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Size, Value, and Momentum in Polish Equity Returns: Local or International Factors?

Abstract

This paper tests the performance of the Capital Asset Pricing Model (CAPM) and the Fama-French three-factor and Carhart four-factor models on the Polish market. We use stock level data from April 2001 to January 2014 and find strong evidence for value and momentum effects, but only weak evidence for size premium. We formed portfolios double-sorted on size and book-to-market ratios, as well as on size and momentum, and we explain their returns with the above-mentioned asset pricing models. The CAPM is rejected and the three-factor and four-factor models perform well for the size and B/M sorted portfolios, but fail to explain returns on the size and momentum sorted portfolios. With the exception of the momentum factor, local Polish factors are not correlated with their European and global counterparts, suggesting market segmentation. Finally, the international value, size and momentum factors perform poorly in explaining crosssectional variation in stock returns on the Polish market.

Keywords: value effect, size effect, momentum effect, Fama-French three-factor model, Carhart four-factor model, Polish market, asset pricing, market segmentation **JEL**: G11, G12, G14, G15

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Introduction

The value, size and momentum effects are not only well documented in the international markets, but also commonly applied in portfolio management, performance evaluation, and asset pricing. Research on the value effect dates back to Basu [1975, 1977, 1983], who found that low P/E stocks perform better than high P/E stocks. The value effect is the tendency of value stocks (stocks with low prices relative to their fundamentals) to outperform growth stocks (stocks with high prices relative to their fundamentals). Formal statistical evidence of the value effect was presented by Stattman [1980] and Rosenberg et al. [1985]. They use the book-to-market ratio as a value indicator. Davis et al. [1994] confirm the value effect in U.S. stock markets. Chan et al. [1991] and Capaul et al. [1993] confirm the value effect in markets outside the United States. The value effect is also found in stock returns by Fama and French [1998, 2012], Rouwenhorst [1999], Chui et al. [2010], and Asness, Moskowitz, and Pedersen [2013]. The size effect stems from observing the low capitalization stocks outperforming the large capitalization stocks and probably was first documented by Banz [1981]. Reinganum [1981], Blume and Stambaugh [1983], and Brown et al. [1983] confirm the evidence of the size effect by using a broader sample and decile portfolios. The size effect was also detected in several international markets by a variety of researchers [Herrera, Lockwood, 1994; Heston et al., 1999; Rouwenhorst, 1999; Fama, French, 2008; Michou et al., 2010; Asness et al., 2015; Hearn, 2016; Clarke et al., 2017]. Finally, the momentum effect refers to the phenomenon that stocks that have performed well during the past year tend to outperform the market in the future. It was initially documented by Jegadeesh and Titman [1993], who focused on a short-term investment horizon ranging from 3 to 12 months. Evidence for the momentum effect in returns from stocks on the U.S. and other international markets is put forward by, among others, Asness [1994], Fama and French [1998, 2012], Jegadeesh and Titman [2001], Rouwenhorst [1999], Grinblatt and Moskowitz [2004], Chui, Wei, and Titman [2010], Hearn [2016], Asness, Moskowitz, and Pedersen [2013], and Asness, Frazzini, Israel, Moskowitz, and Pedersen [2015].

Based on the above-described evidence, Fama and French [1992, 1993a] proposed a three-factor model and Carhart [1997] introduced a four-factor one. Both models became standard and are commonly used in financial and investment applications in developed markets, for example in portfolio performance evaluations [Kosowski et al., 2006; Fama, French, 2010]. The Carhart and Fama-French models to a great extent replaced the earlier popular CAPM model [Sharpe, 1964, 1966; Lintner, 1965; Mossin, 1966]. However, both multifactor models are not yet commonly employed in Poland.

There are two main reasons for this. The first is the lack of necessary data. There is a growing body of financial literature on integrated international asset pricing³, which generally indicates that using only local pricing factors is applicable in asset pricing, contrary to regional or global asset pricing factors [Griffin, 2002; Hou et al., 2011; Fama,

French, 2012; Cakici et al., 2013]. Unfortunately, the high quality and comprehensive data on the Fama-French and Carhart factors for the Polish market are not easily accessible. The second is the lack of developed empirical literature on cross-sectional pricing in the Polish market. There is limited research on asset pricing anomalies, which generally confirms value [Borys, Zemcik, 2009; Lischewski, Voronkova, 2012; Zaremba, Konieczka, 2014, 2015a, 2015b], size [Borys, Zemcik, 2009; Welc, 2012; Lischewski, Voronkova, 2012; Sekuła, 2013; Zaremba, Konieczka, 2014, 2015a, 2015b], and momentum effects [Szyszka, 2006; Żebrowska-Suchodolska, Witkowska, 2008; Zaremba, Konieczka, 2014, 2015a, 2015b]. Some literature attempts to apply the Fama-French model [Czapkiewicz, Skalna, 2010; Olbryś, 2010; Urbański, 2012; Waszczuk, 2013a, 2013b]. However, we are not aware of any study that comprehensively examines applicability of the Fama-French and Carhart models based on local and international factors on the Polish market.

The crucial purpose of this study is to at least partially fill the above-described knowledge gap. In other words, this paper aims to comprehensively explore and compare the applicability of three pricing models in the Polish market: the CAPM, the Fama-French three-factor model, and the Carhart four-factor model. It contributes to the economic literature in four ways. First, it investigates the value, size, and momentum premium in the Polish market. Second, it examines correlations between Polish and international asset pricing factors. Third, it tests the explanatory power of the three above-mentioned asset pricing models for Poland. Finally, it compares the performance of multifactor models based on local and international factors.

The principal findings can be summarized as follows. First, we find positive and significant value and momentum premium, but positive and non-significant size premium. Second, local Polish pricing factors are not correlated with their European or global counterparts, with the exception of momentum. Third, the Fama-French and Carhart models explain the B/M and size double-sorted portfolios, but fail to explain the portfolios double-sorted on momentum and size. Fourth, the multifactor models based on international factors perform poorly in the Polish market.

We use stock level data from Poland. The sample period is 2001–2014. In the asset pricing tests, we explain the returns of size and B/M and size and momentum double-sorted portfolios typical in the literature. We evaluate their performance using three well-known models.

The structure of the paper is as follows. In section 2 we discuss the examined assetpricing models and the statistical tests we employ to examine the model performance. Next, in section 3, we analyze the data and the variables. Our findings are presented in section 4, and section 5 concludes this paper.

Research Methods and Asset Pricing Models

We test the explanatory power of three distinct pricing models, which are all estimated using cross-sectional data. The first model is the classical Capital Asset Pricing Model [Sharpe, 1964, 1966; Lintner, 1965; Mossin, 1966]. The model assumes that asset returns depend only on the market portfolio and is described by the following regression equation:

$$R_{i,t} = \alpha_i + R_{f,t} + \beta_{rm,i} \cdot \left(R_{mt} - R_{f,t} \right) + \varepsilon_{i,t}, \tag{1}$$

where $R_{i,t}$, $R_{m,t}$, and $R_{f,t}$ are returns on the analyzed asset *i*, market portfolio and risk-free returns at time *t*, and α_i , and $\beta_{rm,i}$ are regression parameters. The α_i intercept measures the average abnormal return (the so called Jensen-alpha). The second model is the Fama-French three-factor model [Fama, French, 1992, 1993a]:

$$R_{i,t} = \alpha_i + R_{f,t} + \beta_{rm,i} \cdot \left(R_{m,t} - R_{f,t}\right) + \beta_{SMB} \cdot SMB_t + \beta_{HML} \cdot HML_t + \varepsilon_{i,t},$$
(2)

where $\beta_{rm,i}$, $\beta_{SMB,i}$, $\beta_{HML,i}$, and α_i are the estimated parameters of the model. $\beta_{rm,i}$ is analogical to the CAPM beta, but it is not equal to it. The $\beta_{SMB,i}$, $\beta_{HML,i}$ are exposed to SMB_i and HML_i risk factors, which denote returns from zero-cost arbitrage portfolios. SMB_i is the difference in returns on diversified portfolios of small and large caps at time *t*, whereas HML_i is, in general, the difference in returns on portfolios of diversified value (high B/V) and growth (low B/V) stocks. In other words, SMB and HML are returns on zero-cost market-neutral long/short portfolios that are formed based on size and value characteristics. The Fama-French model was tested multiple times, in particular with respect to the U.S. market [Fama, French, 1996; Daniel, Titman, 1997; Davis et al., 2000]. For the most part, the model was also tested on developed markets and the global market. At the same time, tests on emerging markets were fairly infrequent. With respect to Poland, research on the applicability of the model to the Warsaw Stock Exchange was conducted by Kowerski [2008] and Czapkiewicz and Skalna [2010].

The last model is the four-factor model, which was originally introduced by Carhart [1997]. Its corresponding regression equation is:

$$R_{i,t} = \alpha_i + R_{f,t} + \beta_{rm,i} \cdot \left(R_{m,t} - R_{f,t} \right) + \beta_{SMB,i} \cdot SMB_t + \beta_{HML,i} \cdot HML_t + \beta_{WML,i} \cdot WML_t + \varepsilon_{i,t}, \quad (3).$$

The model additionally incorporates momentum returns measured by returns on so-called winner and loser portfolios, which were used in the initial studies of this anomaly [Jegadeesh, Titman, 1993]. The WMLt denotes the difference between returns on diversified winner and loser portfolios during the previous year. The model was developed by Carhart

[1997] and was later tested by Jegadeesh [2000], Liew and Vassalou [2000], Kim and Kim [2003], L'Her, Masmoudi, and Suret [2004], Bello [2007], and Lam, Li, and So [2009].

All the regression models are estimated using OLS regression and tested in a parametric way. Following the extensive literature on the subject, we test the models by assessing the performance of various value, momentum, and size sorted portfolios, which are described in detail in the data section. We examine whether the model application to a certain portfolio leaves a statistically significant intercept unexplained. In order to find whether the intercepts in a group of portfolios are statistically different from zero, we evaluate the models' performance with the popular GRS test statistic, as suggested by Gibbons, Ross, and Shanken [1989]. The test statistic is given by:

$$GRS = \left(\frac{T}{N}\right) \cdot \left(\frac{T-N-L}{T-L-1}\right) \cdot \hat{\alpha}' \hat{\Sigma}^{-1} \hat{\alpha} \cdot \left[1 + E_T(f)' \hat{\Omega}^{-1} E_T(f)\right]^{-1} \sim F_{N,T-N-K},$$
(4)

where *T* is the length of the time-series (sample size), *N* is the number of portfolios to be explained in the examined group, and *L* denotes the number of explanatory factors. $E_T(f)$ is a vector of expected returns to asset pricing factors (estimated as a simple average during the investigated period; see Cochrane [2005, p. 231]), $\hat{\Omega}$ is a covariance matrix of the asset pricing factors, $\hat{\alpha}$ is a vector of regression intercepts, and $\hat{\Sigma}$ is a residual covariance matrix in the sample. The test's critical values are obtained from Fisher's distribution with *N* and *T*-*N*-*L* degrees of freedom.

Data Sources and Preparation

Bloomberg was the primary data source and stock level data on all the companies in the Polish market available in Bloomberg were used. Both listed and delisted companies were analyzed so as to avoid survivorship bias. The primary sample period comprised April 2001 to January 2014. To include a company into the sample in a given time, all necessary characteristics to compute a pricing factor had to be obtained (for example: size and B/M for the HML factor). The number of companies in the sample grew from 119 to 827 and the average number was 308. Earlier data were not used due to the fact that pool of small companies did not allow reasonable portfolios to be formed. Moreover, in some cases, we had to curtail the data period from November 2011 to January 2014, as there were too few companies available in earlier months to form the necessary number of portfolios. These cases are precisely indicated in the results description⁴.

According to the models presented in equations (1), (2), and (3), we used four distinct pricing factors: R_m - R_ρ HML, SMB, and WML. Whenever we refer to the European or

global pricing factors, data from Kenneth French's website were used; however, factors from the Polish market are computed for the purpose of this paper. The R_m - R_f is the difference between the return on the WIG Index (the broadest Polish equity market total return index, which encompasses almost the entire Polish market) and the 1-month Warsaw Interbank Bid Rate (WIBID). Furthermore, all the excess returns in the study are calculated during the 1-month WIBID rate.

In order to calculate the remaining factors (HML, SMB, and WML), we sorted all the stocks each month according to three distinct characteristics:

- B/M ratio: the book value of equity to market value of equity,
- size: the total stock market capitalization of the equity, and
- momentum: the cumulative stock return from time t-12 to t-2⁵.

The computational methodology of the traits described above is consistent with the methodology in similar asset pricing studies [Fama, French, 2012; Cakici et al., 2013; De Groot et al., 2012].

First, for presentational purposes, returns were calculated on B/M, size, and momentum sorted quantile portfolios. Stocks were divided into five independent quantiles based on B/M, size, and momentum. For each month, we calculated the 20, 40, 60, and 80 percentiles for B/M, size, and momentum breakpoints. Based on these breakpoints, five distinct quantile portfolios were created in the case of each characteristic. The value-weighting scheme⁶ was used.

Next, the precise returns on HML, SMB, and WML factors were calculated. Again, the computational methodology is consistent with most of the popular asset pricing studies. Initially, the stocks were divided into two size portfolios based on their stock capitalization. We define the size breakpoint as the median size of all the stocks in the Polish market in a given month. The stocks above the median were classified as the large stocks, and the remaining ones as the small stocks. In other words, the number of stocks in both portfolios is usually equal. It is important to note that in the Polish market there is a considerable and increasing number of very-low capitalization stocks, so the above-described large-cap portfolio constituted almost 97% of the stock market capitalization in the beginning of the study and more than 99% in the end. Again, for all stocks, we determined the standard top 30% (value), middle 40% (neutral), and bottom 30% (value) breakpoints. In other words, stocks with the highest B/M ratios are regarded as value stocks and stocks with the lowest B/M ratios as growth stocks. The computed B/M breakpoints were applied to the big and small stocks, so six groups of stocks that emerged from the double-sorts on size and B/M were developed. Next, based on the described division, we formed six valueweighted portfolios, which were denoted by BV, BN, BG, SV, SN, and SG, where B and S refer to big or small, and V, N and G refer to value, neutral, and growth. The HML return in month t was estimated as the difference between the equal weighted average returns of small and large value stocks (R_{SU2}, R_{RV}) and the equal weighted average returns of small and big growth stocks (R_{SG} , R_{BG}):

$$HML_{t} = \frac{1}{2} \Big(R_{SV,t} + R_{BV,t} \Big) - \frac{1}{2} \Big(R_{SG,t} + R_{BG,t} \Big).$$
(5)

Additionally, we computed HML factors specific for small stocks (HML_s) and big stocks (HML_g) , which are basically computed within the small and big subgroups:

$$HML_{S,t} = R_{SV,t} - R_{SG,t},\tag{6}$$

$$HML_{B,t} = R_{BV,t} - R_{BG,t}.$$
(7)

The next factor, *SMB*, is the difference between the equal weighted average return of the three small-cap portfolios and the equal weighted average return of the three large-cap portfolios:

$$SMB_{t} = \frac{1}{3} \Big(R_{SV,t} + R_{SN,t} + R_{SG,t} \Big) - \frac{1}{3} \Big(R_{BV,t} + R_{BN,t} + R_{BG,t} \Big).$$
(8)

The calculation of the *WML* factor is almost identical to the *HML* factor, but instead of B/M ratio momentum was used. We determined the standard top 30% (winners), middle 40% (neutral), and bottom 30% (losers) breakpoints. The momentum breakpoints were applied to the big and small stocks, so we created six groups of stocks that emerge from double-sorts on size and momentum. Next, we built six value-weighted portfolios, which are denoted by BW, BN, BL, SW, SN, and SL, where B and S refer to big or small, and W, N, and L refer to winners, neutral, and losers. The *WML* return in month *t* was computed as the difference between the equal weighted average returns of small and large winner stocks (R_{SW} , R_{BW}) and the equal weighted average returns of small and big loser stocks (R_{SL} , R_{BL}):

$$WML_{t} = \frac{1}{2} \Big(R_{SW,t} + R_{BW,t} \Big) - \frac{1}{2} \Big(R_{SL,t} + R_{BL,t} \Big).$$
(9)

Furthermore, we computed the WML factors specific for small stocks (WML_s) and big stocks (WML_s) , which were basically computed within the small and big subgroups:

$$WML_{S,t} = R_{SW,t} - R_{SL,t},\tag{10}$$

$$WML_{B,t} = R_{BW,t} - R_{WL,t}.$$
(11)

The models described in equations (1), (2), and (3) were tested against two distinct groups of portfolios: 25 sorts on B/M and size and 25 sorts on momentum and size. Formation of those 5×5 size-momentum and size-B/M portfolios is analogical to the formation of 2×3 size-momentum and size-B/M portfolios necessary to obtain the asset pricing factors. Beginning with the B/M and size portfolio, we initially sorted all stocks on

the book-to-market ratio to find the 20, 40, 60, and 80 percentile B/M breakpoints. Next, the procedure was repeated for the size factor, so that companies were sorted according to their stock market capitalization and 20, 40, 60, and 80 percentile size breakpoints were found. Finally, intersecting the two independent sorts on the B/M and size, all stocks were placed into one of the value-weighted B/M-size portfolios. Formation of the 25 momentum-size portfolios was identical, however, with one obvious exception: the momentum ratio (cumulative return in months t-12 to t-2) was used, instead of the B/M one.

Results and Interpretation

This section, summarizes statistics for value, size, and momentum sorted portfolios and for asset pricing factors in the Polish market. Next, it turns to the 25 portfolios formed on B/M, size and momentum. Then, it investigates the interdependencies between Polish and international pricing factors. Finally, it reports on the results of asset pricing tests, which make use of asset pricing factors such as the RHS explanatory returns and the 25 double-sorted portfolios such as the LHS assets in the regressions.

	Min	2	3	4	Max						
	Size										
Mean	1.96	0.76	0.37	0.43	0.22						
Std. Dev.	9.56	8.52	7.63	7.62	6.72						
B/M ratio											
Mean	0.14	0.08	0.54	0.27	0.95						
Std. Dev.	7.30	7.71	6.68	6.75	8.67						
		Mom	entum								
Mean	-1.21	-0.55	-0.21	0.36	1.31						
Std. Dev.	10.11	9.18	8.09	7.01	7.86						

TABLE 1. Excess returns on quantile portfolios sorted on B/M, size, and momentum

The table reports the means and standard deviations of excess log-returns on quantile portfolios formed on book equity to market equity (B/M) ratios, size (market capitalization), and momentum. For portfolios created at the end of month t, the lagged momentum return is the stock cumulative return from time *t*-12 to *t*-2. Computations were based on monthly time-series. All firms were sorted into 10 size groups and value weighted to obtain quantile portfolios. All returns were calculated using stock level data from Bloomberg. The data period is 04/30/2001-01/31/2014. S o u r c e : own study.

Table 1 reports excess returns for factor sorted portfolios. Starting with the B/M ratio, during the entire research period high B/M stocks had larger returns than the low B/M stocks. The top B/M portfolios mean excess log-return was 0.95% (value weighted), whereas

the low B/M means were 0.14%. What is interesting is that the extreme B/M portfolios seem to be slightly riskier in terms of standard deviation than the neutral B/M portfolios. Although value stocks appear to perform better than growth stocks, the exact size of this dominance seems to be highly time-variant.

The superior performance of small stocks is also evident on the Polish market. The smallest stocks' mean excess log-return was 1.96% and the same parameter for large-caps was 0.22%. Nonetheless, small-caps also seemed to be riskier with a standard deviation of 9.56%, contrary to a standard deviation of 6.72% for the biggest companies.

The momentum effect seems to be the strongest of the three examined anomalies. In the case of value weighted portfolios, the top-momentum portfolios earned a mean monthly excess log-return of 1.31%, whereas the bottom momentum portfolio on average lost 1.21%. What is quite interesting is that the better performing winners were actually less risky. For example, turning to the value weighted portfolios, the winners' excess log-returns' standard deviation was 7.86%, whereas for the losers it amounts to 10.11%.

The value effect was particularly strong among the small companies (Table 2). This observation is consistent with previous studies, which show that the value premium is strongest in the small-cap universe [Kothari et al., 1995; Loughran, 1997; Dhatt et al., 1999; Fama, French, 2006; Asness et al., 2015]. For the value weighted portfolios, the high B/M small-caps earned 1.34% excess log-returns monthly, whereas the low-B/M small-caps earned 0.24%. In the case of the large-caps, this value amounted to 0.69% and 0.03%, so the difference was much smaller. The domination of value premium across the small firms was more or less time-invariant.

		Mean		Sta	Standard deviation				
	Low	Medium	High	Low	Medium	High			
			B/M ratio						
Small	0.24	0.72	1.34	9.71	8.01	8.71			
Big	0.03	0.28	0.69	7.02	6.76	7.81			
			Momentum						
Small	0.00	0.71	1.39	9.51	7.88	9.23			
Big	-1.11	-0.33	1.05	9.43	7.7	7.26			

TABLE 2. Excess returns on portfolios from 2 × 3 sorts on B/M, momentum, and size

The table reports the means and standard deviations of excess log-returns on six portfolios formed on the book equity to market equity (B/M) ratios, momentum (total return in months t-12 to t-2), and size (market capitalization). All firms were sorted into two size groups and three momentum groups. We intersected the two sorts on size and three on value and value weight to obtain six portfolios. The computations were based on monthly time-series. All returns were calculated using stock level data from Bloomberg. The data period is 04/30/2001-01/31/2014.

Source: own study.

Surprisingly the situation is quite different in the case of momentum effect. Recent research shows that momentum effect is generally stronger for small companies [Hong et al., 2000; Fama, French, 2012]. By contrast. the obtained results show that in Poland the differences in mean excess returns was larger in the large-cap universe. For value weighted portfolios, differences between winners and losers equaled 1.39% in the small-cap universe and 2.16% in the large-cap universe. These differences were naturally time-variant; however, in both investigated periods the momentum effect was stronger among larger companies.

			Mean				Standard deviation					
	Low	2	3	4	High	Low	2	3	4	High		
					B/M rat	io						
Small	1.40	1.15	1.47	2.00	3.29	16.08	10.77	11.32	11.83	11.53		
2	0.20	0.67	1.42	1.07	1.64	11.25	10.11	9.63	9.35	11.08		
3	0.60	0.52	0.68	0.25	0.68	10.11	9.90	8.97	8.53	10.48		
4	0.74	-0.03	0.36	0.28	1.10	8.19	7.66	7.64	8.80	9.77		
Big	-0.21	0.06	0.28	0.83	0.78	6.70	6.95	7.17	6.98	9.00		
					Momenti	ит						
Small	2.57	3.00	1.86	2.07	1.77	11.47	14.39	10.79	12.54	12.75		
2	0.19	1.57	1.01	0.23	1.76	11.21	10.61	9.50	9.16	12.04		
3	-1.23	-0.89	0.28	1.49	1.95	9.85	9.64	8.41	9.71	11.56		
4	-0.98	-0.26	0.45	0.67	2.25	10.72	8.70	7.97	7.52	9.30		
Big	-1.08	-0.34	0.17	-0.26	1.44	10.83	9.82	8.28	7.85	8.75		

TABLE 3. Excess returns on portfolios from 5 × 5 sorts on B/M ratio, momentum, and size

The table reports the means and standard deviations of excess returns on 25 portfolios formed on the book value to market value ratio (B/M), momentum (cumulative return in *t*-12 to *t*-2), and size (market capitalization). All the firms were sorted into five size groups and five B/M groups. We intersected the five sorts on size and B/M and value weight in order to obtain 25 portfolios. The computations were based on monthly time-series. All the returns were calculated using stock level data from Bloomberg. The data period is 11/30/2002-01/31/2014.

Source: own study.

The results of the 5×5 double sorted B/M-size and momentum-size (Table 3) portfolios generally echo the numbers in Tables 1 and 2. Concentrating on the 25 value-weighted portfolios from 5×5 sorts on B/M and size, one can see that the high B/M small firms performed particularly well compared to the remaining portfolios and the mean excess log-returns is equal to 3.29%. On the other hand, the performance of large-cap low B/M stocks is particularly poor and the excess returns amounted to only -0.21%. Additionally, it is important to note that the distribution of the means was quite uneven. For example, although the small high B/M stocks performed better than the large high B/M stocks,

both portfolios outperformed mid-size high B/M stocks. The pattern is similar in the small-cap universe. The small-cap stocks with neutral B/M tended to have lower returns than both stocks with high and low B/M. The results for the equal weighted B/M-size portfolios generally resembled the above-described statistics.

The 25 portfolios from sorts on size and momentum confirm the confusing anomaly with large-cap momentum premium magnitude. Among the smallest companies (top row of the matrices), it is the low momentum quantile which performed better. In the universe of large companies, the situation seems to be rather in line with previous studies on the momentum, and the winner stocks performed better than the losers.

TABLE 4. Means, standard deviations, and t-statistics for asset pricing factors

	Rm-Rf	SMB	HML	WML
Mean	0.56	0.43	0.71	1.39
Std. Dev.	6.60	5.17	5.39	6.56
<i>t</i> -stat	1.05	1.03	1.66	2.64

The table describes the means and standard deviations of asset pricing factors in Poland. Rm-Rf is the return on the WIG Index minus 1-month WIBID rate. SMB is the small minus big factor, HML is the high minus low factor, and WML is the momentum factor. S and B subscripts stand for small stocks and big stocks, respectively. The computations are based on monthly time-series. All the returns were calculated using stock level data from Bloomberg. The data period is 04/30/2001–01/31/2014. The table also reports the t-statistics (t-stat).

Source: own study.

Table 4 shows means and standard deviation for factor returns on the Polish market. The R_m - R_f is equal to 0.56%, and is not economically significant and highly time-variant. Nonetheless, the lack of statistical significance may be a result of the relatively short investigation period. Turning to the *SMB* factor, it was equal to 0.43%. Its size is relatively small compared to *WML* and *HML* factors and statistically insignificant. These observations echo the study of Fama and French [2012], who also did not find evidence for the *SMB* premium in the post-1990 period.

Evidence for the *HML* factor seems to be stronger. This premium was positive and statistically significant at the 90% level. Its monthly effect was 0.71%. The *WML* factor appeared to be the strongest of all. With the test statistic of 2.64%, it was significant at the 99% level. Its monthly effect was positive in all subperiods and equal to 1.39% in the entire time-series sample.

We also tested the correlation between asset pricing factors in Poland and the international markets, which should indicate whether the use of international pricing factors in the Polish market is appropriate or not. On the other hand, they are important for investors pursuing size, value, and momentum strategies with a geographical focus.

Panel A: Pol	and vs Polan	d							
	Correlatio	on coeffic	ients			t-s	tatistic		
	$Mkt\text{-}RF_{\rm PL}$	$\mathrm{SMB}_{\mathrm{PL}}$	$\mathrm{HML}_{\mathrm{PL}}$	$\mathrm{WML}_{\mathrm{PL}}$		$Mkt\text{-}RF_{_{PL}}$	$\mathrm{SMB}_{\mathrm{PL}}$	$\mathrm{HML}_{\mathrm{PL}}$	$\mathrm{WML}_{\mathrm{PL}}$
$Mkt-RF_{PL}$	1.00	-0.02	0.15	-0.20	Mkt-RF	-	-0.19	1.92	-2.55
$\mathrm{SMB}_{\mathrm{PL}}$		1.00	-0.23	0.04	SMB_{PL}		-	-2.95	0.52
$\mathrm{HML}_{\mathrm{PL}}$			1.00	-0.43	HML_{PL}			-	-5.87
$\mathrm{WML}_{\mathrm{PL}}$				1.00	WML_{PL}				-
Panel B: Pola	and vs Europ	e							
	Correlatio	n coeffic	ients			t-s	tatistic		
	$Mkt-RF_{EU}$	$\mathrm{SMB}_{\mathrm{EU}}$	$\mathrm{HML}_{\mathrm{EU}}$	$\mathrm{WML}_{\mathrm{EU}}$		$Mkt\text{-}RF_{\rm EU}$	$\mathrm{SMB}_{\mathrm{EU}}$	$\mathrm{HML}_{\mathrm{EU}}$	$\mathrm{WML}_{\mathrm{EU}}$
Mkt-RF _{PL}	0.67	0.08	0.32	-0.42	Mkt-RFPL	11.24	1.00	4.19	-5.76
$\mathrm{SMB}_{\mathrm{PL}}$		0.20	0.05	-0.05	SMB_{PL}		2.52	0.66	-0.59
$\mathrm{HML}_{\mathrm{PL}}$			0.18	-0.28	HML_{PL}			2.24	-3.65
WML_{PL}				0.46	WML _{PL}				6.32
Panel C: Pol	and vs world								
	Correlatio	n coeffic	ients			t-s	tatistic		
	$Mkt-RF_{GL}$	$\mathrm{SMB}_{\mathrm{GL}}$	$\mathrm{HML}_{\mathrm{GL}}$	$\mathrm{WML}_{\mathrm{GL}}$		$Mkt\text{-}RF_{GL}$	$\mathrm{SMB}_{\mathrm{GL}}$	$\mathrm{HML}_{\mathrm{GL}}$	WML_GL
Mkt- _{RF}	0.71	0.16	0.16	-0.37	Mkt-RF	12.30	2.01	1.97	-4.93
SMB		0.20	0.01	-0.04	SMB		2.58	0.10	-0.51
HML			0.09	-0.31	HML			1.14	-4.02
WML				0.48	WML				6.79

TABLE 5. Correlation coefficients and t-statistics for global and local asset pricing factors

The table presents the correlation coefficient between pricing factors in the Polish, European, and global settings. MKT-RF is the return on the WIG Index minus 1-month WIBID rate. SMB is the small minus big factor, HML is the high minus low factor, and WML is the momentum factor. S and B subscripts stand for small stocks and big stocks, respectively. The computations are based on monthly time-series. All the returns were calculated using stock level data from Bloomberg. The data period is 04/30/2001–12/31/2013. The table also reports on the t-statistics (t-stat). The PL subscript refers to the Polish factors, whereas the EU and GL refer to the European and global pricing factors, respectively. The correlation coefficients of Polish asset pricing factors in vertical columns were computed against the Polish (panel A), European (panel B), and global (panel C) factors. Factors for Europe and the world were obtained from Kenneth French's website.

First, we focus on intra-country correlations between pricing factors (Table 5). The correlations were generally low and ranged from -0.23 to 0.15. However, an interesting exception is the correlation between value and momentum (*HML* and *WML*). It was negative, amounting to -0.43, and its corresponding test statistic was -5.87. This observation is consistent with the studies of Asness, Moskowitz, and Pedersen [2013], and Cakici, Fabozzi,

and Tan [2013], who find that value and momentum factors are negatively correlated, making it possible to combine them into efficient portfolios.

TABLE 6. Intercepts from value-pricing models to explain monthly excess returns on
portfolios from 5 × 5 sorts on size and B/M

Panel A: CAPM

			Intercept	t			t-statistic					
	Low	2	3	4	High	Low	2	3	4	High		
Small	2.27	0.98	1.30	1.89	3.13	1.40	1.13	1.52	1.98	3.61		
2	0.20	0.44	1.09	0.74	1.29	0.21	0.57	1.61	1.13	1.68		
3	0.43	0.27	0.29	-0.09	0.28	0.55	0.39	0.48	-0.16	0.38		
4	0.35	-0.45	-0.04	-0.05	0.60	0.65	-1.08	-0.10	-0.09	1.05		
Big	-0.60	-0.50	-0.20	0.37	0.32	-1.69	-2.11	-0.67	1.08	0.67		

Panel B: three-factor model

			Intercept	t			t-statistic					
	Low	2	3	4	High	Low	2	3	4	High		
Small	2.13	0.55	0.77	1.39	1.90	1.37	0.68	0.94	1.65	2.60		
2	-0.09	-0.14	0.36	-0.17	-0.18	-0.12	-0.22	0.63	-0.34	-0.31		
3	0.12	-0.45	-0.20	-0.81	-0.83	0.18	-0.81	-0.37	-1.62	-1.33		
4	0.09	-0.77	-0.56	-0.59	-0.11	0.18	-1.93	-1.29	-1.05	-0.21		
Big	-0.29	-0.27	-0.13	0.15	0.12	-0.87	-1.19	-0.42	0.47	0.25		

Panel C: four-factor model

			Intercept	t			t-statistic					
	Low	2	3	4	High	Low	2	3	4	High		
Small	2.41	1.00	0.62	1.41	2.41	1.46	1.20	0.71	1.59	3.16		
2	-0.17	-0.08	-0.15	-0.26	-0.56	-0.21	-0.12	-0.25	-0.48	-0.93		
3	0.02	-0.96	-0.36	-0.53	-0.46	0.02	-1.65	-0.62	-1.02	-0.71		
4	-0.18	-0.66	-0.24	-0.36	0.01	-0.33	-1.55	-0.54	-0.61	0.03		
Big	-0.42	-0.06	-0.26	-0.14	0.16	-1.19	-0.25	-0.83	-0.42	0.31		

The table describes the intercepts and t-statistics of the intercepts of 25 portfolios formed on the book value to market value ratio (B/M) and size (market capitalization). All firms were sorted into five size groups and five B/M groups. We intersected the five sorts on size and B/M and value weight to obtain 25 portfolios. The regressions used the CAPM (panel A), three-factor (panel B), and four-factor (panel C) models with Polish factors to explain excess returns on 25 double-sorted portfolios formed from independent size and B/M sorts. The calculations were based on monthly time-series. All the returns were determined using stock level data from Bloomberg. The data period is 11/30/2002–12/31/2013.

Source: own study.

Second, referring to correlations with the foreign asset pricing factors, we find that the correlation coefficients between Polish and foreign *HML* and *SMB* factors were generally very low, but positive and ranged from 0.01 to 0.20. Again, the behavior of the WML factor appears to be quite different. On the one hand, it was positively correlated at the 0.46–0.48 level with the European and global pricing factors. On the other hand, it was negatively correlated with the international R_m - R_f and *HML* factors.

Table 6 reports on intercepts and their test statistics of 25 sorts on B/M and size tested against the Polish factors-based CAPM, three-, and four-factor models. Generally, the CAPM does the poorest job in explaining abnormal returns. The model leaves unexplained intercepts for a few small-cap (the top row of the matrix) and high B/M (the right column of the matrix) portfolios. This failure to explain returns is almost entirely corrected by the three- and four-factor models. Both models leave only two portfolios with statistically significant positive intercepts: the two top B/M portfolios in the smallest companies' quantile universe. The alphas of the most extreme high B/M small-cap portfolios were 1.90% (three-factor) and 2.41% (four-factor) with corresponding t-statistics of 2.60 and 3.16.

Explaining returns of the 25 size and momentum sorted portfolios is difficult within the investigated models (Table 7). The CAPM and three-factor models are unable to explain returns of numerous small-cap-, loser-, and winner-portfolios. The matrices in panels A and B reveal many statistically significant alphas. This improves after applying the four-factor model, which included the momentum factor. Most portfolios show no notable intercept patterns. However, the model fails to explain the reversed momentum spread among small companies and significant negative returns to loser portfolios. Apart from the anomalous low-momentum mid-cap portfolio, this leaves a few portfolios with intercepts statistically different than 0 at the 95% level, which ranged to 1.82%.

Panel A of Table 8 summarizes the research on whether the Polish, European and global asset pricing factors explain returns on the B/M and size double-sorted portfolios. First, the performance of the foreign factors was rather weak. The GRS test statistics reject all the models at the 95% confidence level. The models explain only 22–30% of variation in the portfolios' excess returns and the average absolute intercept varies from 0.62 to 0.70. Turning to the local factors, the Polish CAPM model is also rejected, with the GRS statistic of 8.27. However, the model explains 46% of the variation, which is much more than its European and global counterparts. The corresponding average absolute intercept was 0.73%. When the two additional factors —*HML* and *SMB*— were applied, the performance of the model improved significantly. The average absolute intercept fell to 0.53 and the R² rose to 60%. The corresponding GRS statistics was 1.14, which means that the model is not rejected. Furthermore, inclusion of the momentum factor to the model did not introduce much improvement. The R² increased by only 0.6 percentage points and the average absolute and GRS statistic actually marginally rose. Nonetheless, the model is not rejected based on the GRS statistic.

TABLE 7. Intercepts from value-pricing models to explain monthly excess returns on
portfolios from 5 × 5 sorts on size and momentum

Panel A: CAPM

			Intercept			t-statistic					
	Low	2	3	4	High	Low	2	3	4	High	
Small	2.45	3.44	1.57	1.89	2.80	2.92	2.84	1.65	1.76	2.39	
2	-0.35	1.54	0.55	0.57	0.81	-0.52	1.85	0.84	0.86	0.84	
3	-1.67	-0.75	-0.02	1.41	1.92	-2.80	-1.15	-0.05	2.13	2.43	
4	-1.33	-0.74	0.15	1.45	2.29	-2.07	-1.38	0.30	2.09	2.89	
Big	-1.12	-0.49	-0.57	-0.34	0.93	-1.53	-0.80	-1.42	-0.84	1.89	

Panel B: three-factor model

			Intercept	t		t-statistic					
	Low	2	3	4	High	Low	2	3	4	High	
Small	1.47	2.16	0.69	1.10	1.96	2.00	2.03	0.85	1.13	1.88	
2	-1.50	0.37	-0.21	-0.21	0.22	-2.75	0.54	-0.40	-0.37	0.25	
3	-2.39	-1.65	-0.62	0.74	1.30	-4.37	-2.86	-1.39	1.27	2.27	
4	-2.27	-1.39	-0.47	1.12	1.71	-3.98	-2.83	-1.12	1.68	2.35	
Big	-1.66	-1.13	-0.58	-0.20	1.09	-2.29	-1.93	-1.42	-0.47	2.27	

Panel C: four-factor model

			-							
			Intercep	t				t-statistic	C	
	Low	2	3	4	High	Low	2	3	4	High
Small	2.07	2.09	0.41	0.62	1.27	2.72	1.86	0.48	0.61	1.17
2	-1.12	0.97	-0.56	-1.02	-1.34	-1.97	1.37	-1.01	-1.83	-1.60
3	-1.82	-1.19	-0.19	0.60	0.26	-3.26	-2.00	-0.42	0.98	0.48
4	-1.37	-0.92	-0.19	0.95	0.68	-2.48	-1.82	-0.42	1.33	0.95
Big	-0.56	-0.15	-0.54	-0.65	0.16	-0.79	-0.26	-1.23	-1.52	0.37

The table describes the intercepts and t-statistics of the intercepts of 25 portfolios formed on momentum and size (market capitalization). For portfolios created at the end of month t, the lagged momentum return is the stock cumulative return from time t-12 to t-2. All the firms were sorted into five size groups and five momentum groups. We intersected the five sorts on size and momentum and value weight to obtain 25 portfolios. The regressions used the CAPM (panel A), three-factor (panel B), and four-factor (panel C) models with Polish factors to explain the excess returns on 25 double-sorted portfolios formed from independent size and value sorts. The computations were based on monthly time-series. All the returns were calculated using stock level data from Bloomberg. The data period is 11/30/2002–12/31/2013.

Source: own study.

TABLE 8. Summary to explain monthly excess returns on portfolios from 5 × 5 sorts onsize and value and 5 × 5 sorts on size and momentum

Panel A: size and B/M

	GRS	α	R ²	s(a)		
Polish factors						
САРМ	8.27	0.73	45.89	0.88		
Three-factor	1.14	0.53	59.98	0.81		
Four-factor	1.16	0.56	60.60	0.86		
European factors						
CAPM	10.27	0.63	22.44	0.89		
Three-factor	1.65	0.62	28.36	0.89		
Four-factor	1.70	0.64	29.23	0.89		
Global factor						
CAPM	11.24	0.63	24.20	0.90		
Three-factor	1.88	0.70	29.21	0.90		
Four-factor	2.02	0.69	30.28	0.90		

Panel B: size and momentum

	GRS	α	R ²	s(a)			
Polish factors							
САРМ	24.34	1.25	42.20	1.39			
Three-factor	2.78	1.13	57.09	0.97			
Four-factor	2.08	0.87	60.48	1.05			
European factors							
САРМ	21.08	1.27	22.40	1.47			
Three-factor	2.36	1.18	28.82	1.26			
Four-factor	1.90	1.02	30.61	1.24			
Global factor							
САРМ	20.59	1.26	23.64	1.48			
Three-factor	2.60	1.19	28.88	1.32			
Four-factor	2.37	1.09	30.97	1.31			

The table shows regression results for the CAPM, three-factor, and four-factor models. The models aim to explain the excess returns of 25 portfolios formed on the book equity to market equity ratio (B/M) and size and 25 portfolios formed on momentum and size. The models' parameters were estimated based on Polish, European, and global factors. Factors for Europe and the world were obtained from Kenneth French's website. For portfolios created at the end of month t, the lagged momentum return is the stock cumulative return from time *t*-12 to *t*-2. GRS is the Gibbons, Ross, and Shanken [1989] statistic, $|\alpha|$ is the average absolute intercept, R^2 is the average R^2 , and $s(\alpha)$ is the standard deviation of the intercepts. The critical values for GRS statistics in all models are 1.45 for 90%, 1.61 for 95%, and 1.95 for 99%. Panel A presents the regression results for size and B/M portfolios and panel B refers to size and momentum portfolios. The data period is 11/30/2002–12/31/2013. S o u r c e : own study.

Finally, as it may be presumed that the 25 portfolios formed from 5×5 sorts on size and momentum seem much more difficult with cross-sectional pricing models. First, the performance of the international models is very poor. The models explained only 22–31% of cross-sectional variation and are were rejected based on the GRS statistic at the 99% confidence level. Second, the performance of the Polish models based on local factors appears better, but is still far from ideal. The CAPM model explained 42% of cross-sectional variation and the average absolute alpha was 1.25. The GRS statistic of 23.24 definitely rejects the model. The three-factor model reveals some improvement. The R² rose to 57% and the corresponding average absolute intercept fell to 1.13. Further improvement was observed after the inclusion of the momentum factor into the model. The intercept declined to 0.87 and the R² increased to 60%. However, the corresponding GRS statistics for local factors-based three-factor and four-factor models were, respectively, 2.78 and 2.08. In other words, both models are still rejected at the 99% confidence level. Summing up, although the Polish multifactor Fama-French and Carhart models are able to explain the B/M and size sorted portfolios, they fail to fully explain the impact of momentum effect.

Conclusions and Areas for Further Research

The importance of the capital market for Poland's economy has been growing for the past 20 years. Therefore, there is a need for valid tools to analyze market behavior

The Fama-French and Carhart pricing models are just two examples.

The purpose of this paper is to comprehensively examine the applicability of the above-mentioned models on the Polish markets. Achieving this aim relies on several steps, which in themselves may be important for asset management, performance evaluation, and asset pricing.

First, the paper documents the performance of cross-sectional asset pricing factors in Poland. We find particularly strong and statistically significant value and momentum premium. The size premium is also observed, however, it lacks statistical significance. Moreover, interdependencies between factors generally follow patterns observed in developed markets, with the exception of the momentum premium, which seems to be stronger among the large-caps than among the small-caps.

Second, we test the integration of the Polish stock market with international markets. With the exception of momentum, local cross-sectional factors appear to be neither correlated nor explained by European and global factors.

Third, we examine and compare performance of the CAPM, three-factor, and fourfactor pricing models in Poland in explaining returns on portfolios double-sorted on B/M and size and on momentum and size. The CAPM model generally fails to explain the value, size, and momentum effect and is rejected. Conversely, the Fama-French and Carhart models explain well the B/M and size sorted portfolios, with the exception of the most extreme high B/M small-cap portfolio. Finally, all three models fail to fully explain the returns on size and momentum sorted portfolios, although the Carhart model performs best and the CAPM performs worst.

Fourth, we compare the performance of European and global asset pricing factors in explaining cross-sectional variation in returns on the Polish market. In general, all models are rejected. In other words, employing international factors-based models for the Polish market does not seem to be a valid approach.

Further research should concentrate on three main issues. First, it should explore the sources of value, size, and momentum premiums on the Polish market. Second, it should identify the reasons underlying the anomalous behavior of some factors in Poland, which perform differently than in the developed markets (e.g., the reversed large-cap momentum spread is). Finally, whether more sophisticated pricing models, such as the five-factor pricing model [Fama, French, 2013], could also be used for the Polish stocks.

Notes

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- ³ An interesting review may be found in the paper by Karolyi and Stulz [2003].
- ⁴ Whenever we used global or the European pricing factors, the analyzed timespan ends in December 2013, as the January data were unavailable when the calculations were performed.
 - ⁵ In other words, it is a one-year return excluding the last month so as to avoid look-ahead bias.

⁶ For presentational purposes, we first aggregated cross-sectional arithmetic returns and then computed time-series' means and standard deviation of quantile portfolios using log-returns.

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