000	0.0000				
C4F	average	-0.0040***	0.0442***	0.0167***	-0.0091***	-0.0044***			
	standard error	0.00001	0.0007	0.0011	0.0017	0.0011			0.66
	p-value	0.0000	0.0000	0.0000	0.0000	0.0000			
FF5F	average	-0.0041***	0.0440***	0.0148***	-0.0039**		0.0086***	0.0000	
	standard error	0.0001	0.0007	0.0011	0.0018		0.0012	0.0017	0.67
	p-value	0.0000	0.0000	0.0000	0.0254		0.0000	0.9768	
FF6F	average	-0.0039***	0.0450***	0.0157***	-0.0063***	-0.0061***	0.0098***	0.0014	
	standard error	0.0001	0.0008	0.0011	0.0018	0.0011	0.0012	0.0017	0.67
	p-value	0.0000	0.0000	0.0000	0.0005	0.0000	0.7774	0.4037	
2009–2019									
		α	**MKT**	**SMB**	**HML**	**WML**	**RMW**	**CMA**	**Adj. R^2**
FF3F	average	-0.0021***	0.0414***	0.0098***	-0.0098***				
	standard error	0.00000	0.0004	0.0006	0.0007				0.48
	p-value	0.0000	0.0000	0.0000	0.0000				
C4F	average	-0.0022***	0.0431***	0.0112***	-0.0073***	0.0056***			
	standard error	0.0000	0.0005	0.0006	0.0008	0.0005			0.49
	p-value	0.0000	0.0000	0.0000	0.0000	0.0000			
FF5F	average	-0.0021***	0.0416***	0.0096***	-0.0096***		0.0008	0.0001	
	standard error	0.0000	0.0005	0.0006	0.0008		0.0007	0.0008	0.48
	p-value	0.0000	0.0000	0.0000	0.0000		0.2688	0.8969	
FF6F	average	-0.0022***	0.0429***	0.0112***	-0.0056***	0.0066***	0.0006	-0.0038***	
	standard error	0.0000	0.0005	0.0007	0.0009	0.0006	0.0007	0.0009	0.49
	p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.4490	0.0000	

Table 5
The GRS statistics

	GRS	α	$s(\alpha)$	adj. R^2
FF3F	16.00	-0.00231	0.00004	0.54
C4F	6.17	-0.00221	0.00007	0.55
FF5F	17.61	-0.00234	0.00004	0.58
FF6F	24.79	-0.00228	0.00007	0.58

Table 6
Excess returns for one-way sorted portfolios

2004–2019										
	R (%)					**Standard deviation**				
	min	**2**	**3**	**4**	**max**	**min**	**2**	**3**	**4**	**max**
SMB	-0.02	-0.01	0.02	0.01	0.01	0.0023	0.0026	0.0026	0.0028	0.0028
HML	-0.02	0.01	0.00	-0.02	0.06	0.0023	0.0023	0.0022	0.0033	0.0027
WML	0.04	-0.01	0.01	-0.02	-0.01	0.0030	0.0021	0.0023	0.0020	0.0033
RMW	0.06	0.08	-0.05	-0.01	-0.05	0.0030	0.0024	0.0022	0.0027	0.0025
CMA	0.09	0.02	-0.02	-0.01	-0.05	0.0022	0.0025	0.0022	0.0028	0.0031
2004–2008										
	R (%)					**Standard deviation**				
	min	**2**	**3**	**4**	**max**	**min**	**2**	**3**	**4**	**max**
SMB	-0.04	-0.07	-0.01	-0.02	0.12	0.0021	0.0035	0.0035	0.0047	0.0025
HML	-0.04	0.00	-0.23	0.04	-0.01	0.0030	0.0024	0.0048	0.0036	0.0027
WML	-0.25	0.03	0.05	0.04	-0.05	0.0028	0.0017	0.0024	0.0033	0.0052
RMW	0.04	-0.12	-0.04	-0.11	0.07	0.0022	0.0043	0.0033	0.0035	0.0035
CMA	0.05	0.05	-0.09	-0.01	-0.16	0.0024	0.0032	0.0042	0.0028	0.0041
2009–2019										
	R (%)					**Standard deviation**				
	min	**2**	**3**	**4**	**max**	**min**	**2**	**3**	**4**	**max**
SMB	0.00	-0.01	0.04	0.04	-0.01	0.0022	0.0024	0.0023	0.0021	0.0028
HML	-0.03	0.03	0.01	-0.01	0.07	0.0021	0.0021	0.0021	0.0027	0.0026
WML	0.11	-0.01	0.01	-0.04	-0.01	0.0027	0.0022	0.0023	0.0021	0.0023
RMW	0.12	0.06	-0.03	0.00	-0.07	0.0025	0.0024	0.0018	0.0026	0.0021
CMA	0.09	0.02	0.00	-0.04	-0.01	0.0022	0.0025	0.0020	0.0023	0.0027

Table 7
Excess returns of two-way sorted portfolios

	SMB × HML						SMB × WML				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.42	-0.05	-0.14	-0.41	-0.35	min	-0.28	-0.28	-0.37	-0.23	-0.41
2	-0.37	-0.27	-0.22	-0.28	-0.24	2	-0.30	-0.28	-0.15	-0.25	-0.44
3	-0.19	-0.31	-0.28	-0.15	-0.20	3	-0.31	-0.20	-0.32	-0.24	-0.19
4	-0.13	-0.24	-0.13	-0.37	-0.09	4	-0.18	-0.23	0.00	-0.09	-0.35
max	-0.24	-0.32	-0.29	-0.02	-0.33	max	-0.30	-0.34	-0.17	-0.31	-0.21
	SMB × CMA						**SMB × RMW**				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.20	-0.19	-0.36	-0.46	-0.43	min	-0.21	-0.15	-0.32	-0.51	-0.35
2	-0.24	-0.20	-0.37	-0.24	-0.28	2	-0.19	-0.15	-0.22	-0.33	-0.34
3	-0.09	-0.15	-0.27	-0.26	-0.35	3	-0.18	-0.18	-0.27	-0.29	-0.25
4	-0.50	-0.26	-0.18	-0.07	-0.25	4	-0.14	-0.16	-0.32	-0.20	-0.55
max	-0.08	-0.11	-0.29	-0.26	-0.31	max	-0.22	-0.27	-0.34	-0.14	-0.27
	HML × WML						**HML × CMA**				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	0.92	-0.07	-0.64	-3.52	-1.85	min	4.23	7.35	-0.28	-2.86	-3.13
2	-1.43	-1.08	0.27	2.11	-1.47	2	1.18	3.40	-1.56	-1.95	-2.00
3	3.24	-0.54	-0.23	-0.88	1.44	3	1.65	0.85	-2.99	1.19	-1.36
4	-1.25	-0.43	-0.16	0.71	0.50	4	0.15	1.03	-0.56	-2.45	0.60
max	2.26	2.82	2.98	1.68	-1.73	max	4.74	1.66	-1.76	1.29	-3.16
	HML × RMW						**WML × RMW**				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.75	-1.75	-0.91	-1.23	-3.41	min	2.66	0.92	1.43	0.90	0.58
2	1.15	0.90	-2.74	-1.92	1.81	2	5.25	-1.82	0.85	-0.77	0.98
3	3.38	-0.35	1.07	-0.95	-2.62	3	1.00	-0.23	-1.53	-2.15	-0.21
4	0.93	-1.68	-2.41	0.79	0.06	4	-1.49	0.18	-1.16	-0.18	-0.48
max	6.26	4.83	5.31	-0.62	0.06	max	-3.04	2.22	4.79	0.48	-6.76
	WML × CMA						**RMW × CMA**				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-4.95	0.06	1.33	2.58	5.65	min	7.01	3.16	-0.44	1.46	-1.56
2	-9.76	-0.07	1.44	2.98	5.01	2	5.61	3.27	0.38	0.52	-4.49
3	-4.02	0.17	1.23	2.37	4.77	3	-0.30	2.01	-3.25	0.41	-2.20
4	-3.40	-0.28	1.09	2.64	6.44	4	1.59	-1.16	0.02	-2.63	1.03
max	-3.84	-0.22	1.18	2.79	6.30	max	0.94	2.28	-3.44	-5.47	-1.70

Table 8
α from SMB × HML sorted portfolios

The Fama and French three-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	0.0004	-0.0005	-0.0062	-0.0061	0.0008	min	0.1843	0.7562	0.0000	0.0000	0.0983
2	-0.0005	-0.0014	0.0010	0.0003	0.0020	2	0.1828	0.0010	0.0510	0.6936	0.0000
3	-0.0036	-0.0050	-0.0028	0.0054	-0.0053	3	0.0000	0.0000	0.0000	0.0000	0.0000
4	-0.0013	-0.0015	0.0123	-0.0031	-0.0053	4	0.0000	0.0000	0.0669	0.0000	0.0000
max	0.0003	-0.0026	-0.0021	0.0030	-0.0022	max	0.2435	0.0000	0.0001	0.0012	0.0000
Carhart's four-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	0.0004	-0.0001	-0.0061	-0.0057	0.0028	min	0.2097	0.9269	0.0000	0.0000	0.0000
2	0.0002	-0.0046	0.0022	0.0025	0.0022	2	0.2885	0.0000	0.0003	0.0072	0.0000
3	-0.0025	-0.0034	-0.0019	0.0055	-0.0062	3	0.0000	0.0000	0.0000	0.0000	0.0000
4	-0.0013	-0.0015	-0.0037	-0.0028	-0.0059	4	0.0000	0.0000	0.0000	0.0000	0.0000
max	0.0004	-0.0026	-0.0038	0.0120	-0.0024	max	0.1133	0.0000	0.0000	0.0000	0.0000
The Fama and French five-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	0.0020	-0.0022	-0.0369	-0.0077	0.0008	min	0.0002	0.0000	0.0000	0.0000	0.3294
2	-0.0047	-0.0002	-0.0028	-0.0003	0.0023	2	0.0000	0.5179	0.0000	0.7364	0.0000
3	-0.0040	-0.0067	-0.0036	0.0049	0.0007	3	0.0000	0.0000	0.0000	0.2154	0.3407
4	-0.0013	-0.0020	-0.0028	-0.0023	-0.0052	4	0.0000	0.0000	0.0000	0.0000	0.0000
max	0.0003	-0.0026	-0.0127	0.0165	-0.0058	max	0.3581	0.0000	0.0000	0.0000	0.0000
The Fama and French six-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	0.0036	-0.0006	0.0010	-0.0074	0.0121	min	0.0000	0.0000	0.1017	0.0000	0.0000
2	-0.0047	-0.0048	-0.0075	0.0012	0.0027	2	0.0000	0.0000	0.0000	0.1918	0.0000
3	0.0042	-0.0140	-0.0042	-0.0032	-0.0009	3	0.0000	0.0000	0.0000	0.0000	0.0308
4	-0.0013	-0.0024	-0.0032	-0.0013	-0.0053	4	0.0000	0.0000	0.0000	0.0138	0.0000
max	0.0008	-0.0027	-0.0078	0.0225	-0.0198	max	0.0350	0.0000	0.0000	0.0000	0.0000

Table 9
α from SMB × WML sorted portfolios

The Fama and French three-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0014	-0.0021	0.0008	0.0008	-0.0051	min	0.0147	0.0000	0.0036	0.0090	0.0000
2	0.0006	-0.0023	0.0029	-0.0018	-0.0498	2	0.3260	0.0000	0.0000	0.0001	0.0000
3	-0.0045	-0.0021	0.0024	-0.0025	-0.0039	3	0.0000	0.0000	0.2974	0.0000	0.0000
4	-0.0040	0.0006	-0.0002	-0.0009	-0.0036	4	0.0000	0.0432	0.7082	0.0000	0.0000
max	-0.0053	-0.0055	-0.0002	-0.0006	-0.0008	max	0.0000	0.0000	0.2527	0.0073	0.0018
Carhart's four-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0013	0.0028	0.0001	0.0024	-0.0072	min	0.0292	0.0000	0.8556	0.0000	0.0000
2	0.0020	-0.0023	0.0038	-0.0012	0.0186	2	0.0047	0.0000	0.0000	0.0126	0.2895
3	-0.0031	-0.0021	-0.0013	-0.0059	-0.0021	3	0.0000	0.0000	0.0013	0.0000	0.0006
4	-0.0033	-0.0001	-0.0002	-0.0009	-0.0028	4	0.0000	0.7742	0.7082	0.0000	0.0000
max	-0.0053	-0.0103	0.0024	-0.0009	0.0004	max	0.0000	0.0000	0.0000	0.1485	0.3344
The Fama and French five-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0037	0.0014	0.0027	0.0045	-0.0013	min	0.0000	0.0087	0.0000	0.0000	0.2116
2	-0.0016	-0.0023	0.0027	-0.0029	0.0241	2	0.0074	0.0000	0.0000	0.0000	0.2130
3	-0.0047	-0.0022	-0.0026	-0.0019	-0.0085	3	0.0000	0.0000	0.0000	0.0000	0.0000
4	-0.0035	0.0007	-0.0004	-0.0009	-0.0037	4	0.0000	0.0902	0.0038	0.0000	0.0000
max	-0.0054	-0.0229	-0.0054	-0.0018	-0.0003	max	0.0000	0.0000	0.0000	0.0000	0.4088
The Fama and French six-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0033	0.0015	0.1043	0.0036	-0.0031	min	0.0000	0.2316	0.0000	0.0004	0.0000
2	0.0028	-0.0023	0.0034	-0.0030	0.0155	2	0.0040	0.0000	0.0000	0.0000	0.2457
3	-0.0047	-0.0024	-0.0026	0.0006	-0.0045	3	0.0000	0.0000	0.0000	0.4388	0.0000
4	-0.0033	0.0009	-0.0004	-0.0009	-0.0028	4	0.0000	0.0096	0.0038	0.0000	0.0000
max	-0.0056	-0.0229	0.0142	0.0000	0.0008	max	0.0000	0.0000	0.0004	0.9446	0.0354

Table 10
α from SMB × RMW sorted portfolios

The Fama and French three-factor model											
			α					p-value			
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0005	-0.0009	-0.0008	-0.0049	-0.0058	min	0.0303	0.0025	0.0028	0.0000	0.0000
2	0.0008	0.0001	-0.0013	-0.0059	0.0077	2	0.0838	0.7519	0.0000	0.0000	0.0016
3	-0.0016	-0.0006	-0.0030	0.0020	-0.0032	3	0.0000	0.0318	0.0000	0.0000	0.0000
4	0.0186	-0.0017	-0.0031	-0.0027	-0.0050	4	0.0000	0.0000	0.0000	0.0000	0.0000
max	-0.0024	-0.0061	-0.0017	0.0005	-0.0007	max	0.0000	0.0000	0.0008	0.0266	0.0026
Carhart's four-factor model											
			α					p-value			
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0007	-0.0016	-0.0008	-0.0068	-0.0116	min	0.0019	0.0000	0.0028	0.0000	0.0000
2	0.0017	0.0002	0.0004	-0.0092	-0.0031	2	0.0004	0.6494	0.3942	0.0000	0.0000
3	-0.0018	-0.0012	-0.0031	0.0054	-0.0034	3	0.0000	0.0001	0.0000	0.0000	0.0000
4	-0.0031	-0.0016	-0.0026	-0.0028	-0.0027	4	0.0000	0.0000	0.0000	0.0000	0.0000
max	-0.0023	-0.0056	-0.0058	0.0006	-0.0004	max	0.0000	0.0000	0.0000	0.0058	0.1106
The Fama and French five-factor model											
			α					p-value			
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0007	-0.0048	-0.0008	-0.0087	-0.0031	min	0.0005	0.0000	0.0028	0.0000	0.0000
2	0.0015	0.0011	-0.0035	-0.0105	-0.0009	2	0.0312	0.0256	0.0000	0.0000	0.5980
3	-0.0011	0.0053	-0.0027	0.0039	-0.0074	3	0.0028	0.0000	0.0000	0.0000	0.0000
4	-0.0029	-0.0024	-0.0016	0.0003	-0.0048	4	0.0000	0.0000	0.0009	0.6671	0.0000
max	-0.0385	-0.0069	-0.1058	0.0032	-0.0008	max	0.0000	0.0000	0.0000	0.0000	0.0459
The Fama and French six-factor model											
			α					p-value			
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0008	-0.0011	-0.0008	-0.0092	-0.0035	min	0.0006	0.0003	0.0028	0.0000	0.0000
2	0.0044	0.0006	-0.0031	-0.0092	0.0020	2	0.0000	0.2000	0.0000	0.0000	0.1213
3	-0.0010	0.0036	-0.0028	0.0036	-0.0055	3	0.0167	0.0015	0.0000	0.0000	0.0000
4	-0.0031	-0.0046	0.0008	0.0010	-0.0047	4	0.0000	0.0000	0.0773	0.2188	0.0000
max	0.0053	-0.0079	-0.0058	0.0046	-0.0008	max	0.0003	0.0000	0.0000	0.0000	0.0716

Table 11
α from SMB × CMA sorted portfolios

The Fama and French three-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0013	-0.0013	-0.0037	0.0081	0.0004	min	0.0000	0.0015	0.0000	0.0000	0.2364
2	-0.0007	-0.0053	-0.0020	-0.0060	-0.0008	2	0.0040	0.0000	0.0000	0.0358	0.0442
3	-0.0023	-0.0043	-0.0033	-0.0018	0.0044	3	0.0214	0.0000	0.0000	0.0000	0.0975
4	-0.0034	-0.0031	-0.0024	-0.0032	-0.0020	4	0.0000	0.0000	0.0000	0.0000	0.0000
max	-0.0008	0.0000	-0.0018	-0.0002	-0.0001	max	0.0064	0.9154	0.0000	0.4817	0.6820
Carhart's four-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0015	-0.0022	-0.0079	-0.0016	0.0010	min	0.0000	0.0001	0.0000	0.0000	0.0017
2	-0.0008	-0.0020	-0.0034	-0.0095	-0.0008	2	0.0030	0.0000	0.0000	0.0038	0.0544
3	0.0204	-0.0038	-0.0033	-0.0003	-0.0031	3	0.0000	0.0000	0.0000	0.2815	0.0000
4	-0.0036	-0.0033	0.0008	-0.0025	-0.0020	4	0.0000	0.0000	0.2658	0.0000	0.0000
max	-0.0006	-0.0003	-0.0018	-0.0004	-0.0001	max	0.0535	0.3996	0.0000	0.2162	0.8321
The Fama and French five-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0025	-0.0011	-0.0025	-0.0031	-0.0001	min	0.0000	0.0100	0.0000	0.0000	0.8852
2	0.0010	-0.0039	-0.0025	-0.0215	0.0020	2	0.0551	0.0000	0.0000	0.0000	0.0001
3	0.0001	-0.0001	-0.0036	-0.0043	-0.0033	3	0.9207	0.8701	0.0000	0.0000	0.0000
4	-0.0048	-0.0024	0.0011	-0.0027	-0.0031	4	0.0000	0.0000	0.1917	0.0000	0.0000
max	-0.0025	0.0006	-0.0011	0.0052	0.0016	max	0.0000	0.1203	0.0033	0.0000	0.0000
The Fama and French six-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0026	-0.0011	-0.0025	-0.0031	-0.0005	min	0.0000	0.0100	0.0000	0.0000	0.3503
2	0.0013	-0.0010	-0.0040	-0.0301	0.0023	2	0.3254	0.0016	0.0000	0.0000	0.0000
3	0.0001	-0.0002	-0.0032	-0.0030	-0.0033	3	0.8941	0.8168	0.0000	0.0000	0.0000
4	-0.0047	-0.0025	0.0029	-0.0018	-0.0031	4	0.0000	0.0000	0.0016	0.0000	0.0000
max	-0.0025	0.0001	-0.0024	0.0062	0.0018	max	0.0000	0.8238	0.0000	0.0000	0.0000

Table 12
α from HML × WML sorted portfolios

The Fama and French three-factor model											
			α					p-value			
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	0.0144	0.0002	-0.0740	-0.0005	-0.0039	min	0.0000	0.3715	0.0000	0.0198	0.0000
2	-0.0008	-0.0006	-0.0024	-0.0028	-0.0020	2	0.0000	0.0900	0.0000	0.0000	0.0000
3	-0.0046	-0.0021	-0.0013	-0.0053	-0.0079	3	0.0000	0.0000	0.0000	0.0000	0.0000
4	-0.0054	-0.0036	-0.0012	-0.0024	-0.0048	4	0.0000	0.0000	0.0204	0.0000	0.0000
max	-0.0025	-0.0016	-0.0072	-0.0029	-0.0003	max	0.0000	0.0000	0.0000	0.0002	0.3440
Carhart's four-factor model											
			α					p-value			
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	0.0134	-0.0009	-0.0111	-0.0058	-0.0029	min	0.0000	0.0118	0.0000	0.0000	0.0000
2	0.0025	-0.0011	-0.0048	-0.0028	-0.0005	2	0.0000	0.1063	0.0019	0.0000	0.1498
3	-0.0170	-0.0019	-0.0016	-0.0032	0.0050	3	0.0000	0.0000	0.0000	0.0005	0.0000
4	-0.0053	-0.0040	-0.0002	0.0010	-0.0004	4	0.0000	0.0000	0.6914	0.1131	0.8574
max	-0.0023	-0.0015	-0.0156	0.0014	0.0010	max	0.0000	0.0000	0.0000	0.0180	0.0029
The Fama and French five-factor model											
			α					p-value			
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	0.0003	-0.0012	-0.0026	-0.0036	-0.0039	min	0.3829	0.0180	0.0000	0.0000	0.0000
2	-0.0029	0.0018	-0.0211	-0.0039	-0.0020	2	0.0000	0.0002	0.0000	0.0000	0.0000
3	-0.0039	-0.0020	-0.0015	-0.0049	-0.0014	3	0.0000	0.0000	0.0000	0.0000	0.0000
4	-0.0050	-0.0035	-0.0009	-0.0021	-0.0051	4	0.0000	0.0000	0.0617	0.0000	0.0000
max	-0.0023	-0.0010	0.0101	0.0033	-0.0005	max	0.0000	0.1231	0.0000	0.1612	0.0537
The Fama and French six-factor model											
			α					p-value			
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0029	-0.0009	-0.0026	-0.0060	-0.0020	min	0.0000	0.0345	0.0000	0.0000	0.0000
2	-0.0033	0.0018	0.0104	-0.0039	-0.0006	2	0.0003	0.0002	0.0000	0.0034	0.1700
3	-0.0039	-0.0020	0.0032	-0.0013	-0.0024	3	0.0000	0.0000	0.0603	0.1479	0.0000
4	-0.0040	-0.0039	-0.0033	0.0038	0.0109	4	0.0000	0.0000	0.0000	0.0000	0.3925
max	-0.0018	0.0103	-0.0049	0.0001	0.0001	max	0.0000	0.0000	0.0000	0.8014	0.7214

Table 13
α from HML × CMA sorted portfolios

The Fama and French three-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	0.0285	-0.0004	-0.0016	-0.0029	-0.0029	min	0.0000	0.0382	0.0000	0.0000	0.0000
2	0.0018	-0.0038	-0.0011	-0.0032	-0.0011	2	0.0520	0.0000	0.0000	0.0000	0.0000
3	-0.0025	-0.0029	-0.0020	-0.0008	-0.0025	3	0.0000	0.0000	0.0000	0.0003	0.0000
4	-0.0001	-0.0028	-0.0024	-0.0076	0.0010	4	0.8551	0.0000	0.0000	0.0000	0.5821
max	-0.0015	-0.0024	-0.0018	-0.0033	-0.0042	max	0.0000	0.0000	0.0000	0.0001	0.0000
Carhart's four-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0039	-0.0004	-0.0005	-0.0031	-0.0032	min	0.0000	0.0382	0.0557	0.0000	0.0000
2	-0.0022	-0.0038	-0.0013	-0.0006	-0.0017	2	0.0000	0.0000	0.0000	0.0006	0.0000
3	-0.0027	-0.0038	-0.0028	-0.0016	-0.0025	3	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0016	-0.0026	0.0035	-0.0062	-0.0006	4	0.0009	0.0000	0.0000	0.0000	0.5657
max	-0.0011	-0.0024	-0.0021	-0.0102	-0.0023	max	0.0001	0.0000	0.0000	0.0000	0.0000
The Fama and French five-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	0.0005	-0.0004	0.0023	-0.0383	-0.0041	min	0.1759	0.0382	0.0000	0.0000	0.0000
2	-0.0049	0.0017	-0.0013	0.0019	0.0032	2	0.0000	0.1142	0.0000	0.0448	0.0000
3	-0.0085	-0.0028	-0.0015	-0.0073	-0.0026	3	0.0000	0.0000	0.0000	0.0000	0.0000
4	-0.0009	-0.0032	-0.0037	-0.0060	0.0010	4	0.1159	0.0000	0.0000	0.0000	0.5821
max	0.0004	-0.0022	-0.0018	0.0013	-0.0045	max	0.1682	0.0000	0.0000	0.0278	0.0000
The Fama and French six-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	0.0005	-0.0004	0.0024	-0.0362	-0.0044	min	0.1759	0.0382	0.0000	0.0000	0.0000
2	-0.0022	0.0023	-0.0023	-0.0007	0.0033	2	0.0000	0.0514	0.0000	0.3874	0.0000
3	-0.0023	-0.0042	-0.0035	-0.0201	-0.0036	3	0.1870	0.0000	0.0000	0.0032	0.0000
4	0.0006	-0.0030	0.0002	-0.0222	-0.0006	4	0.2560	0.0000	0.7322	0.0000	0.5657
max	0.0004	-0.0021	-0.0021	0.0028	-0.0025	max	0.2219	0.0000	0.0000	0.0000	0.0000

Table 14
α from HML × RMW sorted portfolios

The Fama and French three-factor model											
			α					p-value			
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0005	-0.0024	-0.0046	-0.0050	0.0019	min	0.0707	0.0000	0.0000	0.0000	0.0000
2	-0.0010	-0.0030	-0.0021	-0.0024	-0.0053	2	0.0000	0.0000	0.0000	0.0000	0.0000
3	-0.0033	-0.0011	-0.0018	-0.0032	-0.0032	3	0.0000	0.0000	0.0000	0.0000	0.0000
4	-0.0054	-0.0175	-0.0086	-0.0013	-0.0058	4	0.0000	0.0000	0.0000	0.0007	0.0000
max	-0.0024	-0.0019	-0.0040	-0.0036	-0.0025	max	0.0000	0.0009	0.0000	0.0000	0.0000
Carhart's four-factor model											
			α					p-value			
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0005	-0.0023	-0.0054	-0.0050	0.0019	min	0.0605	0.0000	0.0000	0.0000	0.0000
2	-0.0014	-0.0029	-0.0023	-0.0018	-0.0020	2	0.0000	0.0000	0.0000	0.0000	0.0000
3	-0.0035	-0.0012	-0.0025	-0.0060	-0.0037	3	0.0000	0.0000	0.0000	0.0000	0.0000
4	-0.0048	-0.0095	-0.0064	-0.0012	-0.0052	4	0.0000	0.0000	0.0000	0.0025	0.0000
max	-0.0006	-0.0064	-0.0011	-0.0039	-0.0011	max	0.0369	0.0000	0.0000	0.0000	0.0000
The Fama and French five-factor model											
			α					p-value			
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0039	-0.0051	-0.0017	-0.0037	0.0016	min	0.0000	0.0000	0.0094	0.0000	0.0000
2	-0.0006	-0.0052	-0.0021	-0.0051	-0.0053	2	0.1967	0.0000	0.0000	0.0000	0.0000
3	0.0056	0.0017	-0.0029	0.0541	-0.0036	3	0.0000	0.0000	0.0000	0.3567	0.0000
4	-0.0054	-0.0056	-0.0071	-0.0017	-0.0053	4	0.0000	0.0000	0.0000	0.0019	0.0000
max	-0.0090	-0.0006	-0.0018	0.0007	-0.0003	max	0.0000	0.2343	0.0000	0.1455	0.3842
The Fama and French six-factor model											
			α					p-value			
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0039	-0.0036	-0.0025	-0.0037	0.0016	min	0.0000	0.0000	0.0001	0.0000	0.0000
2	0.0005	-0.0062	-0.0022	-0.0042	-0.0020	2	0.2219	0.0000	0.0000	0.0000	0.0000
3	0.0056	0.0014	-0.0033	-0.0005	-0.0033	3	0.0000	0.0000	0.0000	0.7828	0.0000
4	-0.0175	-0.0056	-0.0071	-0.0017	-0.0050	4	0.0000	0.0000	0.0000	0.0012	0.0000
max	0.0121	-0.0017	-0.0011	0.0038	0.0006	max	0.0001	0.0000	0.0000	0.0000	0.0725

Table 15
α from WML × RMW sorted portfolios

The Fama and French three-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0020	-0.0035	-0.0041	-0.0048	-0.0034	min	0.0000	0.0000	0.0000	0.0000	0.0000
2	-0.0017	-0.0028	-0.0024	0.0015	-0.0022	2	0.0000	0.0000	0.0000	0.0013	0.0000
3	0.0040	-0.0015	-0.0013	-0.0017	-0.0034	3	0.0000	0.0000	0.0000	0.0000	0.0000
4	-0.0022	-0.0030	-0.0026	-0.0013	-0.0021	4	0.0000	0.0000	0.0000	0.0000	0.0000
max	-0.0028	-0.0013	-0.0021	-0.0036	-0.0027	max	0.0000	0.0000	0.0000	0.0000	0.0000
Carhart's four-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0022	-0.0041	-0.0031	-0.0127	-0.0030	min	0.0000	0.0000	0.0000	0.0000	0.0000
2	-0.0019	-0.0028	-0.0024	-0.0271	-0.0023	2	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0040	-0.0024	-0.0011	-0.0005	-0.0536	3	0.0000	0.0000	0.0000	0.0403	0.0000
4	-0.0082	-0.0030	-0.0002	0.0054	0.0019	4	0.0000	0.0000	0.7378	0.0000	0.0003
max	-0.0036	0.0002	0.0004	-0.0002	-0.0001	max	0.0000	0.5941	0.1256	0.7164	0.7895
The Fama and French five-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0022	-0.0028	-0.0047	-0.0060	-0.0016	min	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0044	-0.0039	-0.0005	0.0014	-0.0065	2	0.0000	0.0000	0.0122	0.0000	0.0000
3	-0.0035	-0.0012	-0.0014	-0.0031	0.0073	3	0.0000	0.0010	0.0000	0.0000	0.0000
4	-0.0011	-0.0030	-0.0018	-0.0006	-0.0003	4	0.0310	0.0000	0.0000	0.1638	0.6603
max	-0.0024	-0.0067	-0.0025	-0.0035	0.0005	max	0.0000	0.0000	0.0000	0.0000	0.1684
The Fama and French six-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0013	-0.0002	-0.0170	-0.0119	-0.0018	min	0.0000	0.3508	0.0000	0.0000	0.0000
2	0.0044	-0.0026	0.0000	0.0014	-0.0071	2	0.0000	0.0000	0.9700	0.0000	0.0000
3	-0.0035	-0.0079	-0.0007	-0.0074	0.0073	3	0.0000	0.0000	0.0057	0.0000	0.0000
4	-0.0047	-0.0030	-0.0010	0.0054	0.0066	4	0.0000	0.0000	0.2321	0.0000	0.0000
max	-0.0023	-0.0134	0.0021	-0.0004	0.0007	max	0.0001	0.0736	0.0000	0.3165	0.2431

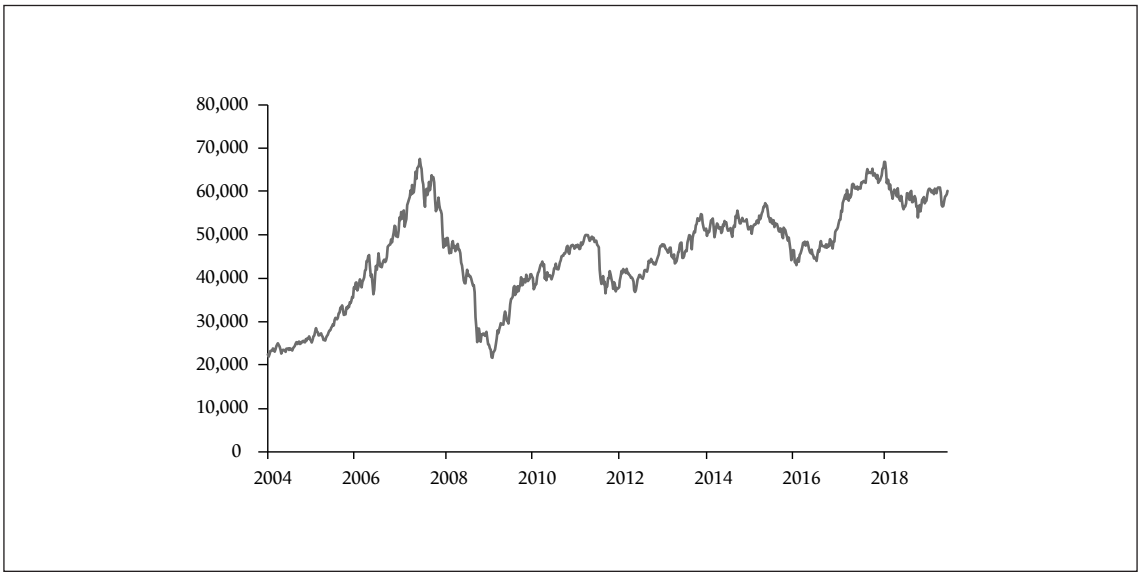
Table 16
α from WML × CMA sorted portfolios

The Fama and French three-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0036	-0.0034	-0.0019	-0.0028	-0.0024	min	0.0000	0.0000	0.0000	0.1293	0.0000
2	-0.0022	-0.0018	-0.0024	-0.0024	-0.0040	2	0.0000	0.0000	0.0000	0.0000	0.0000
3	-0.0026	-0.0025	-0.0012	-0.0024	0.0340	3	0.0000	0.0000	0.0005	0.0000	0.0000
4	-0.0026	-0.0023	-0.0019	-0.0009	-0.0024	4	0.0000	0.0000	0.0000	0.0000	0.0000
max	-0.0021	-0.0014	-0.0032	-0.0050	-0.0034	max	0.0000	0.0000	0.0000	0.0000	0.0000
Carhart's four-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0033	-0.0040	-0.0111	-0.0020	0.0054	min	0.0000	0.0000	0.0000	0.0000	0.0000
2	-0.0024	-0.0021	-0.0025	0.0008	-0.0018	2	0.0000	0.0000	0.0000	0.0468	0.0000
3	-0.0079	-0.0004	-0.0011	-0.0030	-0.0019	3	0.0000	0.1774	0.0005	0.0000	0.0000
4	-0.0041	0.0003	-0.0055	-0.0016	-0.0099	4	0.0000	0.3823	0.0000	0.0000	0.0000
max	-0.0015	colline-arity	0.0003	0.0006	-0.0040	max	0.0000	colline-arity	0.1393	0.0204	0.0000
The Fama and French five-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0063	-0.0042	-0.0011	-0.0004	-0.0054	min	0.0000	0.0000	0.0257	0.1293	0.0000
2	-0.0051	-0.0124	-0.0052	-0.0019	-0.0006	2	0.0000	0.0000	0.0000	0.0000	0.0365
3	0.0043	-0.0011	-0.0011	0.0068	-0.0022	3	0.0000	0.0000	0.0009	0.0000	0.0000
4	-0.0025	-0.0030	0.0008	-0.0048	-0.0036	4	0.0000	0.0000	0.1308	0.0000	0.0000
max	-0.0013	colline-arity	-0.0019	-0.0017	-0.0042	max	0.0005	colline-arity	0.0000	0.1157	0.0000
The Fama and French six-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0064	-0.0038	-0.0089	-0.0020	-0.0054	min	0.0000	0.0000	0.0000	0.0000	0.0000
2	-0.0051	0.0004	-0.0052	-0.0019	-0.0009	2	0.0000	0.8868	0.0000	0.0000	0.0043
3	0.0019	0.0010	-0.0011	0.0075	-0.0022	3	0.0150	0.0176	0.0009	0.0000	0.0000
4	-0.0025	0.0005	0.0029	-0.0049	-0.0036	4	0.0000	0.1716	0.0020	0.0000	0.0000
max	-0.0015	colline-arity	0.0018	0.0096	-0.0043	max	0.0003	colline-arity	0.0000	0.0000	0.0000

Table 17
α from CMA × RMW sorted portfolios

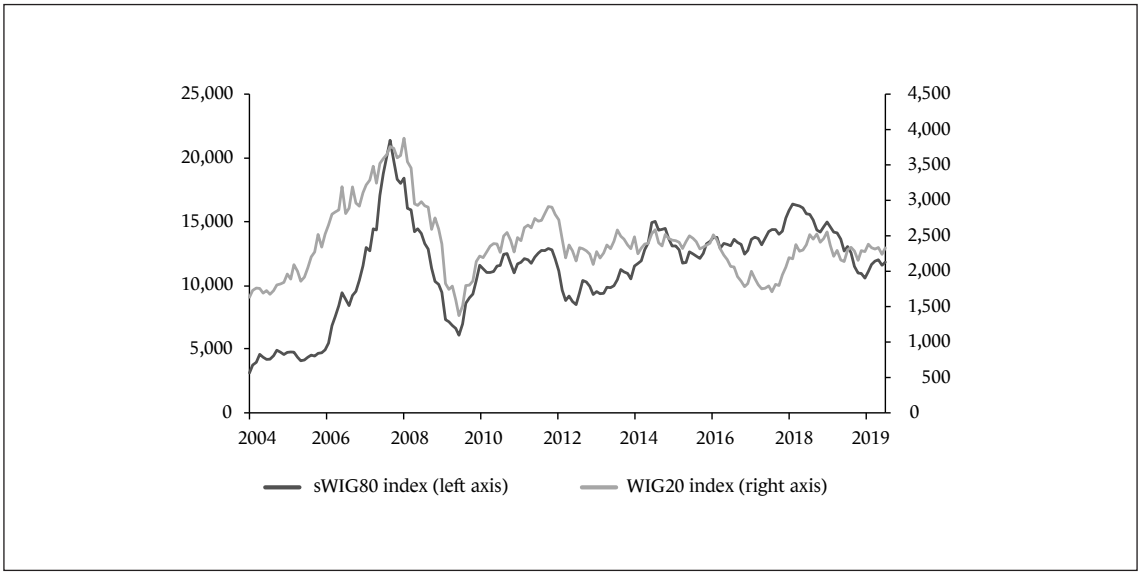
The Fama and French three-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0036	-0.0034	-0.0019	-0.0028	-0.0024	min	0.0000	0.0000	0.0000	0.0000	0.0000
2	-0.0022	-0.0018	-0.0024	-0.0024	-0.0040	2	0.0000	0.0000	0.0000	0.0000	0.0000
3	-0.0026	-0.0025	-0.0012	-0.0024	0.0340	3	0.0000	0.0000	0.0000	0.0000	0.0000
4	-0.0026	-0.0023	-0.0019	-0.0009	-0.0024	4	0.0000	0.0000	0.0000	0.0000	0.0000
max	-0.0021	-0.0014	-0.0032	-0.0050	-0.0034	max	0.0000	0.0000	0.0000	0.0000	0.0000
Carhart's four-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0047	-0.0022	-0.0019	-0.0031	-0.0015	min	0.0000	0.0001	0.0000	0.0000	0.0000
2	-0.0020	-0.0057	-0.0038	-0.0026	-0.0035	2	0.0000	0.0000	0.0000	0.0000	0.0000
3	-0.0024	-0.0025	-0.0016	-0.0018	-0.0039	3	0.0000	0.0000	0.0000	0.0000	0.0000
4	-0.0031	-0.0023	-0.0028	-0.0008	-0.0045	4	0.0000	0.0000	0.0000	0.0000	0.0000
max	-0.0021	-0.0022	-0.0032	0.0027	-0.0030	max	0.0000	0.0000	0.0000	0.2531	0.0000
The Fama and French five-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	-0.0017	-0.0034	-0.0145	-0.0082	-0.0004	min	0.0011	0.0000	0.0000	0.0000	0.0882
2	-0.0015	-0.0253	-0.0004	-0.0037	-0.0009	2	0.0000	0.0000	0.3497	0.0000	0.0872
3	-0.0047	-0.0160	-0.0011	0.0027	-0.0072	3	0.0000	0.0003	0.0000	0.0000	0.0000
4	0.0024	-0.0023	-0.0047	-0.0031	-0.0056	4	0.1022	0.0069	0.0000	0.0000	0.0001
max	-0.0013	0.0015	-0.0035	-0.0005	-0.0028	max	0.0121	0.1955	0.0000	0.7256	0.0001
The Fama and French six-factor model											
	α						p-value				
	min	**2**	**3**	**4**	**max**		**min**	**2**	**3**	**4**	**max**
min	0.0030	-0.0022	-0.0019	0.0085	0.0001	min	0.0000	0.0001	0.0000	0.0418	0.6464
2	-0.0015	-0.0087	-0.0030	-0.0029	-0.0038	2	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0117	-0.0090	-0.0017	-0.0019	-0.0039	3	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0078	-0.0206	-0.0035	-0.0037	-0.0045	4	0.0000	0.0000	0.0000	0.0000	0.0000
max	-0.0009	0.0010	-0.0042	-0.0005	-0.0003	max	0.0657	0.3932	0.0000	0.7256	0.7383

Figure 1
WIG index from January 2004 to June 2019



Source: www.gpw.pl.

Figure 2
sWIG80 and WIG20 index from January 2004 to June 2019



Source: www.gpw.pl.

Zastosowanie wieloczynnikowych modeli do oceny wysokości stóp zwrotu funduszy inwestycyjnych

Streszczenie

Artykuł porusza tematykę oceny stóp zwrotu funduszy inwestycyjnych. Podstawowym celem artykułu jest wskazanie, który z wieloczynnikowych modeli wyceny aktywów w największym stopniu wyjaśnia stopy zwrotu funduszy inwestycyjnych. Dodatkowym celem jest zbadanie, jaki wpływ na wysokość nadwyżkowych stóp zwrotu funduszy inwestycyjnych akcji krajowych mają czynniki ryzyka: wielkość, wartość, momentum, rentowność operacyjna kapitału własnego i zrealizowane inwestycje. W badaniu wykorzystano model Carharta oraz trzy-, pięcio- i sześcioczynnikowy model Famy i Frencha, a także stopy zwrotu 104 funduszy inwestycyjnych akcyjnych z okresu 2004–2019. Główne rezultaty badań są następujące: (1) sześcioczynnikowy model Famy i Frencha jest najlepiej dopasowanym modelem do opisu stóp zwrotu funduszy akcyjnych, (2) na wysokość nadwyżkowych stóp zwrotu polskich funduszy akcji krajowych dodatni i statycznie istotny wpływ ma wielkość i rentowność operacyjna kapitału własnego, (3) czynnik zrealizowanych w spółce inwestycji jest ujemny i statystycznie istotny, (4) czynnik momentum generuje nieistotną statystycznie premię, a czynnik wartości nieistotną statystycznie odwrotną premię.

Słowa kluczowe: efektywność, fundusze inwestycyjne, modele wieloczynnikowe, czynniki ryzyka