# The Fama and French Six-Factor Model – Evidence for the German Market

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## ABSTRACT

The Fama and French models have influenced the research around multi-factor asset pricing in the past decades as no other approach (Fama and French 1993; 2015; 2018). In search of patterns and bias that tend to explain stock performances, investors and financial theorists continuously investigate the three-, five-, and recent six-factor models and their individual factors in different markets.

In their well-known papers, Fama and French developed the models over various years based on data for the US market starting in July 1963. Almost simultaneously with the enhancement evolved also more research regarding the models' applicability and robustness in other markets outside the US. However, even though insights about the international evidence of the models increased, significant research on the German market is still rare.

The present work analyzes the explanatory power of the Fama and French Six-Factor Model (FF6) on average stock returns in Germany. Data is collected from Thomson Reuters Datastream and Worldscope for the time between July 1982 and June 2021 and I create factor portfolios according to the criteria defined by Fama and French.

The evaluation shows a tendency for superior performance of the Fama and French Six-Factor Model over the previous three- and five-factor models. While big stocks seem to perform better than small stocks, there is indication for value and momentum premiums in the German market. Nevertheless, the results reveal only weak evidence for the explanatory power of the Fama and French Six-Factor Model on average stock returns in Germany.



**Keywords:** Asset pricing, Fama and French, Six-Factor Model, Stock portfolios, Germany

**JEL Classification:** G11, G12, G15


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## RESUMO

Nas últimas décadas, os modelos de Fama e French têm influenciado a investigação sobre a precificação de ativos como nenhuma outra abordagem (Fama e French 1993; 2015; 2018). Na procura de padrões que tendem a explicar o desempenho de ações, investidores e teóricos financeiros investigam continuamente estes modelos de três, cinco, e seis fatores e os seus fatores individuais em diferentes mercados.

Nos seus artigos, Fama e French desenvolveram os modelos durante vários anos baseado em dados com início em julho de 1963 do mercado dos EUA. Além das melhorias, foram desenvolvidos estudos sobre a validade e robustez dos modelos em outros mercados. No entanto, mesmo com o aumento do conhecimento sobre a evidência internacional dos modelos, uma investigação substancial sobre o mercado alemão ainda não foi feita.

O presente trabalho analisa o poder explicativo do Modelo de Seis Fatores de Fama-French (FF6) no retorno médio de ações na Alemanha. Consequentemente, recolho os dados da Thomson Reuters Datastream e Worldscope para o período entre julho de 1982 e junho de 2021 e desenvolvo os portfólios de fatores respeitando os critérios definidos por Fama e French.

A avaliação mostra uma tendência de desempenho superior do FF6 relativamente aos modelos anteriores, de três e cinco fatores. Enquanto grandes ações parecem gerar melhores resultados que pequenas ações, há indícios de retornos significativos para a estratégia de valor e a de momentum no mercado alemão. Entretanto, os resultados revelam pouca evidência de que o FF6 consiga explicar os retornos médios de ações na Alemanha.

**Palavras-Chave:** Precificação de Ativos, Fama e French, Modelo de Seis Fatores, Portfólios de ações, Alemanha

**Classificação JEL:** G11, G12, G15

**Título:** O Modelo de Seis Fatores de Fama-French – Evidência do Mercado Alemão

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| | | |
|---|---|---|
| AMEX | – | American Stock Exchange |
| β | – | Asset’s beta with regards to market changes and risk |
| BE | – | Book Value of Common Equity |
| B/M | – | Book-to-Market |
| CAPM | – | Capital Asset Pricing Model |
| CDAX | – | Composite Deutscher Aktienindex |
| CMA | – | Investment premium, Conservative minus Aggressive |
| D/E | – | Debt-to-Equity |
| EURIBOR | – | European Interbank Offered Rate |
| FF3 | – | Fama and French Three-Factor Model |
| FF5 | – | Fama and French Five-Factor Model |
| FF6 | – | Fama and French Six-Factor Model |
| FIBOR | – | Frankfurt Interbank Offered Rate |
| GRS test | – | Gibbons, Ross, Shanken test |
| HML | – | Value premium, High minus Low |
| ME | – | Market Value |
| Nasdaq | – | National Association of Securities Dealers Automated Quotations |
| NYSE | – | New York Stock Exchange |
| P/E | – | Price-to-Earnings |
| RMW | – | Profitability premium, Robust minus Weak |
| SMB | – | Size premium, Small minus Big |
| US | – | United States of America |
| WML | – | Momentum premium, Winners minus Losers |

# 1. INTRODUCTION

The prediction of stock returns is a timeless and omnipresent ambition in the financial world. Every day institutional and private investors, among others, conduct numerous analyses to construct their portfolios in a way that they can maximize their return in the future. The outcomes are as diversified as the approaches, which lead from simple and standardized models until highly complex algorithms.

In the present work I will conduct an empirical research on the explanatory power of a leading multi-factor asset pricing model, the Fama and French Six-Factor Model (FF6), on average stock returns in Germany. For this purpose, I use financial market and accounting data of German stocks from Thomson Reuters Datastream and Worldscope for the time from July 1982 until June 2021. Based on the data, I create factor portfolios following the criteria defined by Fama and French (Fama and French 1993; 2015; 2018). Considering the key components of the main existing asset pricing models, including the Capital Asset Pricing Model (CAPM), Fama and French Three-Factor Model (FF3), Carhart four-factor model, Fama and French Five-Factor Model (FF5), and FF6, I calculate and present the descriptive statistics including excess returns and premiums for the market portfolio and individual factors. Further, I perform multivariate time series regressions for the factor portfolios and the regression results are then processed in a Gibbons, Ross, Shanken test (GRS test). With this procedure I follow former research (Fama and French 2015; 2017) to have a similar basis for comparison. The results show that the FF6 seems to perform slightly better than its predecessors, the FF3 and FF5, in explaining average stock returns in Germany. While there is evidence for value and momentum premiums, the size effect is negative. However, the overall explanatory power of the FF6 on average stock returns in Germany seems to be rather weak.

The research on the area of this present work, which is the study of the relationship between risk and expected returns to explain market and portfolio performances as well as to price specific assets, reaches back to the mid of the twentieth century. Based on the modern portfolio theory by Markowitz (1952), the initial point for decades of research can be seen in the Capital Asset Pricing Model developed by Sharpe (1964). In the following years, the model was enhanced by Lintner (1965), Mossin (1966) and Black (1972).

However, despite representing a vital approach for theory and practice until today, further testing of the model showed weak results for the explanatory power of the CAPM regarding average portfolio returns (Black, Jensen, and Scholes 1972). While for the time before 1969 average returns of United States (US) stocks could be explained by the systematic risk (Fama and MacBeth 1973), called market beta, subsequent research increased the skepticism on this relationship for later time periods (Reinganum 1981 [1]; Lakonishok and Shapiro 1986; Fama and French 1992). In addition, several studies provided evidence that systematic risk can come from other sources besides market beta that also predict the expected return of stock portfolios. Examples are the size (Banz 1981; Reinganum 1981 [2]), price-to-earnings (P/E) ratio (Basu 1977; Reinganum 1981 [2]), dividend yield (Litzenberger and Ramaswamy 1979), debt-to-equity (D/E) ratio (Bhandari 1988), book-to-market (B/M) ratio (Stattman 1980; Rosenberg, Reid, and Lanstein 1985; Chan, Hamao, and Lakonishok 1991), and cash flow yield (Chan, Hamao, and Lakonishok 1991).

In 1992, Fama and French (1992) presented a three-factor asset pricing approach that extends the CAPM by not only considering the excess return of the market portfolio over the risk-free rate, but also including the size of firms and book-to-market ratio into their model in order to explain average monthly stock returns. After deepening their research, they came to the conclusion that the results of their three-factor model can be used for "(a) selection portfolios, (b) evaluating portfolio performance, (c) measuring abnormal returns in event studies, and (d) estimating the cost of capital" (Fama and French 1993, p. 53). The introduction of the new model represents the starting point for a range of tests regarding its explanatory power, both for the model in general as well as for its individual factors (Harris and Marston 1994; Fama and French 1998; Daniel, Titman, and Wei 2001; Griffin 2002; Conrad, Cooper, and Kaul 2003; Ziegler et al. 2003; Chan and Lakonishok 2004; L'Her, Masmoudi, and Suret 2004; Fama and French 2007; Fama and French 2012; Asness, Moskowitz, and Pedersen 2013).

In the meantime, investigations in the former performance of stocks brought up a potential relation to their future returns, at least in short-term (Hendricks, Patel, and Zeckhauser 1993; Jegadeesh and Titman 1993). As a result, Carhart (1997) introduced a four-factor model adding a so-called momentum factor to the already existing factors of the FF3. The explanatory power of the additional factor was examined in studies for markets all around the world. The results mainly confirmed that past performance in general can be used as an indicator to predict future expected returns (Rouwenhorst 1998; Glaser and Weber 2002; L'Her, Masmoudi, and Suret 2004; Chui, Titman, and Wei 2010; Fama and French 2012;

Asness, Moskowitz, and Pedersen 2013), even though some precaution regarding the significant downside risk needs to be taken to maximize the outcome of this portfolio construction strategy (Barroso and Santa-Clara 2015; Daniel and Moskowitz 2016).

But the research for additional factors to explain expected returns of stocks and portfolios continued. The most promising relationships with returns were revealed for operating profitability (Fama and French 2006; Novy-Marx 2013; Sun, Wei, and Xie 2014; Ball et al. 2016; Wahal 2019) and investment (Titman, Wei, and Xie 2004; Fama and French 2006; Watanabe et al. 2013; Hou, Xue, and Zhang 2015). As a result, Chen, Novy-Marx, and Zhang (2011) presented an alternative three-factor approach using an investment factor and return-on-equity factor instead of the size and book-to-market ratio in addition to the market factor. Further testing of the new factors showed significant differences in their explanatory power between different company sizes and markets (Fama and French 2008), especially for the investment factor (Aharoni, Grundy, and Zeng 2013; Watanabe et al. 2013; Titman, Wei, and Xie 2013; Wahal 2019). Fama and French (2015) conducted another study to conclude that a five-factor model, consisting of the market factor, size, value, profitability, and investment serves better to explain average stock returns than their former three-factor model. Finally, following the evidence of former studies (Carhart 1997; Rouwenhorst 1998; Glaser and Weber 2002; L'Her, Masmoudi, and Suret 2004; Chui, Titman, and Wei 2010; Fama and French 2012; Asness, Moskowitz, and Pedersen 2013), the model was complemented with the inclusion of the momentum factor to make it a six-factor approach (Fama and French 2018).

The data for the research that led to the gradual discovery of the factors building the famous FF3, FF5, and FF6 was predominantly derived from the main US stock markets, namely New York Stock Exchange (NYSE), American Stock Exchange (AMEX), and National Association of Securities Dealers Automated Quotations (Nasdaq) (Fama and French 1992; 2015; 2018). This raised the question if the achieved results could also be observed outside the US in other regions and markets of the world. Fama and French themselves conducted several studies to find international evidence for their multi-factor models, focusing on large international regional aggregates such as North America, Japan, Asia Pacific, and Europe (Fama and French 1998; Fama and French 2012; Fama and French 2017). Griffin (2002) examined the explanatory power of the FF3 on a national, international, and global level. While the global approach showed weak results for the model to explain stock returns, country-specific analysis for the US, Canada, United Kingdom, and Japan brought up stronger relationships. Further applications of the model in international markets followed, including the study of L’Her, Masmoudi, and Suret (2004) for the Canadian stock market, a specific test of the momentum factor in forty-one countries by Chui, Titman, and Wei (2010), and FF5 examinations in the Australian (Chiah, Zhong, and Li 2016) and Japanese (Kubota and Takehara 2018) markets.

For the German stock market, research for the Fama and French multi-factor asset pricing models is mainly rather outdated and does therefore neither cover all factors nor complete data sets known by today. While Glaser (2002) only considers the momentum factor, a group of authors investigates for different time frames the explanatory power of the FF3 (Ziegler et al. 2003; Schrimpf and Schröder 2007; Hanauer, Kaserer, and Rapp 2011; Artmann, Finter, and Kempf 2012). Dirkx and Peter (2020) undertake an analysis of the FF6 for the German market. However, they limit their work to companies included in the Composite Deutscher Aktienindex (CDAX) and only consider the time period between 2002 and 2019, leading to no revelation of any significant results.

The present work aims at closing this gap of recent research by conducting an analysis of the Fama and French Six-Factor Model for the German market, considering available data for all stocks from 1982 until 2021. This extends the time frame for the sample by twenty-two years from seventeen years to thirty-nine years in comparison to the study by Dirkx and Peter (2020). The research purpose requires the gathering and combination of accounting and financial market data for German stocks. The goal is to get useful insights regarding the explanatory power of the model and its individual factors regarding average stock portfolio returns in the German market. Therefore, I conduct a literature review in the second part to establish an understanding of the CAPM, FF3, Carhart four-factor model, FF5, and FF6 as basis for the empirical analysis. Further, I provide an overview of the international evidences from former studies to afterwards compare them with the outcome of my research. After the data and source presentation in the third section, as well as the methodology applied and research question for the analysis, I will discuss the statistics and results in the fourth part. Finally, the fifth chapter will conclude the work with a summary of the main findings and suggestions for further potential research.

# 2. LITERATURE REVIEW

## 2.1 Capital Asset Pricing Model

Based on the modern portfolio theory by Harry Markowitz (1952), the CAPM was initially developed by William F. Sharpe in 1964 (Sharpe 1964) and further enhanced by Lintner (1965), Mossin (1966), and Black (1972). The model represented the first conclusive explanation for the relationship between the risk of an asset and its expected return (Fama and French 1992).

Modern portfolio theory is much concerned with the portfolio construction of individual investors based on their risk and return preferences. Especially the proposition that through diversification investors can minimize a significant amount of risk, but not eliminate it completely, conflicts with established research theory from the past (Markowitz 1952). Due to correlation between the assets, a certain amount of risk always remains (Markowitz 1952; Sharpe 1964). This part of the risk of an asset is related to as systematic risk (Sharpe 1964). In this context, variance of returns is seen as a measure of risk (Markowitz 1952; Lintner 1965). The expected return corresponds to this variance, leading to the assumption that "There is a rate at which the investor can gain expected return by taking on variance, or reduce variance by giving up expected return" (Markowitz 1952, p. 79). So, in order to generate a higher expected return, an investor needs to assume more risk in form of variance (Sharpe 1964).

As a result, Sharpe (1964, p.425) concludes for his CAPM that the price of an asset is composed of the "price of time", represented by the risk-free interest rate, and the "price of risk", which is the supposed adequate compensation for the risk assumed by investing in the respective asset. A key element for the consideration of the price of risk is the systematic risk of the market, as well as the individual asset's exposure to it. The stronger the effect on the individual asset by changes in the market, the higher the associated risk, the greater the expected return in addition to the risk-free interest rate (Sharpe 1964; Lintner 1965; Black, Jensen, and Scholes 1972). The return of an investment, both for an individual stock and a portfolio, is defined as "the sum of the cash dividends received plus the change in its market price" (Lintner 1965, p.15), summed up by Black, Jensen, and Scholes (1972) as:

$$R_i = \frac{P_t - P_{t-1} + D_t}{P_{t-1}} \qquad (1)$$

where

$R_i$ = Return of asset i

$P_t$ = Price of asset i at time t
$P_{t-1}$ = Price of asset i at time t-1
$D_t$ = Dividends paid at time t

and the corresponding expected return:

$$E(R_i) = \frac{E(P_t) - P_{t-1} + E(D_t)}{P_{t-1}} \qquad (2)$$

The comparison and correspondance with the systematic risk, essential for the expected return evaluation for a stock or portfolio with the CAPM, is named the asset's beta (β). The β is derived by dividing the covariance of the assets return with that of the market return by the variance of the market return (Black 1972):

$$\beta_i = \frac{\text{cov}\,(R_i, R_m)}{\text{var}\,(R_m)} \qquad (3)$$

where
$\beta_i$ = beta coefficient of asset i
$R_i$ = Return of asset i
$R_m$ = Return of market portfolio of all assets

The consolidation of all assumptions, findings, and definitions from Sharpe (1964), Lintner (1965), Mossin (1966), Black (1972), and Black, Jensen, and Scholes (1972), including the linear relationship between the beta coefficient β and an asset's expected return, finally leads to the well-established formula of the CAPM:

$$E(R_i) = Rf + \beta_i\,(Rm - Rf) \qquad (4)$$

where
$E(R_i)$ = Expected return of investment
Rf = Risk-free rate
Rm = Return of market portfolio
$\beta_i$ = Beta coefficient of investment
Rm – Rf = Market risk premium

Since in the CAPM the return of an asset is explained by one factor, the asset's relationship with the systematic risk of the market return, it is also often referred to as an one-factor asset pricing model, single-factor asset pricing model (Fama and French 1992) or single one-period capital asset pricing model (Banz 1981; Reinganum 1982 [2]).

## 2.2 Multi-Factor Asset Pricing Models

### 2.2.1 Fama and French Three-Factor Model

After the development of the CAPM, the model played a central role in empirical research and investment strategies for decades. However, results show contradictory outcomes regarding the assumption that an asset's beta and the systematic market risk can fully explain the average returns of US stocks and portfolios (Basu 1977; Banz 1981; Reinganum 1981 [1]; Lakonishok and Shapiro 1986). Instead, other factors seem to better correspond with average returns. Two fundamentals that represent most evidence to explain average stock and portfolio returns are the size of a firm (Banz 1981; Reinganum 1981 [2]) and the book-to-market (B/M) ratio (Stattman 1980; Rosenberg, Reid, and Lanstein 1985; Chan, Hamao, and Lakonishok 1991). While size is defined as the company's market value (ME), which is the number of outstanding shares times stock price (Fama and French 1992), B/M is the ratio between a company's book value of common equity (BE) and its ME (Fama and French 1992).

Banz (1981), Reinganum (1981 [2]), and Lakonishok and Shapiro (1986) discover that stocks with a lower ME generate higher average returns than stocks with a higher ME. This "size effect" (Banz 1981, p.4) is especially significant for firms with a very low ME. Contrarily, the disparity diminishes for medium-sized and big companies for US stocks over a long time period of forty years (Banz 1981), a shorter time period of twenty years (Lakonishok and Shapiro 1986), and a very short analysis focus of two years (Reinganum 1981 [2]). Besides the size effect, companies with a higher ratio of BE to ME also show significantly higher average returns than companies with a lower ratio, not only for US stocks (Stattman 1980; Rosenberg, Reid, and Lanstein 1985), but also for the Japanese market (Chan, Hamao, and Lakonishok 1991).

Pursuing the detection of potential relationships of size and the book-to-market ratio with average returns, Fama and French (1992) conduct further research on these factors as well as the CAPM and its market $\beta$. Their empirical analysis, consisting of stocks for the NYSE, AMEX, and Nasdaq for the time between 1963 and 1990, confirms the results previously identified by other authors. Their outcome, if proven to be consistent, would have "practical implications for portfolio formation and performance evaluation by investors whose primary concern is long-term average returns" (Fama and French 1992, p.452). By applying their findings to different scenarios and deepening their analysis with time-series regressions introduced by Black, Jensen, and Scholes (1972), they present the Fama and French Three-Factor Model. Based on the CAPM, the model includes an additional factor for the size premium considering the excess return of small stocks over big stocks (SMB), as well as a value premium which covers the higher average returns by companies with a high B/M ratio against those with a lower ratio (HML) (Fama and French 1993):

$$R_i - Rf = a_i + \beta_i (Rm - Rf) + s_i\, SMB + h_i\, HML + \varepsilon_i \quad (5)$$

where

$R_i$ = Return of the asset i

Rf = Risk-free rate

$R_i$ - Rf = Expected excess return of the asset i

Rm = Return of the market portfolio

Rm – Rf = Market risk premium

SMB = Size premium, Small minus Big

HML = Value premium, High minus Low

$\alpha_i$ = Intercept, Return that cannot be explained by factors

$\beta_i$, $s_i$, $h_i$ = Factor coefficients of investment i

Since the model consists of various factors in order to explain average returns of stocks and portfolios, the FF3 is considered a key element for the area of "multifactor asset-pricing models" (Fama and French 1993, p.55). But besides the evidence for the size and value premia, Fama and Frech (1993) suggest further research, especially regarding the relationship between profitability and average returns, in order to check for other factors that might possess explanatory power for the performance of assets.

### 2.2.2 Carhart Four-Factor Model

In addition to the factors which finally lead to the FF3, one specific phenomenon also receives considerable attention: the evidence of past performance of stocks to explain their future returns. The idea behind it is to analyze the price evolution of past periods and then make decisions for the portfolio construction based on it in order to generate excess returns (De Bondt and Thaler 1985).

However, empirical results show that this strategy leads to different outcomes depending on the investment holding period considered. De Bondt and Thaler (1985) find in their study for US stocks between 1931 and 1982 that those stocks that have performed poor in the past, also referred to as losers, realize considerably higher average returns over a period of three as well as five years than their counterparts that had a better performance in former periods, the so-called winners. In contrast, Jegadeesh and Titman (1993) find in their analysis of shorter time frames that winners outperform losers for the following three, six, and twelve months between 1965 and 1989. But still, showing convergence with the findings of De Bondt and Thaler (1985), these returns diminish by about fifty percent during the course of the following twenty-four months (Jegadeesh and Titman 1993). Further investigations into the same matter present accordance with these results, suggesting an investment strategy that reassembles the portfolio every quarter based on the rolling evaluation of performance for the last twelve months (Hendricks, Patel, and Zeckhauser 1993).

Based on these insights from former research regarding a potential effect of momentum, and the established FF3, Carhart (1997) conducts a detailed exploration in order to form a new model that combines the factors of both approaches. His approach brings together the market excess return and the portfolio construction strategies "high versus low beta stocks, large versus small market capitalization stocks, value versus growth stocks, and one-year return momentum versus contrarian stocks" (Carhart 1997, p.61). With this procedure, Carhart (1997) defines the following formula to test the explanatory power for average returns of his four-factor model:

$$R_i = a_i + \beta_i (Rm - Rf) + s_i \, SMB + h_i \, HML + w_i \, WML + \varepsilon_i \quad (6)$$

where

$R_i$ = Return of the asset i

Rf = Risk-free rate

Rm = Return of the market portfolio

Rm – Rf = Market risk premium

SMB = Size premium, Small minus Big

HML = Value premium, High minus Low

WML = Momentum premium, Winners minus Losers

$\alpha_i$ = Intercept, Return that cannot be explained by factors

$\beta_i$, $s_i$, $h_i$, $w_i$ = Factor coefficients of investment i

The analysis of empirical data, consisting of mutual funds for the time between 1963 and 1993, confirms the short-term superiority for 12 months of stocks that performed well in the past over those with poor performance for the same period found by Jegadeesh and

Titman (1993) and Hendricks, Patel, and Zeckhauser (1993). Especially the size and momentum factors show significant explanatory power regarding average returns (Carhart 1997). The conclusion for portfolio selection strategies is to steer clear of assets with a consistent history of weak performance and to focus for the portfolio construction of the upcoming year on stocks that have performed well in the last twelve months. However, following this strategy, it is essential to restructure the portfolio after the completion of twelve months in order to avoid losing the generated excess returns through the opposite effect for longer periods discovered by De Bondt and Thaler (1985) and Jegadeesh and Titman (1993).

### 2.2.3 Fama and French Five-Factor Model

Among the many fundamentals that are explored and empirically tested for explanatory power since the introduction of the FF3 by Fama and French (1992), two specific factors show remarkable evidence: investment and profitability (Fama and French 2006).

Titman, Wei, and Xie (2004) discover that firms that undertook higher investments in the past, generate lower average returns than companies that were more prudent in this context. The investment is evaluated in form of annual asset growth, which is defined by Cooper, Gulen, and Schill (2008, p.1613) as the "year-on-year percentage change in total assets":

$$\text{ASSETG (t)} = \frac{\text{Total assets (t}-1) - \text{Total assets (t}-2)}{\text{Total assets (t}-2)} \quad (7)$$

So basically, the change in total assets from two years to one year before the period in consideration. This negative relationship between higher investments in prior periods and average returns of future periods is confirmed by several future studies for different periods (Fama and French 2006; Cooper, Gulen, and Schill 2008; Aharoni, Grundy, and Zeng 2013) as well as for other markets than the US (Titman, Wei, and Xie 2013; Watanabe et al. 2013). Besides the potentially positive message that higher investments might have for investors, like the fact that the returns are high and stable enough to sustain this growth of the company, or the fact that market faith in the company is sufficient to receive the necessary financing for investments (Titman, Wei, and Xie 2004), the anomaly seems to appear especially for stocks of smaller size (Fama and French 2008) and in less developed capital markets (Titman, Wei, and Xie 2013; Watanabe et al. 2013).

Concurrent with the rising indications for an additional investment factor to complement existing asset pricing models, empirical analysis shows a potential positive relationship between the operating profitability of a company and its future average returns (Haugen and Baker 1996). Fama and French (2006) explain this connection by using the dividend discount model, where the present value of expected future dividends is used for the determination of a company's ME. Firms with higher profitability, in terms of earnings divided by BE, tend to pay higher dividends and therefor show higher expected returns. In comparison to the size premium, the profitability factor seems to show much stronger evidence as a potential explanation for average returns over various time frames (Fama and French 2006). Novy-Marx (2013, p.1) defines profitability as the "ratio of a firm's gross profits (revenue minus cost of goods sold) to its assets" instead of BE for his study. However, he reaches the same conclusion as prior studies leading to further evidence for a profitability-return relationship (Novy-Marx 2013). Sun, Wei, and Xie (2014) confirm these results in an empirical research across forty-one countries, but as for the investment factor, they show that also operating profitability seems to predict significantly better average returns in more developed markets.

The evidence for potential new factors led Hou, Xue, and Zhang (2015) to undertake an attempt to combine the factors from existing asset pricing models, market factor and size factor, with those investment and profitability factors studied by authors in previous years. This results in a four-factor approach considering

> "the market excess return (…), the difference between the return on a portfolio of small size stocks and the return on a portfolio of big size stocks (…), the difference between the return on a portfolio of low investment stocks and the return on a portfolio of high investment stocks (…), and the difference between the return on a portfolio of high profitability (…) stocks and the return on a portfolio of low profitability stocks" (Hou, Xue, and Zhang 2015, p.651).

Based on their established FF3, Fama and French (2015) add the well-studied profitability and investment factors and present the Fama and French Five-Factor Model:

$$R_i - Rf = a_i + \beta_i (Rm - Rf) + s_i \, SMB + h_i \, HML + r_i \, RMW + c_i \, CMA + \varepsilon_i \quad (8)$$

where

$R_i$ = Return of the asset i

Rf = Risk-free rate

Rm = Return of the market portfolio

Rm – Rf = Market risk premium

SMB = Size premium, Small minus Big

HML = Value premium, High minus Low

RMW = Profitability premium, Robust minus Weak

CMA = Investment premium, Conservative minus Aggressive

$\alpha_i$ = Intercept, Return that cannot be explained by factors

$\beta_i$, $s_i$, $h_i$, $r_i$, $c_i$ = Factor coefficients of investment i

In this context, robust companies indicate those with higher operating profitability, while weak are counterparts with low operating profitability. Correspondent, those companies with low asset growth in past periods are referred as conservative, while those with high investments were called aggressive (Fama and French 2015).

### 2.2.4 Fama and French Six-Factor Model

Finally, Fama and French (2018) complete their FF5 with the momentum factor, introduced by Carhart (1997), turning their model into the Fama and French Six-Factor Model:

$$R_i - Rf = a_i + \beta_i (Rm - Rf) + s_i\,SMB + h_i\,HML + r_i\,RMW + c_i\,CMA + w_i\,WML + \varepsilon_i \quad (9)$$

where

$R_i$ = Return of the asset i

Rf = Risk-free rate

Rm = Return of the market portfolio

Rm – Rf = Market risk premium

SMB = Size premium, Small minus Big

HML = Value premium, High minus Low

RMW = Profitability premium, Robust minus Weak

CMA = Investment premium, Conservative minus Aggressive

WML = Momentum premium, Winner minus Loser

$\alpha_i$ = Intercept, Return that cannot be explained by factors

$\beta_i$, $s_i$, $h_i$, $r_i$, $c_i$, $w_i$ = Factor coefficients of investment i

Even though there exist many more factors with the same purpose (Harvey, Liu, and Zhu 2015), the FF6 represents today a benchmark for multi-factor asset pricing models and is continuously explored. An overview of international research, with focus on the German market, as well as a summary of their key findings is given in the next chapter. This provides the basis for the formulation of the research question.

## 2.3 International Evidence

The development of asset pricing models, either the single-factor model CAPM or multi-factor models like the FF3, Carhart four-factor, FF5, and FF6 mainly focused on the US market (Fama and French 1992; Carhart 1997; Fama and French 2015). In addition to that, there exist innumerable further studies to test these asset pricing models, or its individual factors, for the same market but different periods or other markets outside the US. A detailed list, complementary to the following overview, is provided in the Appendix I.

An early example for research of US stocks is Banz's (1981) discovery of the size effect during a study time frame between 1926 and 1975, which is an important pillar for the later introduced FF3. These findings are confirmed by empirical results achieved for a later period, 1972 until 2012, of US data from Hou, Xue, and Zhang (2015). Besides the size premium, also the evidence for a value premium (Harris and Marston 1994; Fama and French 1998; Conrad, Cooper, and Kaul 2003; Chan and Lakonishok 2004; Fama and French 2007; Fama and French 2012; Asness, Moskowitz, and Pedersen 2013) and positive return relationship of profitability (Fama and French 2006; Chen, Novy-Marx, and Zhang 2011; Novy-Marx 2013; Hou, Xue, and Zhang 2015; Ball et al. 2016; Wahal 2017) are proven as significant for different time frames of the US market. While the results of consecutive studies for the momentum effect also show overall consenting results of a significant evidence for US stocks (De Bondt and Thaler 1985; Chui, Titman, and Wei 2010; Fama and French 2012; Asness, Moskowitz, and Pedersen 2013), contradictory results are achieved for the investment factor. While many researchers find equal indications of a significant and negative relationship between investment and average returns (Titman, Wei, and Xie 2004; Cooper, Gulen, and Schill 2008; Chen, Novy-Marx, and Zhang 2011; Hou, Xue, and Zhang 2015) as discovered in the FF5, some results show an opposite (Aharoni, Grundy, and Zeng 2013) or no significant relation (Wahal 2017).

Besides the extensive number of studies for the US market, empirical analysis also focuses on other markets and cross-country tests of the FF3 and Carhart four-factor model since the end of the twentieth century. Even before the introduction of the FF3, Chan, Hamao, and Lakonishok (1991) discover a very strong value premium for the Japanese market during the time between 1971 and 1988, which is affirmed by various further results for longer (Daniel, Titman, and Wei 2001) and later time periods (Fama and French 1998; Chan and Lakonishok 2004; Fama and French 2012; Asness, Moskowitz, and Pedersen 2013; Fama and French 2017). Also the size premium (Schmidt et al. 2019) and momentum effect (Chui, Titman, and Wei 2010; Fama and French 2012; Asness, Moskowitz, and Pedersen 2013; Barroso and Santa-Clara 2015) seem to be significant and consistent with the evidences found in the addressed multi-factor asset pricing models. In contrast, profitability and investment show no significant explanatory power for average returns in the Japanese market between 1978 and 2014 (Kubota and Takehara 2018). Further non-European markets frequently examined are Canada (Griffin 2002; L'Her, Masmoudi, and Suret 2004; Fama and French 2017) and Australia (Fama and French 1998; Chan and Lakonishok 2004; Fama and French 2012; Chia et al. 2016; Fama and French 2017), all for which the value premium stands out in evidence over the other factors.

A lot of research for international evidence of multi-factor asset pricing models and their individual components also targets the European market, either as a whole, or with special consideration of major markets. Results of empirical data analysis result in the assumption for the existence of significant size (Schmidt et el. 2019) and value premiums (Fama and French 1998; Chan and Lakonishok 2004; Fama and French 2012; Asness, Moskowitz, and Pedersen 2013; Fama and French 2017), a significant and positive profitability relation on returns (Sun, Wei, and Xie 2014; Fama and French 2017), evidence for the short-term momentum effect (Rouwenhorst 1998; Chui, Titman, and Wei 2010; Fama and French 2012; Asness, Moskowitz, and Pedersen 2013), and the known negative relationship between the asset growth rate and average returns (Titman, Wei, and Xie 2013; Watanabe et al. 2013; Fama and French 2017).

Studies for evidence of the models and their factors on one of the most important European markets, Germany, are mainly conducted through cross-country analysis covering a wide range of North America, Europe, and Asia-Pacific. However, some research focuses especially on the German market following a suggestion expressed by Griffin (2002) to analyze country-level markets for indications regarding the Fama and French and Carhart models. The reason is that this domestic focus seems to provide stronger explanatory power than international considerations. Glaser and Weber (2002) find that momentum strategies also outperform their benchmarks in Germany for the time between 1988 and 2001. Their results are strengthened by further research results from Hanauer, Kaserer, and Rapp (2011) in a study between 1996 and 2011, as well as Artmann, Finter, and Kempf (2012) for the period from 1963 to 2006. Ziegler et al. (2003) show that both factors included in the FF3, size and value, have explanatory power for the average returns generated in the German market between 1967 and 1995. In conflict to this, Schrimpf, Schröder, and Stehle (2007) state that existing multi-factor asset pricing models, including the FF3 and Carhart model, are "subject to model instability" (Schrimpf, Schröder, and Stehle 2007, p.881), expressing concerns about their explanatory power for German stock returns. Dirkx and Peter (2020) undertake an attempt to find evidence for the FF6 in their work for stocks traded on the Frankfurt Stock Exchange between 2002 and 2019. However, besides the finding that momentum is superior over the other factors, they cannot find any statistically significant relationships between the factors and average returns during that time period.

The fact that there does not exist any recent and long-term empirical analysis to counter-check the evidence for explanatory power of the FF6 for the German market, represents a gap in research within that field. The present work aims at filling this gap to make sure that investors can consider the application of the strategies linked to the model and to provide the basis for further research on the topic for Germany. The next chapter will therefore explain the methodology, present the research question, and give an overview of the data set gathered in order to achieve significant results for the respective answer.

# 3. DATA & METHODOLOGY

In the second chapter, a summary of the substantial research across different countries and time periods on the Fama and French models was presented. However, even though the multi-factor asset pricing models and their components represent a central constituent of investment theory and practice, recent and long-term studies for the German market are rare. Not only being of interest for researchers, also investors in the German stock market might seek evidence for a potential explanatory power of the model or its individual factors for their portfolio construction. In order to provide response and significant results in regard to the German market, the present work will investigate on the following research question:

Can the Fama and French Six-Factor Model explain average stock returns in the German market for the time period between 1982 and 2021?

I conduct an empirical research for German stocks covering the time between July 1982 and June 2021, what accounts for 468 months to calculate the average portfolio returns. In comparison to the latest comprehensive study by Dirkx and Peter (2020), the sample for my analysis will cover twenty-two more years of data. I collect the data from the Thomson Reuters Datastream and Worldscope databases and only stocks which trade on the major German stock exchange, the Frankfurt Stock Exchange, are considered. Further, in accordance to common research procedure, I exclude financial companies from the data set as well as companies with negative book equity (Fama and French 2015). Also the analysis considers only company stocks for which the relevant accounting and performance data is available for the observed time period. This leads to an average number of 428 stocks included in the research, with the most stocks of 650 available in 2007 and the lowest number in the first years of the research period. A summary of the development (Appendix II) is shown in Table 1.

| | **Total** | **SMB** | **HML** | **RMW** | **CMA** | **WML** |
|---|---|---|---|---|---|---|
| **1982** | 101 | 101 | 60 | 60 | 60 | 101 |
| **1987** | 151 | 136 | 89 | 89 | 87 | 126 |
| **1992** | 311 | 300 | 234 | 230 | 226 | 289 |
| **1997** | 356 | 348 | 325 | 323 | 304 | 333 |
| **2002** | 615 | 497 | 472 | 465 | 472 | 497 |
| **2007** | 650 | 536 | 497 | 486 | 498 | 468 |
| **2012** | 565 | 494 | 454 | 450 | 457 | 462 |
| **2017** | 485 | 437 | 398 | 390 | 409 | 395 |
| **2020** | 542 | 539 | 400 | 399 | 440 | 416 |
| **Ø** | **428** | **375** | **330** | **325** | **331** | **343** |

Table 1: Summary of stocks per year in analysis

My analysis follows former research and considers return of a stock as its price performance and dividends paid (Black, Jensen, and Scholes 1972; Lintner 1965).

Following Fama and French (2015), the portfolio construction is based on independent sorting conducted every year by end of June for the factors described in the second chapter, including size, value, profitability, investment, and momentum. Considering the subsequently listed market, accounting, and performance data of previous periods, the stocks are classified relative to others according to:

Size (SMB): Market capitalization = Market Price x Total number of shares outstanding

Value (HML): Book-to-Market ratio = $\frac{\text{Book Value (t−1)}}{\text{Market Value (t−1)}}$

Profitability (RMW): Operating Profitability = $\frac{\text{Operating Profit (t−1)− Interest Expense(t−1)}}{\text{Book Value (t−1)}}$

Investment (CMA): Annual Asset Growth = $\frac{\text{Total assets (t−1) − Total assets (t−2)}}{\text{Total assets (t−2)}}$

Momentum (WML): Monthly returns for t-12 until t-2

The Thomson Reuters Datastream and Worldscope codes I used for portfolio construction and performance measurement can be found in Appendix III.

Fama and French (2015) create in their analysis of the FF5 for each risk premium factor twenty-five US stock portfolios based on the variables described above. However, due to the fact that the number of available companies for the German market is significantly lower, I will create for my study six portfolios based on independent two times three sorts for each individual factor. Therefore, I will split the available stocks into a big and small portfolio with the median of the market capitalization of the respective year representing the breakpoint. This sorting and grouping by size is done for all risk factors included in the analysis. Further, the breakpoints for the other factors (value, profitability, investment, momentum) are the thirtieth and seventieth percentile of the stocks from the overall portfolio in analysis, which fulfill the requirements for inclusion. Like that, for each year and factor I get two size groups (Big and Small) as well as three groups based on the individual variable (see Table 2).

| **Factor** | **Groups** |
|---|---|
| Size | Big, Small |
| Value | High, Neutral, Low |
| Profitability | Robust, Neutral, Weak |
| Investment | Conservative, Neutral, Aggressive |

| Factor | Groups |
|---|---|
| Momentum | Winner, Neutral, Loser |

Table 2: Factor groups

In accordance with Fama and French (2015), the intersection of the two size groups and three groups formed for the other variables create six portfolios in total for each individual factor. These portfolios are then used to calculate the premiums SMB, HML, RMW, CMA, and WML included in the FF6 for the German market. An overview of the portfolios created and the computations to determine the differences in the average monthly returns between the individual factor portfolios can be found in Table 3.

| Factor | Portfolios | | Calculation |
|---|---|---|---|
| Size | Small (size) / High (value):<br>Small / Neutral:<br>Small / Low:<br>Big / High:<br>Big / Neutral:<br>Big / Low: | SH<br>SN<br>SL<br>BH<br>BN<br>BL | SMB = (SH+SN+SL)/3 – (BH+BN+BL)/3 |
| Value | Small (size) / High (value):<br>Small / Neutral:<br>Small / Low:<br>Big / High:<br>Big / Neutral:<br>Big / Low: | SH<br>SN<br>SL<br>BH<br>BN<br>BL | HML = (SH+BH)/2 – (SL+BL)/2 |
| Profitability | Small (size) / Robust (profitability):<br>Small / Neutral:<br>Small / Weak:<br>Big / Robust:<br>Big / Neutral:<br>Big / Weak: | SR<br>SN<br>SW<br>BR<br>BN<br>BW | RMW = (SR+BR)/2 – (SW+BW)/2 |
| Investment | Small (size) / Conservative (investment):<br>Small / Neutral:<br>Small / Aggressive:<br>Big / Conservative:<br>Big / Neutral:<br>Big / Aggressive: | SC<br>SN<br>SA<br>BC<br>BN<br>BA | CMA = (SC+BC)/2 – (SA+BA)/2 |
| Momentum | Small (size) / Winner (performance):<br>Small / Neutral:<br>Small / Loser:<br>Big / Winner:<br>Big / Neutral:<br>Big / Loser: | SW<br>SN<br>SL<br>BW<br>BN<br>BL | WML = (SW+BW)/2 – (SL+BL)/2 |

Table 3: Factor portfolios and calculation

In order to calculate the market risk premium, I first determine the value-weighted average monthly returns of the overall portfolio, including all German stocks from Frankfurt Stock Exchange which fulfill the requirements mentioned above. This is how I define the average return of the market portfolio (Rm). For the determination of the risk-free rate (Rf), I consider two different indicators in order to respect the currency change from Deutsche Mark to Euro realized during the research period. Therefore, for the time between July 1982 and December 1998, I use the one month Frankfurt Interbank Offered Rate (FIBOR) and from January 1999 to June 2021, I take the one month European Interbank Offered Rate (EURIBOR) as risk-free rate. Finally, I subtract the monthly returns of the risk-free rate from the monthly returns of the overall stock portfolio in analysis in order to get the market risk premium (Rm-Rf).

Once all returns and premiums for the overall portfolio, risk-free rate, and individual factors are derived, the analysis of this work follows Fama and French (1993; 2015; 2018) to evaluate the evidence of the FF6 for the German market by conducting multivariate time series regressions. Finally, the model and its regression results for the intercepts $\alpha$ are subject to Gibbons, Ross, Shanken tests (GRS test). This is in accordance to the procedure of former research (Fama and French 2015, 2017) in order to come to a final conclusion regarding the explanatory power (Gibbons, Ross, and Shanken 1989).

I will present the detailed results in the next chapter, starting with the descriptive statistics of the research before providing insights, discussion, and interpretation for the results from the regressions and GRS test.

## 4. RESULTS

As basis for the presentation and analysis of the results, I first determine the correlation of the market portfolio returns with the returns of the MSCI Germany All Cap Index (from 2008 until 2021), FTSE Germany All Cap Index (from 2004 until 2021), and the data presented for the German market by AQR Capital Management on their website (from 1986 until 2021) to ensure the adequacy of the data set to represent the German stock market. The correlation results of 0.96 for the MSCI Germany All Cap Index, 0.98 for FTSE Germany All Cap Index, and 0.98 for AQR Capital Management confirm that the data is an appropriate proxy for the German stock market and its returns. The descriptive statistics of the factors included in the FF6 can be found in Table 4.

| Variable | Mean | St. Deviation | t-Statistic |
|---|---|---|---|
| **Rm** | 0.96 | 5.95 | 3.49 |
| **Rf** | 0.28 | 0.23 | 25.94 |
| **RmRf** | 0.68 | 5.95 | 2.46 |
| **SMB** | - 0.11 | 1.90 | -1.23 |
| **HML** | 0.55 | 2.11 | 5.62 |
| **RMW** | 0.24 | 2.10 | 2.51 |
| **CMA** | 0.39 | 3.09 | 2.72 |
| **WML** | 0.80 | 2.93 | 5.91 |

Table 4: Descriptive statistics for the FF6 factors

We find the strongest excess returns for the momentum factor (WML) with an average of 0.80%, which also shows statistical significance for the 5% significance level. This matches the results by earlier studies for the German market (Hanauer, Kaserer, and Rapp 2011; Dirkx and Peter 2020) and the considerable evidence for the momentum effect in general (Rouwenhorst 1998; Chui, Titman, and Wei 2010; Asness, Moskowitz, and Pedersen 2013). Further, the results show a substantial value premium (HML) for the German market with an average excess return of 0.55% for value over growth stock portfolios. The market excess return (RmRf) is considerable at 0.68% but also shows the highest standard deviation of all factors, still being statistical significant at the 5% significance level. The mean returns for the profitability (RMW, 0.24%) and investment (CMA, 0.39%) factors are in line with the results from Fama and French (2017) for the European market. However, the investment factor shows a higher premium than the 0.15% that Dirkx and Peter (2020) detect. An explanation for these differences can be the stronger performance of the investment factor excess returns before 2002, a period which is not covered by their study. This development can also be followed in Figure 1. In contrary to other markets, e.g. for the US (Fama and

French 2015), the size premium (SMB) seems to be slightly negative for the German market with an average excess return of – 0.11%, even though the result is not statistically significant. The findings are consistent with those of former studies for the German market covering other time periods (Schrimpf, Schröder, and Stehle 2007; Hanauer, Kaserer, and Rapp 2011; Artmann, Finter, and Kempf 2012). This leads to the conclusion that the size premium introduced by Banz (1981) and considered in the FF6 (Fama and French 2018) might not apply for the German market, especially during the time before 2007 as also depicted in Figure 1. Finally, all results are statistically significant at a 5% level besides for the size factor (SMB), and standard deviations are rather low except for the market portfolio returns (Rm) and market risk premium (RmRf).

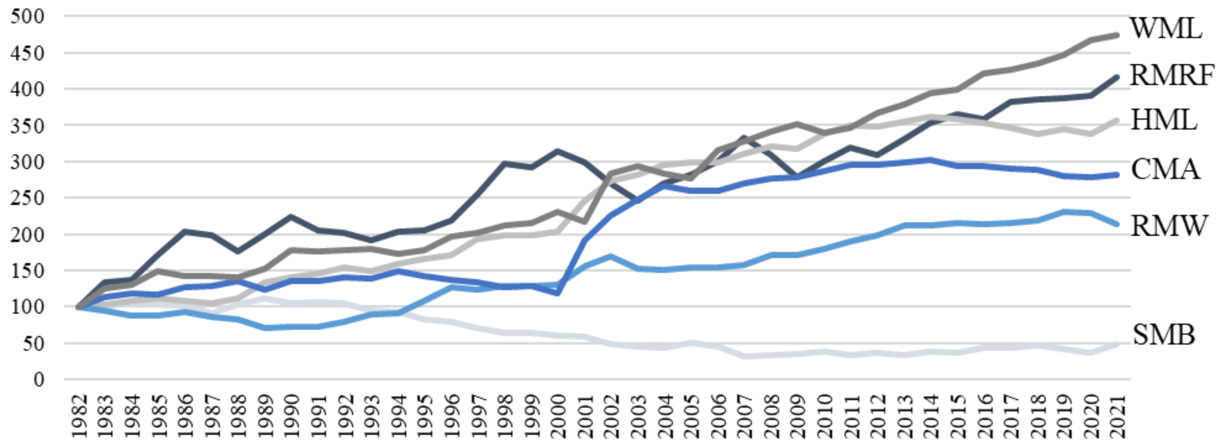


Figure 1: Time series development of FF6 factor excess returns

The correlation table reveals that the market risk premium (RmRf) is negatively correlated to all factors except HML, for which exists a positive but weak correlation of 0.11. These results for RmRf are overall convergent to the findings of Dirkx and Peter (2020), who discovered an even stronger positive correlation to the HML factor (0.22) and also a positive correlation to RMW (0.14). In the data set for this research, which covers a longer time period than their analysis, there is a minimal negative relationship between RmRf and RMW that can be considered as zero. The negative correlations of RmRf with all other factors (SMB - 0.52 vs. - 0.56; CMA - 0.29 vs. - 0.28; WML - 0.06 vs. - 0.19) show also convergence to the results of Dirkx and Peter (2020). However, the findings contradict to those for the US market where Fama and French (2015) find almost only negative correlations of the market risk premium to the other factors, except for the size premium. Further, SMB is positively correlated with CMA (0.27) and negatively correlated to RMW (- 0.19) and WML (- 0.04), which in general only show negative or zero correlations to the other factors with the exemption of their low positive correlation (0.16) to each other. The value premium

HML, is mainly positively correlated with the other factors, including as already discussed RmRf (0.11) but also CMA (0.35) and a minor correlation with SMB (0.02). Further details are presented in Table 5.

| | RmRf | SMB | HML | RMW | CMA | WML |
|---|---|---|---|---|---|---|
| **RmRf** | 1.00 | | | | | |
| **SMB** | - 0.52 | 1.00 | | | | |
| **HML** | 0.11 | 0.02 | 1.00 | | | |
| **RMW** | - 0.00 | - 0.19 | - 0.13 | 1.00 | | |
| **CMA** | - 0.29 | 0.27 | 0.35 | - 0.12 | 1.00 | |
| **WML** | - 0.06 | - 0.04 | - 0.00 | 0.16 | - 0.03 | 1.00 |

Table 5: Correlations between the FF6 factors

Besides the analysis of the FF6 factors' returns, it is also worthwhile to take a look at the descriptive statistics in Table 6 for the individual two times three portfolios created based on size and book-to-market (Size-B/M), profitability (Size-Prof), investment (Size-Inv), or momentum (Size-Mom). While for the Size-Mom portfolios the differences between the winner (1.33 and 1.09) and loser (1.09 and 0.60) stock portfolios are large and statistically significant for the 5% significance level, both for big and small stocks, some deltas in returns for the other cross-factor portfolios are less clear. For the big size portfolios the superiority of high B/M (1.21) over low B/M (0.43) stocks, conservative (0.98) over aggressive (0.46) investment stocks, and winner (1.09) over loser (0.60) momentum stocks is distinct. However, it is weaker for the big Size-Prof portfolios (robust 0.92 vs. weak 0.76). Further, even though for the small size portfolios the returns also follow the assumptions from theory and past research, there seems to be weaker differences for the Size-B/M (1.13 vs. 0.90) and Size-Inv (1.18 vs. 0.95) portfolios. In general, it can be stated that the standard deviations are greater than for the individual factor returns and the results are statistically significant at the 5% significance level, except for the big size portfolios with low book-to-market ratio (t-statistic 1.70) and aggressive investment (t-statistic 1.61). In addition to that, there seems to be a minor pattern for greater differences in cross-factor portfolio returns in the big size sections than for the small size portfolios.

| *Size-B/M* | Small | | | Big | | |
|---|---|---|---|---|---|---|
| | **High** | **Neutral** | **Low** | **High** | **Neutral** | **Low** |
| **Mean** | 1.13 | 1.01 | 0.90 | 1.21 | 0.89 | 0.43 |
| **St. Deviation** | 4.78 | 4.30 | 4.62 | 4.93 | 5.15 | 5.50 |
| **t-Statistic** | 5.10 | 5.10 | 4.21 | 5.31 | 3.72 | 1.70 |

| *Size-Prof* | | Small | | | Big | |
|---|---|---|---|---|---|---|
| | Robust | Neutral | Weak | Robust | Neutral | Weak |
| **Mean** | 1.23 | 0.94 | 0.86 | 0.92 | 0.81 | 0.76 |
| **St. Deviation** | 4.40 | 4.23 | 4.90 | 4.90 | 4.69 | 5.37 |
| **t-Statistic** | 6.04 | 4.78 | 3.77 | 4.05 | 3.75 | 3.08 |

| *Size-Inv* | | Small | | | Big | |
|---|---|---|---|---|---|---|
| | Conservative | Neutral | Aggressive | Conservative | Neutral | Aggressive |
| **Mean** | 1.18 | 1.00 | 0.95 | 0.98 | 0.97 | 0.46 |
| **St. Deviation** | 4.95 | 3.98 | 5.05 | 4.50 | 4.60 | 6.15 |
| **t-Statistic** | 5.17 | 5.45 | 4.05 | 4.70 | 4.57 | 1.61 |

| *Size-Mom* | | Small | | | Big | |
|---|---|---|---|---|---|---|
| | Winner | Neutral | Loser | Winner | Neutral | Loser |
| **Mean** | 1.33 | 1.03 | 0.76 | 1.09 | 0.86 | 0.60 |
| **St. Deviation** | 4.31 | 3.81 | 5.35 | 4.74 | 4.16 | 5.91 |
| **t-Statistic** | 6.66 | 5.85 | 3.08 | 4.97 | 4.49 | 2.21 |

Table 6: Descriptive statistics for the cross-factor portfolios

The regression results for the FF6 factors, presented in Table 7, illustrate throughout very low intercepts (α) close or equal to zero. This is an indicator that the expected returns can be explained in some way by the other considered factors, however, some α do not show statistical significance at the 5% level. Further, it should be highlighted that excluding the intercept values, the majority of coefficients is negative. This especially applies for the regression results with RmRf as dependent variable, while the opposite is the case for HML. However, it also needs to be mentioned that 14 out of 36 coefficient results are not statistically significant at the 5% significance level. The adjusted $R^2$ shows the greatest match for the regression with RmRf as test asset, for which 34.59% of the variance in expected returns can be explained by the risk factors. This result is followed by the SMB (31.98%), CMA (24.14%), HML (17.39%), RMW (8.18%), WML (3.32%) factors. Besides these differences, the explanatory power in general can be summarized as weak since no regression result shows a value for the adjusted $R^2$ above 50%.

| | Intercept | RmRf | SMB | HML | RMW | CMA | WML | Adj. $R^2$ |
|---|---|---|---|---|---|---|---|---|
| **RmRf** | | | | | | | | |
| Coefficient | 0.58% | | - 1.51 | 0.53 | - 0.24 | - 0.46 | - 0.15 | 34.59% |
| t-Statistic | 2.43 | | - 12.13 | 4.64 | - 2.18 | - 5.75 | - 1.99 | |
| **SMB** | | | | | | | | |
| Coefficient | 0.03% | - 0.16 | | 0.02 | - 0.15 | 0.06 | - 0.03 | 31.98% |
| t-Statistic | 0.36 | - 12.13 | | 0.51 | - 4.28 | 2.08 | - 1.15 | |
| **HML** | | | | | | | | |
| Coefficient | 0.39% | 0.08 | 0.03 | | - 0.08 | 0.27 | 0.03 | 17.39% |
| t-Statistic | 4.06 | 4.64 | 0.51 | | - 1.80 | 8.92 | 0.90 | |

| | Intercept | RmRf | SMB | HML | RMW | CMA | WML | Adj. $R^2$ |
|---|---|---|---|---|---|---|---|---|
| **RMW** | | | | | | | | |
| Coefficient | 0.23% | - 0.04 | - 0.25 | - 0.09 | | - 0.04 | 0.10 | 8.18% |
| t-Statistic | 2.29 | - 2.18 | - 4.28 | - 1.80 | | - 1.12 | 3.03 | |
| **CMA** | | | | | | | | |
| Coefficient | 0.26% | - 0.14 | 0.16 | 0.54 | - 0.07 | | - 0.04 | 24.14% |
| t-Statistic | 1.90 | - 5.75 | 2.08 | 8.92 | - 1.12 | | - 0.88 | |
| **WML** | | | | | | | | |
| Coefficient | 0.76% | - 0.06 | - 0.10 | 0.06 | 0.20 | - 0.04 | | 3.32% |
| t-Statistic | 5.40 | - 1.99 | - 1.15 | 0.90 | 3.03 | - 0.88 | | |

Table 7: Regression results for the FF6 factors

The regression details for the double sorted portfolios based on size and B/M, profitability, investment, and momentum, displayed in the Tables 8-11, affirm the results regarding the intercepts α from the previous factor regressions. The coefficients for all intercepts are close to zero, ranging between 0.48% and 1.22% (WML) and being statistically significant at the 5% significance level. Further, the regressions show a pattern for positive coefficients for b, s, and h, while r, c, and w have mainly negative coefficient results. For HML factor, h, the regressions reveal again more difficulty to find statistically significant coefficient results, especially for the regressions with Size-Prof, Size-Inv, and Size-Mom as test assets.

Considering the regression results with Size-B/M portfolios as test assets (Table 8), the intercepts α range between 0.57% and 1.15%. The market factor b reveals only positive coefficients above 0.60 with strong statistical significance. While for the size factor s the coefficients for the small Size-B/M portfolios are also high and positive (0.71, 0.58, and 0.67), the ones for the big Size-B/M portfolios are negative. For the value factor h the results show a negative correlation for stocks with low B/M, both for small (- 0.57) and big (- 0.54) size portfolios, and positive coefficients for the portfolios with higher B/M. These results are also statistically significant. The factors r, c, and w show mainly negative coefficient values, with the exception of the big-value portfolio that reveals a slightly positive correlation for the investment factor c (0.07).

For the regressions with Size-Prof as test asset (Table 9) we also find intercepts α close to but still different from zero (between 0.60% and 1.03%). As for the regressions on the Size-B/M portfolios, the market factor β shows throughout positive coefficient values between 0.58 and 0.65 and strong statistical significance. Following the overall impression, the factors r, c, and w have almost only negative coefficients, except for the robust portfolios for the profitability factor r (0.17 and 0.05). It should also be highlighted that again for the size factor s the coefficients are positive for small Size-Prof portfolios, however they are negative for the big size counterparts. Further, the for the value factor h basically all coefficients are close to zero, however, showing almost no statistical significance at the 5% level.

*Size-B/M*

| | α | | | t(α) | | |
|---|---|---|---|---|---|---|
| | **Low** | **Neutral** | **High** | **Low** | **Neutral** | **High** |
| **Small** | 1,15% | 0,85% | 0,85% | 8.21 | 6,50 | 6.11 |
| **Big** | 0,73% | 0,57% | 0,65% | 5.70 | 4.57 | 5.53 |

| | b | | | t(b) | | |
|---|---|---|---|---|---|---|
| | **Low** | **Neutral** | **High** | **Low** | **Neutral** | **High** |
| **Small** | 0.63 | 0.61 | 0.60 | 23.54 | 24.06 | 22.40 |
| **Big** | 0.62 | 0.68 | 0.65 | 25.02 | 27.85 | 28.29 |

| | s | | | t(s) | | |
|---|---|---|---|---|---|---|
| | **Low** | **Neutral** | **High** | **Low** | **Neutral** | **High** |
| **Small** | 0.71 | 0.58 | 0.67 | 8.65 | 7.50 | 8.25 |
| **Big** | - 0.19 | - 0.29 | - 0.19 | - 2.50 | - 3.84 | - 2.76 |

| | h | | | t(h) | | |
|---|---|---|---|---|---|---|
| | **Low** | **Neutral** | **High** | **Low** | **Neutral** | **High** |
| **Small** | - 0.57 | 0.08 | 0.62 | - 8.48 | 1.19 | 9.24 |
| **Big** | - 0.54 | 0.11 | 0.47 | - 8.69 | 1.85 | 8.20 |

| | r | | | t(r) | | |
|---|---|---|---|---|---|---|
| | **Low** | **Neutral** | **High** | **Low** | **Neutral** | **High** |
| **Small** | - 0.31 | - 0.20 | - 0.40 | - 4.88 | - 3.30 | - 6.29 |
| **Big** | - 0.58 | - 0.26 | - 0.22 | - 9.78 | - 4.45 | - 3.96 |

| | c | | | t(c) | | |
|---|---|---|---|---|---|---|
| | **Low** | **Neutral** | **High** | **Low** | **Neutral** | **High** |
| **Small** | - 0.13 | - 0.06 | - 0.14 | - 2.77 | - 1.36 | - 2.92 |
| **Big** | - 0.52 | - 0.04 | 0.07 | - 11.69 | - 1.00 | 1.70 |

| | w | | | t(w) | | |
|---|---|---|---|---|---|---|
| | **Low** | **Neutral** | **High** | **Low** | **Neutral** | **High** |
| **Small** | - 0.20 | - 0.20 | - 0.29 | - 4.50 | - 4.73 | - 6.62 |
| **Big** | - 0.13 | - 0.20 | - 0.17 | - 3.06 | - 4.95 | - 4.57 |

Table 8: Regression results for double sorted portfolios based on size and B/M

Regressions for six Size-B/M portfolios and the equation is the one of FF6:

$$R_i - R_f = a_i + \beta_i (R_m - R_f) + s_i\, SMB + h_i\, HML + r_i\, RMW + c_i\, CMA + w_i\, WML + \varepsilon_i$$

The test assets on the left-hand side are the monthly excess returns on the six Size-B/M portfolios. The risk factors on the right-hand side are the excess market return (RmRf), the size factor (SMB), value factor (HML), profitability factor (RMW), investment factor (CMA), and momentum factor (WML) formed through independent two x three sorts for each of the variables.

*Size-Prof*

| | α | | | t(α) | | |
|---|---|---|---|---|---|---|
| | **Weak** | **Neutral** | **Robust** | **Weak** | **Neutral** | **Robust** |
| **Small** | 0,94% | 0,80% | 1,03% | 6.86 | 6.23 | 7.67 |
| **Big** | 0,68% | 0,60% | 0,65% | 5.19 | 5.63 | 5.54 |

| | b | | | t(b) | | |
|---|---|---|---|---|---|---|
| | **Weak** | **Neutral** | **Robust** | **Weak** | **Neutral** | **Robust** |
| **Small** | 0.64 | 0.58 | 0.63 | 24.37 | 23.22 | 24.48 |
| **Big** | 0.63 | 0.62 | 0.65 | 25.08 | 30.06 | 28.42 |

| | s | | | t(s) | | |
|---|---|---|---|---|---|---|
| | **Weak** | **Neutral** | **Robust** | **Weak** | **Neutral** | **Robust** |
| **Small** | 0.73 | 0.59 | 0.59 | 9.05 | 7.74 | 7.38 |
| **Big** | - 0.31 | - 0.20 | - 0.20 | - 4.01 | - 3.18 | - 2.84 |

| | h | | | t(h) | | |
|---|---|---|---|---|---|---|
| | **Weak** | **Neutral** | **Robust** | **Weak** | **Neutral** | **Robust** |
| **Small** | 0.00 | 0.14 | - 0.02 | 0.07 | 2.17 | - 0.27 |
| **Big** | 0.03 | 0.02 | 0.02 | 0.52 | 0.44 | 0.44 |

| | r | | | t(r) | | |
|---|---|---|---|---|---|---|
| | **Weak** | **Neutral** | **Robust** | **Weak** | **Neutral** | **Robust** |
| **Small** | - 0.86 | - 0.22 | 0.17 | - 13.64 | - 3.70 | 2.69 |
| **Big** | - 0.83 | - 0.26 | 0.05 | - 13.83 | - 5.27 | 0.92 |

| | c | | | t(c) | | |
|---|---|---|---|---|---|---|
| | **Weak** | **Neutral** | **Robust** | **Weak** | **Neutral** | **Robust** |
| **Small** | - 0.01 | - 0.16 | - 0.10 | - 0.17 | - 3.65 | - 2.23 |
| **Big** | - 0.24 | - 0.14 | - 0.13 | - 5.25 | - 3.80 | - 3.21 |

| | w | | | t(w) | | |
|---|---|---|---|---|---|---|
| | **Weak** | **Neutral** | **Robust** | **Weak** | **Neutral** | **Robust** |
| **Small** | - 0.28 | - 0.20 | - 0.20 | - 6.47 | - 4.70 | - 4.64 |
| **Big** | - 0.13 | - 0.17 | - 0.22 | - 2.99 | - 4.84 | - 5.79 |

Table 9: Regression results for double sorted portfolios based on size and profitability

Regressions for six Size-Prof portfolios and the equation is the one of FF6:

$$Ri - Rf = ai + \beta i\ (Rm - Rf) + si\ SMB + hi\ HML + ri\ RMW + ci\ CMA + wi\ WML + \varepsilon i$$

The test assets on the left-hand side are the monthly excess returns on the six Size-Prof portfolios. The risk factors on the right-hand side are the excess market return (RmRf), the size factor (SMB), value factor (HML), profitability factor (RMW), investment factor (CMA), and momentum factor (WML) formed through independent two x three sorts for each of the variables.

For the coefficient results of the regressions with portfolios created by sorting on size and investment as test asset (Table 10), the values for the intercepts continue mainly at levels close to zero and one percent (0.59% to 1.09%). Further, again the coefficients for the market factor b are high and positive with strong statistical significance, as for the regression results presented before.

The findings for the size factor s, with positive coefficients for small size and negative ones for big size stocks, can also be identified in the regression results for the Size-Inv portfolios. While for the profitability r and momentum w factors the coefficients are coherent negative, for the investment factor c one can detect a positive correlation for the conservative portfolios (0.38 and 0.24).

*Size-Inv*

| | α | | | t(α) | | |
|---|---|---|---|---|---|---|
| | **Aggressive** | **Neutral** | **Conservative** | **Aggressive** | **Neutral** | **Conservative** |
| **Small** | 1,09% | 0,78% | 1,07% | 7.80 | 6.08 | 7.22 |
| **Big** | 0,60% | 0,62% | 0,59% | 4.65 | 5.66 | 5.04 |

| | **b** | | | **t(b)** | | |
|---|---|---|---|---|---|---|
| | **Aggressive** | **Neutral** | **Conservative** | **Aggressive** | **Neutral** | **Conservative** |
| **Small** | 0.62 | 0.54 | 0.68 | 23.14 | 21.93 | 23.93 |
| **Big** | 0.69 | 0.62 | 0.61 | 27.58 | 29.10 | 27.23 |

| | **s** | | | **t(s)** | | |
|---|---|---|---|---|---|---|
| | **Aggressive** | **Neutral** | **Conservative** | **Aggressive** | **Neutral** | **Conservative** |
| **Small** | 0.75 | 0.55 | 0.68 | 9.01 | 7.23 | 7.72 |
| **Big** | - 0.25 | - 0.24 | - 0.22 | - 3.32 | - 3.75 | - 3.11 |

| | **h** | | | **t(h)** | | |
|---|---|---|---|---|---|---|
| | **Aggressive** | **Neutral** | **Conservative** | **Aggressive** | **Neutral** | **Conservative** |
| **Small** | 0.00 | 0.16 | - 0.13 | 0.00 | 2.61 | - 1.83 |
| **Big** | - 0.11 | 0.12 | 0.05 | - 1.76 | 2.29 | 0.84 |

| | **r** | | | **t(r)** | | |
|---|---|---|---|---|---|---|
| | **Aggressive** | **Neutral** | **Conservative** | **Aggressive** | **Neutral** | **Conservative** |
| **Small** | - 0.30 | - 0.10 | - 0.61 | - 4.65 | - 1.76 | - 8.90 |
| **Big** | - 0.61 | - 0.14 | - 0.27 | - 10.29 | - 2.68 | - 5.06 |

| | **c** | | | **t(c)** | | |
|---|---|---|---|---|---|---|
| | **Aggressive** | **Neutral** | **Conservative** | **Aggressive** | **Neutral** | **Conservative** |
| **Small** | - 0.60 | - 0.04 | 0.38 | - 12.50 | - 0.87 | 7.41 |
| **Big** | - 0.72 | - 0.01 | 0.24 | - 16.07 | - 0.32 | 6.01 |

| | **w** | | | **t(w)** | | |
|---|---|---|---|---|---|---|
| | **Aggressive** | **Neutral** | **Conservative** | **Aggressive** | **Neutral** | **Conservative** |
| **Small** | - 0.23 | - 0.18 | - 0.26 | - 5.11 | - 4.24 | - 5.48 |
| **Big** | - 0.19 | - 0.16 | - 0.13 | - 4.46 | - 4.48 | - 3.52 |

Table 10: Regression results for double sorted portfolios based on size and investment

Regressions for six Size-Inv portfolios and the equation is the one of FF6:

$$Ri - Rf = ai + \beta i\ (Rm - Rf) + si\ SMB + hi\ HML + ri\ RMW + ci\ CMA + wi\ WML + \varepsilon i$$

The test assets on the left-hand side are the monthly excess returns on the six Size-Inv portfolios. The risk factors on the right-hand side are the excess market return (RmRf), the size factor (SMB), value factor (HML), profitability factor (RMW), investment factor (CMA), and momentum factor (WML) formed through independent two x three sorts for each of the variables.

Finally, the regression results with Size-Mom portfolios as test assets are in line with those of the previous ones regarding the intercepts α, market factor b, and size factor s. Also the low correlations close to zero for the value factor h can be found, but with mainly no statistical significance.

*Size-Mom*

| | α | | | t(α) | | |
|---|---|---|---|---|---|---|
| | **Loser** | **Neutral** | **Winner** | **Loser** | **Neutral** | **Winner** |
| **Small** | 1,22% | 0,85% | 0,88% | 8.30 | 7.11 | 6.30 |
| **Big** | 0,83% | 0,48% | 0,60% | 6.15 | 4.52 | 4.68 |

| | b | | | t(b) | | |
|---|---|---|---|---|---|---|
| | **Loser** | **Neutral** | **Winner** | **Loser** | **Neutral** | **Winner** |
| **Small** | 0.63 | 0.56 | 0.61 | 22.23 | 24.09 | 22.75 |
| **Big** | 0.68 | 0.57 | 0.60 | 26.08 | 27.78 | 24.22 |

| | s | | | t(s) | | |
|---|---|---|---|---|---|---|
| | **Loser** | **Neutral** | **Winner** | **Loser** | **Neutral** | **Winner** |
| **Small** | 0.71 | 0.61 | 0.80 | 8.12 | 8.60 | 9.66 |
| **Big** | - 0.36 | - 0.14 | - 0.19 | - 4.44 | - 2.26 | - 2.50 |

| | h | | | t(h) | | |
|---|---|---|---|---|---|---|
| | **Loser** | **Neutral** | **Winner** | **Loser** | **Neutral** | **Winner** |
| **Small** | - 0.03 | 0.01 | 0.05 | - 0.43 | 0.24 | 0.72 |
| **Big** | 0.00 | 0.11 | 0.00 | 0.05 | 2.13 | - 0.07 |

| | r | | | t(r) | | |
|---|---|---|---|---|---|---|
| | **Loser** | **Neutral** | **Winner** | **Loser** | **Neutral** | **Winner** |
| **Small** | - 0.50 | - 0.17 | - 0.34 | - 7.32 | - 3.02 | - 5.24 |
| **Big** | - 0.43 | - 0.09 | - 0.31 | - 6.86 | - 1.90 | - 5.17 |

| | c | | | t(c) | | |
|---|---|---|---|---|---|---|
| | **Loser** | **Neutral** | **Winner** | **Loser** | **Neutral** | **Winner** |
| **Small** | - 0.13 | 0.06 | - 0.03 | - 2.62 | 1.53 | - 0.58 |
| **Big** | - 0.12 | 0.02 | - 0.17 | - 2.47 | 0.44 | - 3.77 |

| | w | | | t(w) | | |
|---|---|---|---|---|---|---|
| | **Loser** | **Neutral** | **Winner** | **Loser** | **Neutral** | **Winner** |
| **Small** | - 0.78 | - 0.15 | 0.23 | - 16.48 | - 4.02 | 5.11 |
| **Big** | - 0.73 | - 0.08 | 0.25 | - 16.75 | - 2.32 | 6.15 |

Table 11: Regression results for double sorted portfolios based on size and momentum
Regressions for six Size-Mom portfolios and the equation is the one of FF6:

$$R_i - R_f = a_i + \beta_i (R_m - R_f) + s_i\, SMB + h_i\, HML + r_i\, RMW + c_i\, CMA + w_i\, WML + \varepsilon_i$$

The test assets on the left-hand side are the monthly excess returns on the six Size-Mom portfolios. The risk factors on the right-hand side are the excess market return (RmRf), the size factor (SMB), value factor (HML), profitability factor (RMW), investment factor (CMA), and momentum factor (WML) formed through independent two x three sorts for each of the variables.

For the momentum factor w, we can find positive correlations for the winner portfolios (0.23 and 0.25), while the coefficient results for the investment factor c have a tendency towards zero and being not statistically significant for some of the gathered values.

In order to get an indicator for the performance of the FF6 in the German market, and therefore the basis to answer the research question of this work, I test if the intercepts α from the performed regressions are jointly equal zero. Therefore, a GRS test as defined by Gibbons, Ross, and Shanken (1989) is used for the FF3, FF5, and FF6. The null hypothesis that is to be confirmed or rejected for each model through the test is that all regression intercepts α are jointly equal to zero. On the opposite, the alternative hypothesis is that one or more alphas are different from zero. The GRS test is a finite-sample statistical F-test that assumes a normal distribution of independent error terms. Its formula is defined as:

$$\text{GRS Test Statistic} = \frac{T\,(T-N-K)}{N\,(T-K-1)} \text{ x } \frac{\hat{\alpha}\,\Sigma^{-1}\,\hat{\alpha}}{1+\bar{\mu}\,\hat{\Omega}^{-1}\,\bar{\mu}} \quad (10)$$

where

T = Size of the sample

N = Number of factor portfolios

K = Number of risk factors

â = N times one vector of estimates for the intercepts α ($\alpha_{1}$,...$\alpha_{n}$)

Σ = N times N unbiased estimate of error covariance matrix

Ω = K times K risk factor covariance matrix

μ = K times one vector of average monthly excess returns of the factor portfolios

There are two criteria that need to be fulfilled by the GRS test results in order to confirm the null hypothesis. First, the GRS Test Statistic must be below the critical F-value based on the desired significance level of 0.05 (5%) and therefore close to zero. Second, the p-value must be greater than the level of significance of 0.05. If both criteria apply, the null hypothesis can be confirmed and the intercepts α are jointly equal to zero, an indicator for explanatory power by the respective model, e.g. FF6, in the German market. In contrast, if one of the criteria is not achieved, the null hypothesis must be rejected.

The larger the distance of the GRS Test Statistic from zero, the stronger the evidence for a rejection of the null hypothesis and the weaker the performance of the model in analysis. However, following Fama and French (2015, 2017), besides the GRS Test Statistic, also other parameters like Mean Absolute α of all intercepts and the Mean Adjusted $R^2$ should be taken into consideration in order to come to an overall conclusion. Table 12 illustrates the results from the GRS test, performed for the FF3 (3-Factor), FF5 (5-Factor), and FF6 (6-Factor).

| | | GRS Test Statistic | p-Value | Mean Absolute α | Mean Adjusted $R^2$ | Sharpe Ratio |
|---|---|---|---|---|---|---|
| **Size-B/M** | | | | | | |
| | 6-Factor | 13.16 | 0.00 | 0.80% | 71% | 0.45 |
| | 5-Factor | 11.60 | 0.00 | 0.65% | 69% | 0.41 |
| | 3-Factor | 9.00 | 0.00 | 0.52% | 66% | 0.36 |
| **Size-Prof** | | | | | | |
| | 6-Factor | 11.40 | 0.00 | 0.79% | 71% | 0.42 |
| | 5-Factor | 8.20 | 0.00 | 0.64% | 69% | 0.34 |
| | 3-Factor | 9.33 | 0.00 | 0.50% | 64% | 0.36 |
| **Size-Inv** | | | | | | |
| | 6-Factor | 11.71 | 0.00 | 0.80% | 70% | 0.43 |
| | 5-Factor | 8.36 | 0.00 | 0.65% | 69% | 0.35 |
| | 3-Factor | 8.32 | 0.00 | 0.51% | 62% | 0.34 |
| **Size-Mom** | | | | | | |
| | 6-Factor | 15.40 | 0.00 | 0.81% | 69% | 0.49 |
| | 5-Factor | 14.42 | 0.00 | 0.65% | 62% | 0.46 |
| | 3-Factor | 13.32 | 0.00 | 0.54% | 60% | 0.43 |

Table 12: Results of the GRS test for the intercepts α

The isolated observation of the results for the GRS test, including the GRS Test Statistic and p-value, clearly rejects a good performance of the FF3, FF5, and FF6 for Germany. In the table, all values for the GRS Test Statistic for the FF6 (6-Factor) are high and with notable differences to zero, with values between 11.40 and 15.40. The same applies for the FF3 and FF5, even though they show slightly lower values for the GRS Test Statistic. Further, the p-values are throughout 0.00 for the cross-factor portfolio returns and therefore below the critical value of 0.05 for the 5% significance level. In conclusion, the null hypothesis must be rejected. Therefore, it can be stated that the intercepts α, the returns for the German market that cannot be explained by the factors of the FF3, FF5, and especially the FF6, are jointly not equal to zero. Because of that, the explanatory power of the FF6 has to be also rejected for the German market based on the isolated observation of the GRS test results.

However, it is worthwhile checking also the other outputs from the test, especially the Mean Absolute α and Mean Adjusted $R^2$. From the results for the Mean Absolute α, which is also an important indicator for the model performance, the conclusion can be taken that the averages of the intercepts α are throughout less than 1%, however also consistently around 0.80% for the FF6 and therefore different from zero. This means that there is still a part of returns that cannot be explained by the model or its individual factors. The results for the Mean Adjusted $R^2$ reveal an estimate that the FF6 explains between 69% and 71% of the cross-section returns gathered by the factor portfolios investigated. In general, considering only the Mean Adjusted $R^2$, the FF6 performs better than the FF3 (between 60% and 66%) and the FF5 (between 62% and 69%). But the values are much lower than the ones achieved by the FF5 for the US market, 71% to 94% (Fama and French 2015). Also, the FF6 shows throughout higher Sharpe ratios than the other two models with less factors.

These results for the Mean Adjusted $R^2$ show a tendency for a slightly superior performance of the FF6 over the FF5 and FF3 for the German market. However, the values for the GRS Test Statistic require an opposite interpretation. Further, the additional factors profitability and investment seem to already improve the explanatory power of the FF5 over the FF3. This shows potential for a minor explanatory power of the model, or at least some individual factors for the German market. However, this evidence seems to be rather weak.

# 5. CONCLUSIONS

The present work contributes to the existing research for multi-factor asset pricing models, especially the Six-Factor Model developed over decades by Fama and French (1993; 2015; 2018), by investigating its applicability and explanatory power for the German market. While former analysis mainly focuses on the US market or international evidence in general, little is known about the functioning of the model for average returns of German stocks. Available studies are either limited on individual factors of the model, consider relatively short times frames, or both. The research of this work aimed at closing this gap by providing an answer to the question if the Fama and French Six-Factor Model explains average stock returns in the German market, considering data from 468 months between 1982 and 2021.

The results gathered confirm many tendencies from earlier studies, including the strong evidence for a momentum factor in the German market, a considerable value premium, and positive average excess returns for the profitability and investment factors. Also, the inverse size effect in Germany, already detected by former research, with big stocks outperforming small stocks, was found in the data set investigated. In addition, the correlation of the market factor is negative for all other factors except for the value premium.

The consideration of the regression results and values gathered from the GRS test show weak evidence for an explanatory power of the FF6 in Germany. While the model is rejected by the GRS Test Statistics and p-values, at least the results for the Mean Adjusted $R^2$ show some potential for superiority over the FF3 and FF5 as well as an appropriate estimation of the cross-section returns gathered by the factor portfolios investigated. However, the values are throughout lower than the ones demonstrated by Fama and French (2015) for the US market. It is also to mention that the FF5 seems to perform better than its predecessor with three factors, leading to the reasoning that the additional factors profitability and investment enhance the model in terms of Adjusted $R^2$. Even though the momentum shows the strongest factor results in the FF6, following the results of the GRS tests it seems to provide only limited improvement regarding the explanatory power in comparison to the FF5.

Finally, an answer to the research question of this work, introduced in the third chapter and presented below, can be given:

Can the Fama and French Six-Factor Model explain average stock returns in the German market for the time period between 1982 and 2021?

With consideration of the analysis performed, it seems that the Fama and French Six-Factor Model cannot explain fully and reliably average stock returns in Germany when considering data between 1982 and 2021. This conclusion supports previous findings that there is weak evidence for an explanatory power of the model for the German market.

However, the results of the empirical research performed in this work reveal interesting results for which additional analysis is worthwhile. The phenomena of the negative size premium for the German market should be investigated more in detail and reasons explored for this inverse behavior in comparison to other countries. Further, including data for the time before 1982, in order to consider even more years in the analysis, might bring new insights into the explanatory power of the FF6 in Germany over long time periods. Since the available data in Thomson Reuters Datastream and Worldscope is limited to 1980 for German stocks, other data bases need to be considered in order to perform such a study.

Concluding, the present work represents a good basis for further research into the matter and bring more findings on the FF6 and its individual factors regarding the German market. Like that, the extent of the explanatory power of the model, which was mainly developed based on US data, for average stock returns in Germany might become even more precise so that practitioners can make use of the results for their investment decisions.

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# APPENDIX I: OVERVIEW ON INTERNATIONAL EVIDENCE

| **Reference** (sorted by year of publication) | **Time period** | **Country** | **Factor** |
|---|---|---|---|
| Banz (1981) | 1926-1975 | US | Size |
| De Bondt and Thaler (1985) | 1926-1982 | US | Momentum |
| Chan, Hamao, and Lakonishok (1991) | 1971-1988 | Japan | Size, Value |
| Harris and Marston (1994) | 1982-1989 | US | Value |
| Carhart (1997) | 1962-1993 | International | Market, Size, Value, Momentum |
| Fama and French (1998) | 1975-1995 | US, JP, BE, FR, DE, IT, NL, CH, SE, AU, HK, SG | Market, Size, Value |
| Rouwenhorst (1998) | 1980-1995 | International (AT, BE, DK, FR, DE, IT, NL, NO, ES, SE, CH, UK) | Momentum |
| Daniel, Titman, and Wei (2001) | 1971-1997 | Japan | Value |
| Glaser and Weber (2002) | 1988-2001 | Germany | Momentum |
| Griffin (2002) | 1981-1995 | US, Canada, Japan, UK | Market, Size, Value |
| Conrad, Cooper and Kaul (2003) | 1955-1995 | US | Value |
| Ziegler et al. (2003) | 1967-1995 | Germany | Market, Size, Value |
| Chan and Lakonishok (2004) | 1975-1995 | US, JP, UK, FR, DE, IT, NL, BE, CH, SE, AU, HK, SG | Value |
| L'Her, Masmoudi, and Suret (2004) | 1960-2001 | Canada | Market, Size, Value, Momentum |
| Titman, Wei, and Xie (2004) | 1973-1996 | US | Investment |
| Fama and French (2006) | 1963-2004 | US | Value, Profitability, Investment |
| Fama and French (2007) | 1926-2005 | US | Value |
| Schrimpf, Schröder, and Stehle (2007) | 1969-2002 | Germany | Market, Size, Value |
| Cooper, Gulen, and Schill (2008) | 1964-2003 | US | Investment |
| Chui, Titman, and Wei (2010) | 1980-2003 | International (55 countries) | Momentum |

| | | | |
|---|---|---|---|
| Chen, Novy-Marx, and Zhang (2011) | 1972-2010 | US | Market, Investment, Profitability |
| Hanauer, Kaserer, and Rapp (2011) | 1996-2011 | Germany | Market, Size, Value, Momentum |
| Artmann, Finter, and Kempf (2012) | 1963-2006 | Germany | Market, Size, Value, Momentum |
| Fama and French (2012) | 1989-2011 | North America, Europe, Japan, Asia-Pacific | Market, Size, Value, Momentum |
| Aharoni, Grundy, and Zeng (2013) | 1963-2009 | US | Investment |
| Asness, Moskowitz, and Pedersen (2013) | 1972-2011 | Continental Europe, Japan, UK, US | Value, Momentum |
| Novy-Marx (2013) | 1963-2010 | US | Profitability |
| Titman, Wei, and Xie (2013) | 1980-2010 | International (55 countries) | Investment |
| Watanabe et al. (2013) | 1982-2010 | International (42 countries outside US) | Investment |
| Sun, Wei, and Xie (2014) | 1980-2010 | International (41 countries) | Profitability |
| Barroso and Santa-Clara (2015) | 1926-2011 | France, Germany, Japan, UK | Momentum |
| Hou, Xue, and Zhang (2015) | 1972-2012 | US | Market, Size, Investment, Profitability |
| Ball et al. (2016) | 1963-2014 | US | Profitability |
| Chia et al. (2016) | 1982–2013 | Australia | Market, Size, Value, Profitability,Investment |
| Fama and French (2017) | 1990-2015 | US, CA, AT, BE, DK, FI, FR, DE, GR, IE, IT, NL, NO, PT, ES, SE, CH, UK, JP, AU, HK, SG, NZ | Market, Size, Value, Profitability, Investment |
| Wahal (2017) | 1940-1963 | US | Profitability |
| Kubota and Takehara (2018) | 1978-2014 | Japan | Market, Size, Value, Profitability, Investment |
| Schmidt et el. (2019) | 1991-2018 | US, Europe, Japan | Size |

| | | | |
|---|---|---|---|
| Dirkx and Peter (2020) | 2002-2019 | Germany | Market, Size, Value, Profitability, Investment, Momentum |

Table 13: Overview on international evidence

## APPENDIX II: NUMBER OF STOCKS PER YEAR AND FACTOR

| | Total | SMB | HML | RMW | CMA | WML |
|---|---|---|---|---|---|---|
| **1982** | 101 | 101 | 60 | 60 | 60 | 101 |
| **1983** | 107 | 101 | 60 | 60 | 60 | 101 |
| **1984** | 116 | 108 | 68 | 68 | 60 | 102 |
| **1985** | 121 | 117 | 78 | 78 | 72 | 111 |
| **1986** | 134 | 122 | 82 | 82 | 81 | 117 |
| **1987** | 151 | 136 | 89 | 89 | 87 | 126 |
| **1988** | 225 | 153 | 114 | 114 | 94 | 138 |
| **1989** | 263 | 247 | 174 | 168 | 139 | 154 |
| **1990** | 285 | 265 | 195 | 190 | 184 | 248 |
| **1991** | 302 | 286 | 221 | 219 | 207 | 272 |
| **1992** | 311 | 300 | 234 | 230 | 226 | 289 |
| **1993** | 316 | 312 | 256 | 252 | 239 | 306 |
| **1994** | 323 | 316 | 284 | 276 | 262 | 307 |
| **1995** | 338 | 324 | 285 | 279 | 291 | 316 |
| **1996** | 345 | 338 | 297 | 292 | 300 | 326 |
| **1997** | 356 | 348 | 325 | 323 | 304 | 333 |
| **1998** | 412 | 355 | 338 | 336 | 340 | 338 |
| **1999** | 532 | 406 | 389 | 379 | 395 | 366 |
| **2000** | 637 | 524 | 485 | 473 | 490 | 437 |
| **2001** | 645 | 577 | 540 | 538 | 507 | 518 |
| **2002** | 615 | 497 | 472 | 465 | 472 | 497 |
| **2003** | 584 | 521 | 466 | 458 | 484 | 462 |
| **2004** | 571 | 485 | 444 | 428 | 465 | 442 |
| **2005** | 571 | 487 | 421 | 433 | 456 | 458 |
| **2006** | 617 | 492 | 452 | 449 | 463 | 456 |
| **2007** | 650 | 536 | 497 | 486 | 498 | 468 |
| **2008** | 645 | 498 | 464 | 455 | 469 | 470 |
| **2009** | 628 | 518 | 477 | 469 | 485 | 462 |
| **2010** | 615 | 510 | 467 | 464 | 479 | 490 |
| **2011** | 598 | 498 | 456 | 453 | 460 | 468 |
| **2012** | 565 | 494 | 454 | 450 | 457 | 462 |
| **2013** | 532 | 480 | 434 | 425 | 442 | 444 |
| **2014** | 509 | 461 | 411 | 405 | 421 | 412 |
| **2015** | 493 | 440 | 391 | 384 | 406 | 407 |
| **2016** | 483 | 436 | 390 | 380 | 404 | 394 |
| **2017** | 485 | 437 | 398 | 390 | 409 | 395 |
| **2018** | 493 | 434 | 399 | 391 | 405 | 391 |
| **2019** | 489 | 430 | 397 | 390 | 403 | 393 |
| **2020** | 542 | 539 | 400 | 399 | 440 | 416 |
| **Ø** | **428** | **375** | **330** | **325** | **331** | **343** |

Table 14: Number of stocks per year and factor

## APPENDIX III: DATASTREAM AND WORLDSCOPE CODES

Market portfolio:

- WSCOPEBD: Company Accounts Worldscope Germany = Market portfolio

Risk-free rate:

- BDINTER3: Germany, Frankfurt Interbank Offered Rate = for time between July 1982 and December 1998
- EIBOR3M: EBF Euribor = for time between January 1999 and June 2021

Size factor:

- MV: Market Value (Capital) = Market capitalization

Value factor:

- MV: Market Value (Capital) = Market capitalization
- WC03501: Common Equity = Book Value

Profitability factor:

- WC01250: Operating Income = Operating Profit
- WC01251: Interest Expense on Debt = Interest Expense
- WC03501: Common Equity = Book Value

Investment factor:

- WC02999: Total Assets = Total assets

Momentum factor:

- RI: Total Return Index = Price performance plus dividends paid

Performance measure:

- RI: Total Return Index = Price performance plus dividends paid
- P: Price – Trade = Price