ERASMUS UNIVERSITY ROTTERDAM
ERASMUS SCHOOL OF ECONOMICS
MSc Economics & Business
Master Specialisation Financial Economics

Does the five-factor asset pricing model hold for European Equities?

An inquiry into the value, size, profitability and investment risk factors in the S&P Euro index

Author: Rory van Veen
Student number: 335923
Thesis supervisor: Dr. R. Xing
Finish date: July 2016

PREFACE AND ACKNOWLEDGEMENTS

I would like to thank my supervisor Dr. Xing for helping me with this thesis.

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ABSTRACT

This paper investigates the Fama and French five-factor model for European equities. The size and value factors in Europe have large average returns and explain a significant amount of test portfolio returns, with relatively low alphas. The two-step Fama-Macbeth regression estimates a large risk premium for the size factor, which is smaller for the value factor. The GRS-test shows that the alphas are statistically insignificant when using test portfolios double-sorted on size and the book-to-market ratio. The operating profitability and relative investment level factors yield a statistically insignificant average return and risk premium in Europe. Adding them to the three-factor model does not drastically decrease alpha size, relative to Fama and French (2015).

Keywords: Asset Pricing Model, Risk Factor Model, Size, Value, Profitability, Investment

JEL Classification: G12

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CHAPTER 1 Introduction

1.1 Research Background and Motivation

In this thesis, I research the exposure of the S&P Euro index to the value, size, profitability and investment risk factors. A full understanding of the pricing of stocks on these types of indices is more important than ever with greater use of exchange-traded funds in recent years that invest passively in indices such as those of the S&P (Gastineau, 2010). I choose the S&P Euro index in particular due to the large amount of constituents it holds and that it accounts for 70 percent of the total free float-adjusted market capitalization of the Eurozone. Furthermore, since it only holds equities listed in Eurozone countries, all the listed stocks trade in euros, which removes exchange rate risk and makes the statistical analysis easier and more reliable.

Research into risk factors is important, due to the increasing amount of institutional and individual investing into risk factor portfolios and many index providers create factor indices based on value, size, volatility, dividend and momentum. Based on these risk factor indices, asset managers and exchange-traded funds have a benchmark to build a portfolio on when investing using risk factors (Bender et al., 2013). Investment strategies based on risk factors are not only used for stocks, but also for fixed-income securities, in particular corporate bonds, which use the characteristics of the firms that issue the bonds and the bond market as a way to create risk factor portfolios (Houweling & van Zundert, 2015).

The basis for this type of investing originates from the three-factor model proposed by Fama and French (1992) which adds the value and size factors to the capital asset pricing model in order to increase the explanation of the cross-sectional variation of returns. Fama and French (2015) expands on the three-factor model by adding two more factors based on profitability and investment levels. They obtain significant evidence of the effect of these risk factors on U.S. stock portfolios and I compare those results with European stocks.

1.2 Research Question

In order to find out whether the pricing of European equities traded on the S&P Euro index are affected by the risk factors proposed by Fama and French (2015), this thesis proposes the following research question:

Does the five-factor asset pricing model hold for European Equities?

1.3 Methodology and Results

First, I test the exposure of European equities to the five risk factors by running time-series regressions between test portfolios and risk factors. By analysing the pattern in the resulting coefficients, it can be determined whether the returns of test portfolios containing a particular set of stocks (small or value stocks, for example) have a larger sensitivity to the risk factor. The first set of regressions I make use the size and value factors from the three-factor model by Fama and French (1992) as independent variables. Using quartiles as breakpoints, 16 test portfolios are created containing stocks with varying levels of market capitalizations and book-to-market ratios. The resulting coefficients show that there is a pattern in sensitivity levels for the size and value factors. Portfolios containing smaller cap stocks have positive coefficients and portfolios with larger cap stocks have negative or statistically insignificant coefficients. The smallest cap portfolios have size coefficients ranging from 0.55 to 1.93 and the coefficients of the largest cap portfolios range from -0.02 to -0.78. I find the same for the value factor, with portfolios containing low (growth) and high (value) book-to-market stocks obtaining negative and positive coefficients, respectively. The coefficients from growth portfolios range from -0.17 to -0.43 and 0.22 to 1.12 for value stocks. The results are comparable to Fama and French (1992) which test U.S. stocks and finds size factor coefficients ranging from 1.17 to 1.46 for small cap portfolios and -0.05 to -0.23 for large cap portfolios. Their value factor coefficients for growth stock portfolios also range from -0.29 to -0.52 and 0.62 to 0.76 for value stock portfolios. A second set of regressions has the momentum factor added to the model, but does not find any pattern in the size or sign of the coefficients, as most of the coefficients are small or statistically insignificant.

I expand the three-factor model by adding the investment and profitability risk factors. In order to test the sensitivity levels towards these factors I create additional test portfolios double-sorted on size-profitability and size-investment. The resulting coefficients from the profitability factor, when using size-profitability test portfolios, show an increasing level of sensitivity towards the risk factor for portfolios containing stocks with higher profitability levels. Low and high profitability portfolios have significantly negative (from -0.53 to -0.93) and positive (from 0.26 to 0.4) coefficients, respectively. This corresponds with the regressions made by Fama and French (2015), which finds negative profitability factor coefficients around -0.70 for low profitability portfolios and 0.45 for high profitability portfolios. The coefficients resulting from the size-investment test portfolios show a different relationship, as high investment portfolios have negative coefficients (from -0.22 to -0.72) and low investment portfolios have either positive or insignificant coefficients (from -0.06 to 1.21). The coefficients Fama and French (2015) finds also lie in the same range for high investment portfolios (from -0.31 to -0.76), but are not comparable for low investment portfolios (from 0.22 to 0.69).

I continue testing the two models using a two-step Fama-Macbeth regression (Fama & Macbeth, 1973). This type of cross-sectional regression uses the coefficients estimated in the previous part as independent variables and relates them to the average returns of the test portfolios. The resulting coefficients from the Fama-Macbeth regression indicate the level of risk premium awarded for the exposure to a risk factor. I estimate the risk premium coefficients for the three-factor model and find that there is a large risk premium for the size factor of 0.61 and a small risk premium for the value factor of 0.22. The profitability and investment risk factors have statistically insignificant risk premium coefficients and when added to the three-factor model, the risk premium decreases for the value factor. The size factor remains large and significant in all models, regardless of the type of test portfolio sorting used.

I use the GRS-test to test the significance level of all the intercepts estimated from the time-series regression (Gibbons, Ross, & Shanken, 1989). Having a small and statistically insignificant = intercept coefficient (or alpha) in a time-series regression model means that there are few unexplained returns, which indicate an accurate model. The results of the GRS-test indicate that the alphas are statistically insignificant when using test portfolios sorted on size and book-to-market ratios, with GRS-statistics ranging from 0.92 to 1.04. The alphas of the size-profitability and size-investment test portfolios are significant at the 90 and 95 percent confidence level. Adding additional risk factors to the model does not decrease the significance of the alphas, in contrast to Fama and French (2015) which finds decreasing GRS-statistics (and therefore significance) when adding the investment and profitability risk factors. Furthermore, the insignificance of the alphas of the value-size sorted test portfolios is also in contradiction with Fama and French (2015), which finds significant alphas for U.S. stocks. Fama and French (2012), however, finds insignificant alphas for stocks traded in Europe and Japan, using both locally and globally created risk factors.

1.4 Comparison and Contribution

These results support the previous research of Fama and French (1992) by confirming the robustness of the size and value risk factors, but it cannot say for certain whether the profitability and investment factors added to the model are actual risk factors that yield a risk premium. The only risk factor that has a significant risk premium is the size factor. The value factor has a small and positive risk premium, however this is only significant at the 80 percent confidence level. This thesis therefore rejects the Fama and French five-factor model, as the factors from the three-factor model explain the returns of European equities robustly.

Comparing these results with Fama and French (2012), which looks at the international exposure to risk factors, I find a number of differences. They find large value and momentum factor average returns for European equities and insignificant returns for the size factor. This contradicts my findings of large average size returns, small average value returns and insignificant momentum average returns. Possibly due to their use of a larger time and stock sample. Malin and Veeraraghavan (2004) finds the size effect in French and German stocks, but do not find a value effect. The paper instead finds that growth stocks outperform value stocks on average. This contradicts previous research by Fama and French (1998), which finds that globally, value stocks outperform growth stocks with an average excess return of 7.68 percent per year. For the thirteen countries tested from 1975 to 1995, only one did not show significant average returns for the value factor.

This thesis contributes to academic research, by confirming the presence of the size and value factor in Europe in recent years. However, it finds little evidence for the presence of the investment, profitability and momentum factors. It is important to examine these factors in many different regions over different time periods in order to find out if they are consistent. The fact that some proposed risk factors in this thesis prove to be small or insignificant at times undermines the robustness of risk being the main source of higher returns estimated in other studies. This might mean that some of the returns may be due to mispricing or varying risk preferences over time and per country.

For investors, the high level of average returns and premiums obtained from the size factor should indicate that when investing in indices such as the S&P Euro index, you are exposed to size risk. When investing in funds that track indices, the portfolio weights based on the market capitalization are usually limited. This means that large cap stocks make up a relatively smaller part of the total portfolio relative to the market and small cap stocks make up a relatively larger part, thereby increasing exposure to the size risk factor.

1.5 Structure

I structure the thesis in the following way. I begin with a summary in chapter 2 of the relevant literature on risk factors and equity mispricing. Chapter 3 explains the hypotheses I use to answer the research question. In chapter 4, I describe the sources used to obtain the return and book data, how they are applied to create portfolios and risk factors and their summary statistics. Chapter 5 examines the methodology used by Fama and French to test the risk factors they create. Chapter 6 shows the results of the empirical analysis and they are compared with the results from Fama and French. In chapter 7, I conclude this thesis by answering the research question.

CHAPTER 2 Literature Review

In this chapter I give an overview of the previous research done on risk factors and pricing anomalies, which helps to explain the structure of my thesis and its empirical results.

2.1 Risk Factors

Since the release of the first paper written by Fama and French in 1992 on the cross-sectional effect of size and book-to-market equity on average stock returns, financial empirical research has focused on whether the higher excess returns obtained from smaller firms and firms with a lower book-to-market ratio is an actual compensation for a higher systematic risk or an anomaly due to mispricing which can be exploited. Fama and French (1992) reason that the positive excess returns that could be gained by financing a portfolio of small firm stocks with a short portfolio of large firm stocks and financing a portfolio with high book-to-market stocks with a short portfolio with low book-to-market stocks is due to the relatively higher risk of small size and high book-to-market firms, with size being defined as the firm's market capitalization. The combined long and short positions are placed into one portfolio and its subsequent returns are defined as a risk factor. These two factors are referred to as the size and value risk factors and are added to the capital asset pricing model to form the three-factor model.

In 2015 Fama and French added two additional risk factors to their three-factor model in order to increase the cross-sectional explanatory power of the risk factor model. They reason that higher excess returns can be found for firms with higher profitability and lower investment. They use the percentage change in total assets and the earnings-to-equity ratio obtained from accounting data as proxies for investment and profitability respectively. They choose these factors in particular based on evidence from Noxy-Marx (2013) which finds that gross-profits-to-assets ratio has the same explanatory power as the book-to-market ratio when it comes to the cross-section of average returns. On average, more profitable firms generate higher returns and this indicates a premium is obtained based on the profitability of a firm, perhaps because these firms take more risk in order to obtain these high profits. The investment factor is based on evidence from Titman, Wei and Xie (2004) which finds that there is a negative relation between the increase in investments and average stock returns. Stock returns tend to be lower for firms that have a higher level of capital investment.

Other additional risk factors have been proposed based on historical patterns in returns, such as the momentum factor, which is based on the empirical findings that recent historical average returns are predictors of future short-term average returns. Jegadeesh and Titman (1993) find that strategies consisting of buying stocks that have done well in the past and selling stocks that have performed poorly results in positive excess returns for a period of three to twelve months. These average returns eventually dissipate after a period of two years. Cahart (1997) turns this strategy into a risk factor much like the risk factors created by Fama and French (1992), by subtracting the returns of a portfolio of stocks that have a higher than average past performance with the returns of a portfolio of stocks that have performed poorly.

Furthermore, Amihud (2002) creates a risk factor based on the liquidity of stocks, by buying a portfolio of stocks with a low level of liquidity and selling a portfolio of stocks with a high level of liquidity, resulting in a positive excess return explained by the fact that less liquid stocks are riskier and therefore require a higher risk premium. Amihud (2002) defines this illiquidity by the daily ratio of absolute stock return to stock trading volume.

Previous research has already been done on the three-factor model internationally by Fama and French (2012). For European stocks they find statistically insignificant average returns for the size factor and large average returns for the value and momentum factors. Furthermore, the paper attempts to create a global risk factor model and this is applied to a global portfolios of stocks, but finds that using domestic factors for domestic stock portfolios (using risk factors created from Europe and applying them to European portfolios, for example) explains stock returns more accurately, with fewer unexplained returns. These results imply that risk factors are not observed in every stock market and that every market needs to be analysed independently for risk factors. Griffin (2002) corroborates this by comparing country-specific with global risk factors and finds that domestic factors explain more of the variation in returns. Malin and Veeraraghavan (2004) estimate risk factor exposure in Europe and find a large size effect and a growth effect instead of a value effect as growth portfolios outperformed value portfolios.

2.2 Mispricing

Other papers find that these returns based on size and value are not obtained from a higher risk level, but due to mispricing possibly resulting from the behavioural biases of investors. The evidence being that test portfolios with differing levels of factor loadings have the same sensitivity to factors and have the same amount of risk premium awarded to them, instead returns could be ascribed to specific firm characteristics (Daniel & Titman, 1997). Lakonishok, Shleifer and Vishny (1994) finds that the higher excess returns obtained from value stocks might not be a compensation for higher risk, but due to mispricing. This mispricing is based on inaccurate expectations of value and glamour stocks by investors, possibly due to over- or underestimation of future growth rates of glamour and value stocks respectively. This means that the returns of a portfolio financed by shorting glamour stocks in order to invest in value stocks could simply be an arbitrage opportunity instead of compensation for a higher fundamental risk.

Furthermore, the size effect first found by Banz (1981), explained by Fama and French (1992) to be a compensation for the additional risk faced by smaller firms, is analysed in other papers such as in Brennan, Chordia and Subrahmanyam (1998) which finds that the market cap of a firm is related to the firm’s liquidity, as larger firms tend to be more popular and are therefore traded more often, resulting in higher average returns for lower market cap firms to offset the transaction costs created by a low liquidity market. Barber and Odean (2008) find that attention-grabbing stocks in particular (which are usually large market cap stocks) tend to drive stock purchases, resulting in higher overall turnover which might result in lower returns.

The momentum effect, proposed as a risk factor by Cahart (1997), has also been examined as a possible result of mispricing based on behavioural biases. A model proposed by Daniel, Hirshleifer and Subrahmanyam (1998) explains the momentum pattern together with its dissipation on the long run as a result of overconfidence and self-attribution that bias the decision making of investors. Investors overestimate their personal ability and the accuracy of their private information. When their predictions are proven correct credit themselves, but they blame external factors when they are incorrect. This results in positive short-term autocorrelation for stock returns and negative long-term autocorrelation for when the prices are eventually corrected.

CHAPTER 3 Hypotheses

In this chapter I propose a number of hypotheses which structure the empirical analysis of this thesis and answer the research question. The first hypothesis is based on the linear relationship between returns and risk factors and can be used to discover how sensitive certain portfolios are relative to the proposed risk factors. Based on previous research done into risk factors I expect portfolios with a higher exposure to the risk factor to have a larger and more significant coefficient. For example, a portfolio containing many small cap stocks should have a larger coefficient with the size factor, than a portfolio containing large cap stocks. Estimating these coefficients and testing this hypothesis is done using an OLS time-series regression.

H_0: *The coefficients of the risk factors based on size, value, investment and profitability are not monotonic across test portfolios.*

H_a: *The coefficients of the risk factors based on size, value, investment and profitability are monotonic across test portfolios.*

I use the second hypothesis to estimate the risk premiums awarded to portfolios with higher exposure to particular risk factors. Using a cross-sectional OLS regression, the coefficients estimated from the previous hypothesis are used as independents and the average portfolio returns are used as dependents in order to estimate their linear relationship. The amount the average returns of a portfolio increases relative to the increase in the risk factor sensitivity gives the amount of risk premium that is awarded by a risk factor and is supporting evidence, next to ability to explain cross-sectional variation in returns, that these returns are a result of systematic risk and not due to mispricing.

H_0: *The coefficients of the risk factors based on size, value, investment and profitability do not have a significant linear relationship with the excess returns of the test portfolios.*

H_a: *The coefficients of the risk factors based on size, value, investment and profitability have a significant linear relationship with the excess returns of the test portfolios.*

The third hypothesis looks at returns left unexplained by the OLS time-series regressions and is used to test whether the alphas of all these regressions combined are equal to zero or have values that are statistically significant. This is done using a Gibbons-Ross-Shanken test. If the test results in a rejection of the null hypothesis, it would mean that there are a significant amount of returns over all the portfolios which are not explained. This could be due to a missing risk factor not included in the model or due to mispricing not accounted for by the model.

H_0: There are no returns left unexplained when adding the risk factors to the capital asset pricing model.

H_a: There are returns left unexplained when adding the risk factors to the capital asset pricing model.

CHAPTER 4 Data

This chapter describes where the data used for the empirical analysis in this thesis comes from, how the data is used to create variables and how these variables are used to create test portfolios and risk factors. It concludes by showing the descriptive statistics of the created variables, test portfolios and risk factors.

4.1 Data Sources

The data required for the five Fama and French risk factors is obtained in three parts. The first part is the market data; which includes the close prices at the end of each month, shares outstanding, return adjustment factor and total return factor for every constituent listed on the S&P Euro index on a monthly timescale. These are used to create the monthly return and total market capitalization variables. The data is obtained from Compustat Global and the sample period spans from January 1999 to March 2016. I include delisted constituents of the index, in order to ensure that there is no survivorship bias.

The second part is the firm accounting data used to define portfolios. This includes the total amount of common and ordinary equity issued, earnings before interest and taxes, interest expenses and total assets for every constituent listed on the S&P Euro index and is done using yearly accounting data from annual financial reports. These are used to create the yearly investment, operating profit and book-to-market variables. The accounting data is also obtained from Compustat Global using the time period of January 1999 to December 2015.

The third part is the risk-free rate data. I use the Euribor rate as a proxy for the risk-free rate in the Eurozone. The Euribor is the average rate that 23 Eurozone prime banks offer for interbank euro deposits. Due to the low credit and liquidity risk associated with it, it is a commonly used risk-free rate for pricing models with European equities (Ajili, 2002). I obtain the 1-month Euribor rate from Thompson Reuters Datastream at monthly intervals in order to calculate the excess returns of the test portfolios and of the market portfolio in accordance with the Capital Asset Pricing Model. The explanation for this is simple, in order to attain the returns an investment must be made into the test or market portfolio, this investment is financed by shorting a risk-free asset such as a bond, or simply by taking a loan. Furthermore, this assures that the returns are risk adjusted, and now no longer incorporate the non-risk part of the return. The remaining return can then be seen as a premium paid for the level of systematic risk, conditional on the risk aversion of the market (Fama & French, 2004).

The three datasets are merged using their ISIN codes and monthly time periods. The list of ISIN codes for all the constituents of the S&P Euro index is obtained from Compustat. After merging the three datasets, a number of observations are removed. Due to the introduction of the euro currency in January 1999 (and countries introduced into the Eurozone at later periods), time-periods in which a constituent traded on its original pre-Euro currency are omitted, either when the market prices or the accounting data are denoted in non-Euro currencies (Bertaut, Iyigun, & Troha, 1999). This ensures that all variables are comparable over all the constituents, regardless of the country they are listed in. This removes any possible bias in the test portfolios or risk factors that a change in currency or comparing differing currencies would cause. Furthermore, any missing or negative prices are removed. This results in a total time period of 196 months, from January 2000 to March 2016.

Lastly, a list of all the names, ISIN codes and Compustat GVKEY codes of the constituents of the S&P Euro index used are given in appendix table A1. The variable codes used to obtain the market and accounting data from Compustat are in appendix table A2.

4.2 Variables

First, I create the monthly return variable $R_{i,t}$ for every constituent. Due to the use of monthly close prices in order to create returns, a number of return generating and price adjusting factors are missing, such as stock splits and dividend issues. In order to account for these events, the Compustat database holds two additional variables that can be used to calculate a more accurate return variable. These are the return adjustment factor and total return factor variables. Using these the variables the complete monthly return is calculated using the equation given in table 1.

Second, I create the market capitalization variable $ME_{i,t}$ using market data by taking the product of the closing price and the amount of shares outstanding of each constituent *i* at the end of every month *t* in euros. This variable is a proxy for the size of the firm and is used to create portfolios based on size. The equation used to compute the market capitalization variable is given in table 1.

Third, I create the book-to-market variable $B/M_{i,t}$ using both the market and accounting data. The common and ordinary book value of equity is divided by the market capitalization variable, which represents the market value of equity. This ratio represents the value risk factor and firms with a higher book-to-market ratio are relatively undervalued by the market and firms with a low book-to-market ratio are relatively overvalued by the market.

Fourth, the operating profit variable $OP_{i,t}$ is created by taking the difference between the earnings before interest and taxes and the interest expense and dividing that difference by the book value of equity for every year. Here my variable differs from Fama and French (2015), due to the fact that they use additional accounting data. Fama and French (2015) create the operating profit variable by taking the yearly revenues minus the cost of goods sold, minus selling, general and administrative expenses, minus interest expense and then divide the resulting operating profits by the book value of equity. Due to the limited availability of data from Compustat on these variables, I create this variable using earnings before taxes, which should not differ significantly from the variable created by Fama and French (2015). The equation used to calculate the operating profit variable is given in table 1.

Fifth, the investment variable $INV_{i,t}$ is created by calculating the change in the value of the total assets held by the firm. This is done by dividing the difference between the total assets in the fiscal year t-1 and the current fiscal year t by the total assets of the fiscal year t-1. The resulting variable shows the change in the value of the total assets held by the firm relative to the value of the total assets. The equation is denoted in table 1.

The sixth and last variable I create is the momentum variable $MOM_{i,t}$. Momentum is calculated by taking the moving average of returns for the past twelve months. The returns of the twelve months are equally weighted and are meant to indicate a trend in recent returns in accordance with the model from Cahart (1999) that shows that, on average, recent returns with a positive or negative sign are followed by returns of the same sign in the short term future. As mentioned in the introduction, this is possibly due to a number of behavioural biases or market imperfections. The equation used to calculate the momentum variable can be found in table 1.

Table 1: Construction of Variables

Variable	Equation
Return	$R_{i,t} = \frac{(P_{i,t}/AF_{i,t}) * TRF_{i,t}}{(P_{i,t-1}/AF_{i,t-1}) * TRF_{i,t-1}} - 1$
Market capitalization	$ME_{i,t} = P_{i,t} * SO_{i,t}$
Book-to-market	$B/M_{i,t} = BE_{i,t}/ME_{i,t}$
Operating Profit	$OP_{i,t} = (EBIT_{i,t} - INTX_{i,t})/BE_{i,t}$
Investment Level	$INV_{i,t} = (TA_{i,t} - TA_{i,t-1})/TA_{i,t-1}$
Momentum	$MOM_{i,t} = \sum_{j=1}^{12} R_{i,t-j} \Big/ 12$

Construction of the return, market capitalization, book-to-market, operating profitability, investment and momentum variables using the closing price P, total return factor TRFD, adjustment factor AF, shares outstanding SO, book value of equity BE, earnings before interest and taxes EBIT, interest expenses INTX and total assets TA. These variables are used to define portfolios used to create risk factors.

4.3 Factors

Now that the variables have been calculated, risk factors can be created by assigning the returns of the stocks to a particular portfolios weighted by their market capitalization. Depending on the factor loading of the portfolio (whether it is a portfolio with stocks with the highest or lowest amount of a given variable) it will be chosen to either sell or buy the portfolio. The equally weighted combination of the bought and sold portfolios results in a risk factor.

I start with the value factor HML_t, which is created using six double-sorted portfolios using the book-to-market ratio and the market capitalization. The portfolios are created using the 30th and 70th percentile breakpoints for the book-to-market ratio and the median is used as a breakpoint for the market capitalization. The stocks with the highest and lowest 30 percent book-to-market values are used to create the H and L portfolios, respectively. These portfolios are once again sorted based on the market capitalization of the firms. The stocks with the largest and smallest 50 percent market capitalization create the B and S portfolios respectively. The selected stocks for each portfolio have their returns weighted based on their market capitalization and summed to create the portfolio return. The resulting portfolios are SH_t, BH_t, SL_t and BL_t. The portfolios are created yearly in June using the book-to-market ratio of the previous fiscal year and the market value of equity computed in December of the previous year, in accordance with Fama and French (2015). In order to create the value factor HML_t, the equally-weighted average returns of the portfolios with the lowest book-to-market ratio SL_t and BL_t are subtracted from the equally-weighted average returns of the portfolios with the highest book-to-market ratio SH_t and BH_t. The equation is shown in table 2.

The next three factors, profitability RMW_t, investment CMA_t and momentum UMD_t are created in the same way, by creating double-sorted portfolios with value-weighted returns using the top 30 and bottom 30 percentiles as breakpoints. The investment factor differs in this regard from the other factors, by taking the returns of the portfolios with the lowest investment levels SC_t and BC_t minus the returns of the portfolios with the highest level of investment SA_t and BA_t, because higher levels of investment coincide with relatively lower returns according to the Fama and French (2015) model. Just like the value factor portfolios, the profitability and investment factor portfolios are created in June of each year by using the variables created at the end of the previous fiscal year. The momentum factor portfolios are also created in June, but are based on the return data of the past 12 months.

I create the size factor SMB_t in three steps. First, the size factor $SMB_{B/M,t}$ is created using double-sorted portfolios based on the market cap and the book-to-market ratio. Secondly, I create the size factor $SMB_{OP,t}$ using double-sorted portfolios based on the market cap and operating profit. The third size factor $SMB_{Inv,t}$ is created using double-sorted portfolios based on the market cap and the investment level. These portfolios are created in the same way as those used in the previously created risk factors, by using the 30th and 70th percentile as a breakpoint for the portfolios based on the book-to-market ratio, profitability and investment level. The median is used as a breakpoint when creating the size portfolios. However, when creating these size factors, the portfolio containing the middle 40 percent factor of loadings are also used. The return of a size factor is then calculated by subtracting the equally weighted returns of the portfolios with the largest market cap BL_t, BH_t and BM_t from the equally weighted returns of the portfolios with the smallest market cap SL_t, SH_t and SM_t. The return of the size factors created are now combined using equal weights resulting in the total size factor SMB_t. I chose to create the size factor in this manner, because I can then use the size factor $SMB_{B/M,t}$ in the Fama and French three-factor model (when the only other factor is the value factor) and the total size factor SMB_t in the Fama and French five-factor model (when the risk factors based on value, profitability and investment are used). The size factor is then more accurately incorporated in the model and the same is done in Fama and French (2015).

Lastly, the market factor from the capital asset pricing model by Sharpe (1964), Litner (1965) and Black (1972) is created by taking the sum of the value-weighted returns from all the constituents every month. The market factor is calculated in this way, because it is a more accurate representation of market return and risk, than obtaining the returns from the price of the S&P Euro index. Including this factor in the model will ensure that the returns obtained as compensation for exposure to market risk are accounted for, so that these are not incorrectly explained for by one of the other risk factors or left unexplained.

Table 2: Construction of Factors

Factor	Equation
Value	$HML_t = \frac{1}{2}(SH_t + BH_t) - \frac{1}{2}(SL_t + BL_t)$
Profitability	$RMW_t = \frac{1}{2}(SR_t + BR_t) - \frac{1}{2}(SW_t + BW_t)$
Investment	$CMA_t = \frac{1}{2}(SC_t + BC_t) - \frac{1}{2}(SA_t + BA_t)$
Momentum	$UMD_t = \frac{1}{2}(SU_t + BU_t) - \frac{1}{2}(SD_t + BD_t)$
Size (B/M)	$SMB_{B/M,t} = \frac{1}{3}(SH_t + SM_t + SL_t) - \frac{1}{3}(BH_t + BM_t + BL_t)$
Size(OP)	$SMB_{OP,t} = \frac{1}{3}(SR_t + SM_t + SW_t) - \frac{1}{3}(BR_t + BM_t + BW_t)$
Size(Inv)	$SMB_{Inv,t} = \frac{1}{3}(SC_t + SM_t + SA_t) - \frac{1}{3}(BC_t + BM_t + BA_t)$
Size	$SMB_t = \frac{1}{3}\left(SMB_{B/M,t} + SMB_{OP,t} + SMB_{Inv,t}\right)$
Market (CAPM)	$RM_t - RF_t = \left(\sum_{i=1}^{n} {(R_{i,t} * ME_{i,t})}\big/{\sum_{i=1}^{n} ME_{i,t}}\right) - RF_t$

Construction of the market, size, value, profitability, investment and momentum factors. Value weighted returns are assigned to each double-sorted portfolio based on size and an additional risk factor. The size of the portfolio is indicated with and S (small) or B (big) defined using the median of the market cap. The factor loading of the portfolio is indicated by the secondary letter. For the value factor HML (high minus low book-to-market ratio), H and L indicate the portfolio with the highest and lowest 30 percent of B/M stocks, respectively. The same goes for the profitability factor RMW (robust minus weak profitability), CMA (conservative minus aggressive relative investment) and the momentum factor UMD (up minus down average historical returns) for which the portfolios R, A and U contain stocks with the highest 30 percent of profitability, investment and average historical returns and for which W, C and D indicate the portfolio of stocks lowest 30 percent. The size factor SMB is created by taking the difference between the equally weighted sum of all the small cap portfolios and the equally weighted sum of all the large cap portfolios. The market factor is estimated by taking the sum of the value weighted returns of all stocks listed in the S&P Euro index.

4.4 Test Portfolios

The test portfolios are created in the same way that the factor portfolios are created, only now the 25th percentiles are used as breakpoints for the portfolios. They are also double-sorted on the market cap and their corresponding factor loadings based on the book-to-market ratio, operating profitability and investment level. This results in 4x4 portfolios based on size and one of the factor loadings. No test portfolios are made for the momentum variable as it is only used as a control factor. The returns of the test portfolios are calculated by taking the sum of the value-weighted returns of all the stocks in the portfolio. The returns of the portfolios are then turned into excess returns by subtracting the Euribor rate from it. These excess returns from the 4x4 portfolios are used in chapter 4 as independent variables in the OLS and Fama-Macbeth regressions.

4.5 Descriptive Statistics

The appendix table B1 shows the descriptive statistics of the variables used to create the factors and test portfolios. It shows the average, standard deviation, number of observations, minimum and maximum values for the top 30, middle 40 and bottom 30 percent of the book-to-market, operating profit, investment and momentum variables. For the market cap variable, it gives the descriptive statistics for the top and bottom 50 percent.

Table 3 shows the average returns for every risk factor, together with its standard deviation, t-statistic and significance level. Only the size and market risk factor have returns that differ significantly from zero. This would indicate that during the sample period the value, profitability, investment and momentum factors might have varied in their significance, possibly due to the financial crises in 2000 and in 2008 which would also explain the negative average market factor returns.

Table 3: The average returns for every factor.

	Rm-Rf	SMB(b/m)	SMB	HML	RMW	CMA	UMD
Mean	-1.19	0.68	0.67	0.39	0.07	0.26	0.06
Stn. dev.	5.64	2.39	2.17	4.42	3.36	2.79	4.94
T-statistic	-2.91	3.92	4.13	1.23	0.28	1.26	0.18
Sig.	0.00	0.00	0.00	0.22	0.78	0.21	0.86

Shows the average returns in percentages, standard deviations and t-tests for the market (Rm-Rf), size (SMB), value (HML), profitability (RMW), investment (CMA) and momentum (UMD) risk factors. The sample spans a time period of 178 months, from June 2001 to March 2016.

Table 4 shows the correlation between risk factors. A number of correlations are noteworthy, because they are not consistent with the analysis of Fama and French and other empirical research. First, the returns of the size factor SMB have a positive correlation with the returns of the value factor HML. Second, the returns of the value factor HML are negatively correlated with the profitability factor RMW with a coefficient of -0.82. This contradicts the statistical analysis by Fama and French (2015) which found a very small positive correlation coefficient. Furthermore, this would mean that with increasing profitability the book-to-market ratio would decrease. According to basic accounting, when profits increase, the book value of equity should increase as well. A possible explanation might be that due to the time sample chosen from 1999 to 2016, when two very large financial crises occurred, firms might have used profits to buy back shares due to low share prices. Increasing profits could then lead to a decrease in the book value of equity.

Table 4: The correlation between risk factors.

	SMB(b/m)	SMB	HML	RMW	CMA	UMD
SMB(b/m)	1.00					
SMB	0.97	1.00				
HML	0.44	0.48	1.00			
RMW	-0.39	-0.41	-0.82	1.00		
CMA	0.41	0.38	0.49	-0.51	1.00	
UMD	-0.23	-0.24	-0.54	0.56	-0.16	1.00

Shows the correlation of the returns between every risk factor, calculated over a time span of 178 months, from June 2001 to March 2016.

Table 5 shows the average returns for every test portfolio created. The first section shows the 4x4 double-sorted test portfolios based on the market cap and the book-to-market ratio. Overall it does show increasing returns for portfolios with higher book-to-market ratios, however this is not always a significant increase and sometimes the increase is not constant. This is also what Fama and French (2015) finds, in particular book-to-market portfolios with a large market cap have a small non-constant increase in returns for increasing levels of the book-to-market ratio. The opposite is true for book-to-market portfolios with a lower market cap, which increase far more in returns when the book-to-market ratio increases.

The 4x4 double-sorted portfolios based on investment level show that the returns do not decrease consistently as investment level increases, here Fama and French (2015) also finds some inconsistency in the returns for increasing levels of investment, however not to same degree as my findings. The returns of the profitability test portfolios increase with increasing profitability levels, however the increase is not very large and not always consistent either.

It is clear from the average returns per portfolio that increasing factor loadings will alter the returns linearly, but that this change is only robust for the portfolios with the highest and lowest factor loadings. Furthermore, the increase in returns for portfolios formed with smaller market cap stocks relative to portfolios with larger market cap stocks is robust for all factor loadings.

Table 5: The average returns for every test portfolio.

	Low	2	3	High
Size-B/M test portfolios				
Small	1.19	1.71	1.66	2.00
2	1.04	1.18	1.23	1.10
3	0.86	1.10	0.92	1.00
Big	0.65	0.67	0.72	0.67
Size-Investment test portfolios				
Small	1.84	1.45	1.79	2.00
2	1.42	1.17	1.23	0.96
3	1.15	0.85	0.90	0.87
Big	0.65	0.64	0.65	0.56
Size-Profitability test portfolios				
Small	1.85	1.70	1.96	2.02
2	1.10	1.10	1.06	1.40
3	0.93	0.83	0.99	1.09
Big	0.63	0.63	0.63	0.72

Shows the average monthly returns of test portfolios double-sorted based on size and book-to-market, investment and profitability using the 25th percentile as a breakpoint.

Lastly, I compare the returns of the risk factors from the S&P Euro index with the returns of the risk factors from U.S. equities created by Fama and French (2015) in table 6. The results show some correlation for the risk factors, in particular the market factor. However, the size factor has a relatively low correlation. This is understandable when you look at the sample of stocks chosen. Fama and French (2015) use a far larger sample which includes all NYSE, NASDAQ and AMEX stocks. In this thesis I only use stocks listed on the S&P Euro index and as a result my sample contains stocks that on average have larger market capitalizations. This is due to the methodology used by S&P to create indices which favours larger firms. This, however, does not undermine the empirical analysis, since the variation in market capitalization is still large, as can be seen in the descriptive statistics in appendix table B1.

Table 6: The correlation between US and Euro risk factors.

Mkt-RF	SMB	HML	RMW	CMA
0.88	0.24	0.50	0.55	0.56

This table shows the correlation between the returns of the risk factors of U.S. stocks created by Fama and French (2015) and the returns of the risk factors created using the S&P Euro index stocks.[1] The correlations are calculated over a time span of 178 months, from June 2001 to March 2016.

[1] The returns of the Fama and French risk factors for U.S. stocks are obtained from Kenneth French at the following source: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/

CHAPTER 5 Methodology

In this chapter I describe how I create the asset pricing models using the factors and test portfolios created in chapter 3. First, three time-series regression are made using models based on previous empirical research in order to find out if the risk factors explain the returns. After that, a two-stage Fama-Macbeth regression estimates whether a premium is obtained from these risk factors (whether returns increase with increasing factor exposure). Lastly, a Gibbons-Ross-Shanken test determines whether all returns are explained by the model by testing the significance of the alphas of all the regressions combined.

5.1 Time-Series Regressions

In order to test the first hypothesis, I run multiple time-series regressions using the monthly returns of the test portfolios $R_{i,t}$ in excess of the monthly 1-month Euribor risk-free rate RF_t as dependent variables. The test portfolios used are double-sorted based on the market cap and an additional variable. The independent variables of the regressions are the returns of risk factors created in the previous chapter. Every regression will include the excess return of the market $(RM_t - RF_t)$ from the capital asset pricing model as an independent variable, in order to assure that the returns obtained from market wide price changes are accounted for and are not assigned to one of the other risk factors. The intercept is included for all regressions in order to see how much of the returns of the test portfolio have been left unexplained.

The first hypothesis I pose, states that there is a linear relationship between test portfolios and risk factors and that it is monotonic over test portfolios. This is tested by looking at whether the sensitivity towards a risk factor increases as test portfolio factor loadings increase. This means that test portfolios holding smaller stocks in terms of their market cap should have a larger, positive and significant size factor coefficient. Alternatively, portfolios holding large firms should have significantly negative coefficients. The mid cap portfolios should have sensitivities towards the size factor which are closer to zero and are possibly statistically insignificant. The same goes for the other risk factors. These observations were originally found in Fama and French (1992) and their coefficients are compared with those obtained from my regressions.

5.1.1 Fama & French Three-Factor Model

The first series of regressions I make are based on the three-factor model originally proposed by Fama and French (1992). The test portfolios are double-sorted based on the market cap and the book-to-market ratio. Using the 25^{th} percentile as a breaking point results in 4 x 4 portfolios of stocks. The value-weighted returns of these portfolios $R_{i,t}$ are turned into excess returns using the risk-free rate RF_t. The three factors used as independent variables in this model are the market factor $(RM_t - RF_t)$, the size factor $SMB_{B/M,t}$ (which only incorporates portfolios based on value, as can be seen in chapter 4) and the value factor HML_t. The result of the time-series regressions is an intercept α_i and a coefficient for the market factor β_i, for the size factor s_i and for the value factor h_i. The remaining difference between the estimated returns and the observed returns is denoted in the residual $\varepsilon_{i,t}$. The regression model is formalized in equation 1.

(1) $$R_{i,t} - RF_t = \alpha_i + \beta_i(RM_t - RF_t) + s_i * SMB_{B/M,t} + h_i * HML_t + \varepsilon_{i,t}$$

5.1.2 Cahart Four-Factor Model

The second time-series regression model is an extension of the first model, created by adding the momentum factor UMD_t which is used to estimate the coefficient of the momentum factor u_i. The test portfolios used in this regression are the same as in the Fama and French three-factor. No test portfolios are sorted based on the momentum variable, as it is only used as a control variable. The regression model is represented in equation 2.

(2) $$R_{i,t} - RF_t = \alpha_i + \beta_i(RM_t - RF_t) + s_i * SMB_{B/M,t} + h_i * HML_t + u_i * UMD_t + \varepsilon_{i,t}$$

5.1.3 Fama & French Five-Factor Model

The third and final regression model is once again an extension of the three-factor model and now adds the 2 risk factors from Fama and French (2015). The profitability and investment risk factors, RMW_t and CMA_t respectively are added and the size factor is now adjusted to include portfolios based on profitability and investment, as seen in chapter 4. Furthermore, additional test portfolios are added to the model as independents. Next to the already created test portfolios based on the book-to-market variable, additional test portfolios are created based on profitability and investment levels using the quartiles as breakpoints. These are also double-sorted based on market cap, resulting in a total amount of 3 x 4 x 4 test portfolios. The model is regression model is formalized in equation 3.

(3) $$R_{i,t} - RF_t = \alpha_i + \beta_i(RM_t - RF_t) + s_i * SMB_t + h_i * HML_t + r_i * RMW_t + c_i * CMA_t + \varepsilon_{i,t}$$

5.2 Fama-Macbeth Regression

I test the second hypothesis by using a two-step Fama-Macbeth regression. The first step of this regression is already estimated in the previous models, namely the estimated coefficients obtained from the three-factor ($\hat{\beta}_i$, $\hat{s}_i$ and $\hat{h}_i$), four-factor ($\hat{u}_i$) and five-factor models ($\hat{r}_i$ and $\hat{c}_i$). These coefficients are now used as independent variables which are used to explain the average of the excess returns of the test portfolios used in the previous regression models. The lambda coefficients in the Fama-Macbeth regressions represent the linear relation between the excess return of a portfolio with its respective estimated sensitivity toward a risk factor, representing its risk premium. The equations 4, 5 and 6 represent the Fama-Macbeth regressions made for the three-factor, four-factor and five-factor models, respectively.

(4) $$R_i - RF = \lambda_0 + \lambda_1 * \hat{\beta}_i + \lambda_2 * \hat{s}_i + \lambda_3 * \hat{h}_i + \varepsilon_{i,t}$$

(5) $$R_i - RF = \lambda_0 + \lambda_1 * \hat{\beta}_i + \lambda_2 * \hat{s}_i + \lambda_3 * \hat{h}_i + \lambda_4 * \hat{u}_i + \varepsilon_{i,t}$$

(6) $$R_i - RF = \lambda_0 + \lambda_1 * \hat{\beta}_i + \lambda_2 * \hat{s}_i + \lambda_3 * \hat{h}_i + \lambda_4 * \hat{r}_i + \lambda_5 * \hat{c}_i + \varepsilon_{i,t}$$

The second hypothesis states that there is a linear relation between the risk factor coefficients estimated for every test portfolios and their respective excess returns. This should mean that the estimated lambda coefficients are significantly positive, which would mean that there is a risk premium awarded to portfolios which are exposed to this risk. For the size effect, a positive risk premium would mean that λ_2 should be positive, which would indicate that portfolios with larger weights assigned to small cap stocks are exposed to higher risk and obtain a higher return relative to large cap stocks.

5.3 GRS-test

The third hypothesis is tested by using a Gibbons-Ross-Shanken test in order to find out whether the returns of the test portfolios are fully explained by the risk factors. Unexplained returns are assigned to the intercept of the regression model and for each time-series regression the intercept is tested for its significance independently. The GRS-test tests the significance of all the intercepts for all the regressions combined in order to see if the significance is a systemic occurrence or only occurs in a few particular test portfolios.

The GRS-test can be split into 3 parts. The first part denotes the scale of the test, where the number of time period observations T has the number of test portfolios N and number of risk factors K subtracted from it, which is then divided by the total number of test portfolios. The second part uses the returns explained by the factors, where $E(\boldsymbol{f})$ stands for the expected returns of the risk factors and is represented as a vector of the average returns of the risk factors. This vector is then multiplied by the inverse of the covariance matrix of risk factor returns, denoted by $\widehat{\boldsymbol{\Omega}}^{-1}$. The result is then once again multiplied by the transposed vector of average factor returns $(\boldsymbol{f})'$, summed with one and inversed. The third part uses the unexplained returns of the model, either placed in the vector of intercepts $\widehat{\boldsymbol{\alpha}}$ or in the residual covariance matrix $\widehat{\boldsymbol{\Sigma}^{-1}}$. The vector and transposed vector of intercepts are multiplied with the inverse residual covariance matrix. The three parts are then multiplied with each other and the remaining GRS-statistic is subjected to an F-distribution with N number of numerator degrees of freedom and $T - N - K$ number of denominator degrees of freedom. The test is formalized in equation 7.

(7) $$GRS = \frac{T-N-K}{N} * \left(1 + E(\boldsymbol{f})' * \widehat{\boldsymbol{\Omega}}^{-\mathbf{1}} * E(\boldsymbol{f})\right)^{-1} * \widehat{\boldsymbol{\alpha}}'\widehat{\boldsymbol{\Sigma}^{-\mathbf{1}}}\widehat{\boldsymbol{\alpha}} \sim F(N, T-N-K)$$

The third hypothesis proposes that there are no returns left unexplained when the risk factors are added to the model. When the GRS-test is performed and the value falls with the critical range on the F-distribution, the hypothesis is rejected, as all the estimated alphas combined are significant. This would mean that there are portfolios with excess returns whose variation is not explained by the risk factors included in the model. These returns are possibly accounted for by risk factors not included in the model or possible mispricing resulting from behavioral biases. When the GRS-statistic does not fall in the critical range on the F-distribution, the hypothesis stating that the alphas are equal to zero is not rejected. It can then be said that the model explains all the variation of the excess returns of the test portfolios.

CHAPTER 6 Results

This chapter shows and describes the results of the tests and models proposed in chapter 5 in order to test the hypotheses posed in chapter 3. In the first section I show the coefficients of the risk factors resulting from the time-series regressions for every test portfolio, in the second section I show the coefficients resulting from the Fama-Macbeth regressions and in the third section I show the results from the Gibbons-Ross-Shanken test to estimate the significance of the intercepts.

6.1 Time-Series Regressions

The results of the first time-series regressions based on the Fama-French three-factor model in table 7 indicate that there are significant linear relations between the risk factors and the test portfolios. In particular, the test portfolios with the highest (lowest) market cap and book-to-market equity have significantly positive (negative) coefficients. The portfolios with the highest book-to-market stocks have particularly extreme size coefficients, ranging from -0.78 to 1.93. Furthermore, the intercepts of the regressions overall are not significant, except for a number of small cap portfolios. The betas of these regressions are all significant and hold a value around that of 1, which is to be expected with diversified value-weighted portfolios.

The results of the regressions largely correspond with previous research done by Fama and French (1992) which also show an increase in factor sensitivity with increasing risk factor exposure in the test portfolios. However, the coefficients are more pronounced in their regressions, with larger positive and negative coefficients for the portfolios with the highest and lowest factor exposure, respectively. This can be explained due to the use of 5 x 5 test portfolios by Fama and French, which allows for portfolios with an even higher factor exposure. Furthermore, the alphas and betas are comparable with those of Fama and French (1992), which lie around 0 and 1 for most regressions.

However, one of the value factor coefficients is not consistent in its increase with factor exposure. The small growth portfolio with a coefficient of -0.17 has a lower sensitivity to the value factor than the portfolio with a lower value factor exposure, containing lower book-to-market ratio stocks. But given the low level of significance, the resulting coefficients cannot be said to differ significantly from zero. This shows, in contradiction of Fama and French (1992), that the smallest cap portfolios do not have a large sensitivity to the value factor, except for the extreme value portfolio.

Just like the regressions of Fama and French (2015), the intercepts of a number of small cap portfolios is significant, which already brings into question the validity of the model. The intercepts show an unexplained excess return of 0.65% and 0.50% per month. Unlike the results of Fama and French (2015) these are found in portfolios with average book-to-market ratios, whereas they find them in extreme growth portfolios.

The coefficients of the second regression model which builds upon the Fama and French three-factor model by including the momentum factor can be found in table 8. The additional momentum factor does not seem to increase the explanatory power of the model, as most coefficients are insignificant. Furthermore, the coefficients of the other risk factors and the intercept do not change drastically, indicating there has been no increase in the explanation of the returns of the test portfolios. There is no monotonic relation or pattern to be found in the increasing factor exposure of the portfolios and the sensitivity to the momentum risk factor. More important is the fact that there is only one portfolio with a positive coefficient and that there are two portfolios with negative coefficients, all three of which are portfolios with relatively small stocks. The Cahart four-factor model is therefore rejected, as the momentum factor does not seem to explain excess returns. A possible improvement to test the momentum factor further would be to use test portfolios with varying degrees of momentum exposure as independents in the regression model, as using double-sorted portfolios based on size and book-to-market equity ratios might not show a clear pattern of momentum sensitivity.

Table 7: Time-series regressions for the 3-factor model, using 16 value-weighted Size-B/M portfolios as a dependent variable.

$$R_{i,t} - RF_t = \alpha_i + \beta_i(RM_t - RF_t) + s_i * SMB_{B/M,t} + h_i * HML_t + \varepsilon_{i,t}$$

B/M	Low	2	3	High	Low	2	3	High
	α				β			
	0.12	0.65	0.5	-0.43	1.17	0.99	1.02	1.13
Small	[0.40]	[2.19]	[1.63]	[-1.43]	[27.91]	[11.95]	[16.39]	[11.73]
	-0.04	0.03	0.13	-0.07	1.04	0.87	0.94	0.92
2	[-0.27]	[0.13]	[0.73]	[-0.49]	[30.17]	[13.03]	[18.52]	[23.17]
	-0.16	0.23	0.09	0.14	0.94	0.96	1.01	1.14
3	[-0.92]	[1.14]	[0.61]	[0.91]	[25.84]	[22.84]	[12.92]	[22.06]
	-0.19	-0.02	0.05	0.11	0.96	1.04	0.94	1.07
Big	[-1.33]	[-0.12]	[0.42]	[0.83]	[27.07]	[16.50]	[34.53]	[30.24]
	s				h			
	0.59	0.65	0.55	1.93	0.01	-0.17	0.13	1.12
Small	[1.96]	[5.12]	[2.28]	[4.78]	[0.15]	[-1.34]	[1.41]	[6.95]
	0.6	0.38	0.34	0.42	-0.43	0.00	0.14	0.32
2	[5.88]	[3.75]	[1.91]	[1.08]	[-6.89]	[0.01]	[1.62]	[3.83]
	0.21	0.12	0.16	0.14	-0.25	-0.1	0.06	0.22
3	[3.45]	[1.14]	[1.12]	[0.75]	[-9.31]	[-1.20]	[0.52]	[2.72]
	-0.02	-0.11	-0.33	-0.78	-0.3	-0.05	0.19	0.79
Big	[-0.11]	[-1.30]	[-2.52]	[-7.88]	[-5.03]	[-1.01]	[4.84]	[13.54]

The table shows the coefficients of each factor for every regression with differing test portfolios based on the market cap and the book-to-market ratio. The test portfolios are created at the end of June every year from 2001 to 2015 and are created using the 25th percentiles of the market cap and book-to-market ratio as breakpoints. The excess returns of the test portfolios (Ri) are created using the 1-month Euribor as a risk-free rate (RF). The RM-RF, SMB and HML factors represent the market, size and value risk factor, respectively. The excess returns of the test portfolios and risk factors are obtained from June 2001 to March 2016, for a period of 178 months. The t-statistic is given in brackets below the coefficient.

Table 8: Time-series regressions for the 4-factor model, using 16 value-weighted Size-B/M portfolios as a dependent variable.

$$R_{i,t} - RF_t = \alpha_i + \beta_i(RM_t - RF_t) + s_i * SMB_{B/M,t} + h_i * HML_t + u_i * UMD_t + \varepsilon_{i,t}$$

B/M	Low	2	3	High	Low	2	3	High
	α				β			
	0.12	0.65	0.5	-0.43	1.12	0.97	1.03	1.1
Small	[0.44]	[2.42]	[1.64]	[-1.50]	[19.10]	[10.65]	[20.02]	[9.32]
	-0.04	0.03	0.13	-0.07	1.01	0.92	0.95	0.93
2	[-0.34]	[0.17]	[0.73]	[-0.36]	[38.23]	[12.49]	[18.31]	[19.81]
	-0.16	0.23	0.09	0.14	0.95	0.94	1.02	1.15
3	[-1.10]	[1.23]	[0.61]	[0.91]	[32.87]	[16.48]	[12.85]	[25.47]
	-0.19	-0.02	0.05	0.11	0.97	1.02	0.93	1.07
Big	[-1.28]	[-0.13]	[0.38]	[0.67]	[26.69]	[21.09]	[32.68]	[22.74]
	s				h			
	0.57	0.64	0.56	1.92	-0.06	-0.19	0.15	1.08
Small	[2.02]	[4.11]	[2.26]	[4.59]	[-0.70]	[-1.96]	[1.56]	[8.60]
	0.58	0.4	0.35	0.42	-0.48	0.08	0.15	0.34
2	[7.31]	[4.32]	[1.93]	[1.27]	[-9.68]	[1.22]	[1.86]	[3.50]
	0.22	0.12	0.16	0.14	-0.23	-0.14	0.08	0.23
3	[3.54]	[0.98]	[1.14]	[0.78]	[-6.85]	[-1.85]	[0.82]	[2.55]
	-0.01	-0.12	-0.34	-0.78	-0.29	-0.09	0.17	0.79
Big	[-0.10]	[-1.44]	[-2.99]	[-7.03]	[-6.06]	[-1.86]	[3.65]	[9.33]
	u							
	-0.17	-0.05	0.04	-0.1				
Small	[-2.61]	[-0.43]	[0.33]	[-0.81]				
	-0.11	0.18	0.02	0.04				
2	[-2.74]	[2.80]	[0.63]	[0.49]				
	0.06	-0.07	0.04	0.03				
3	[1.34]	[-0.69]	[0.57]	[0.59]				
	0.02	-0.09	-0.04	-0.02				
Big	[0.38]	[-1.77]	[-1.30]	[-0.25]				

The table shows the coefficients of each factor for every regression with differing test portfolios based on market cap and the book-to-market ratio. The test portfolios are created at the end of June every year from 2001 to 2015 and are created using the 25th percentiles of the market cap and book-to-market ratio as breakpoints. The excess returns of the test portfolios (Ri) are created using the 1-month Euribor as a risk-free rate (RF). The RM-RF, SMB, HML and UMD factors represent the market, size, value and momentum risk factor, respectively. The excess returns of the test portfolios and risk factors are obtained from June 2001 to March 2016, for a period of 178 months. The t-statistic is given in brackets below the coefficient.

The coefficients of the third time-series regression model, which adds the investment and profitability risk factors to the original three-factor model, can be found in tables 9, 10 and 11. In table 9 the regression uses excess returns of test portfolios double-sorted based on the book-to-market ratio and the market cap as independent variables. The result of adding the investment and profitability factors has led to a decrease in the size of some of the intercepts which were significant in the previous model, in particular the intercepts for the portfolios with the smallest cap stocks have lost their statistical significance. However, the small growth portfolio with an alpha of 0.55% still indicates a problem with explaining excess returns, perhaps due to certain mispricing of those types of stocks during this time period. Fama and French (2015) also has this problem, however, their coefficient is smaller and only prevalent in the lowest book-to-market portfolio, whereas this thesis finds a large intercept in the second lowest portfolio. The result therefore corroborates the problem with explaining excess returns of small growth stocks. Furthermore, the coefficients of the size and value factors remain largely the same after the inclusion of the profitability and investment factors.

Table 10 contains the coefficients resulting from the five-factor model using 4 x 4 portfolios double-sorted on size and investment level. The intercepts of the regressions overall are small, however, the alphas for the small cap high investment portfolios show a high level of unexplained returns of 0.57% and 0.98%. This is comparable to Fama and French (2015) which also finds significant alphas for the smallest cap portfolios and in particular for the highest investment levels, however their alphas are negative. The coefficients of the size factor still show that the size effect is robust even when double sorting test portfolios with another factor exposure, as sensitivities to the size factor decrease for portfolios with larger market cap stocks. Furthermore, the sensitivity to the size factor increases with increasing exposure to higher investment stocks, since overall portfolios with the highest investment level stocks have larger coefficients than those with the lowest investment level. This, however, is not the case for the smallest cap portfolios, whose portfolio with the lowest exposure to a high investment level has a coefficient of 1.38.

In accordance with Fama and French (2015) the exposure to higher levels of investment correspond with a higher sensitivity to the investment factor. In particular, for the largest and smallest cap portfolios the change in investment level from low to high results in lower and negative coefficients. The mid cap portfolios, however, show no significant linear relationship to the investment factor, except those containing stocks with the highest investment levels. Fama and French (2015) find a different result, as only the portfolios with the highest investment levels have negative coefficients and all other portfolios seem to have positive coefficients. Lastly, the value and profitability factors do not seem to have any explanatory power when it comes to portfolios sorted on investment level. Most of the coefficients do not differ significantly from zero.

Table 9: Time-series regressions for the 5-factor model, using 16 value-weighted Size-B/M portfolios as a dependent variable.

$$R_{i,t} - RF_t = \alpha_i + \beta_i(RM_t - RF_t) + s_i * SMB_t + h_i * HML_t + r_i * RMW_t + c_i * CMA_t + \varepsilon_{i,t}$$

B/M ->	Low	2	3	High	Low	2	3	High
	α				β			
	0.13	0.55	0.30	-0.39	1.16	1.05	1.07	1.16
Small	[0.45]	[1.66]	[0.89]	[-1.05]	[21.12]	[19.74]	[19.09]	[14.22]
	-0.1	-0.05	0.03	-0.23	1.02	0.92	0.94	0.86
2	[-0.67]	[-0.28]	[0.17]	[-1.46]	[23.20]	[22.42]	[21.34]	[29.79]
	-0.18	0.24	0.00	-0.02	0.94	0.98	1.07	1.07
3	[-1.07]	[0.96]	[-0.00]	[-0.16]	[27.67]	[21.34]	[16.61]	[17.15]
	-0.23	0.10	0.07	0.14	0.96	1.08	0.96	1.02
Big	[-1.08]	[0.78]	[0.58]	[0.85]	[46.22]	[24.99]	[34.66]	[22.48]
	s				h			
	0.61	0.76	0.73	1.71	-0.01	-0.34	0.27	1.14
Small	[2.76]	[5.36]	[3.63]	[6.51]	[-0.07]	[-4.31]	[1.48]	[3.82]
	0.67	0.50	0.47	0.61	-0.46	-0.05	0.15	0.36
2	[7.87]	[3.55]	[3.95]	[2.59]	[-4.55]	[-0.43]	[1.60]	[3.59]
	0.28	0.12	0.22	0.37	-0.17	-0.31	0.06	0.23
3	[3.97]	[1.11]	[2.20]	[2.25]	[-3.13]	[-3.96]	[0.37]	[2.62]
	0.01	-0.26	-0.42	-0.65	-0.27	-0.18	0.17	0.90
Big	[0.12]	[-2.99]	[-4.08]	[-6.24]	[-8.14]	[-3.37]	[3.62]	[8.54]
	r				c			
	-0.1	-0.13	0.30	0.21	-0.17	-0.19	-0.11	0.74
Small	[-0.75]	[-0.94]	[1.63]	[0.57]	[-1.07]	[-1.74]	[-0.47]	[2.12]
	-0.07	0.05	-0.02	-0.13	-0.08	-0.08	-0.25	-0.55
2	[-0.81]	[0.29]	[-0.12]	[-0.69]	[-1.10]	[-0.51]	[-1.88]	[-2.19]
	0.13	-0.23	0.08	-0.1	-0.09	0.05	-0.14	-0.25
3	[1.68]	[-1.31]	[0.49]	[-0.67]	[-1.56]	[0.62]	[-1.09]	[-1.41]
	0.08	-0.13	-0.03	-0.04	0.17	0.11	-0.03	-0.39
Big	[1.07]	[-1.22]	[-0.34]	[-0.32]	[1.83]	[3.40]	[-0.43]	[-4.73]

The table shows the coefficients of each factor for every regression with differing test portfolios based on the market cap and the book-to-market ratio. The test portfolios are created at the end of June every year from 2001 to 2015 and are created using the 25th percentiles of the market cap and book-to-market ratio as breakpoints. The excess returns of the test portfolios (Ri) are created using the 1-month Euribor as a risk-free rate (RF). The RM-RF, SMB, HML, RMW, CMA factors represent the market, size, value, profitability and investment risk factors, respectively. The excess returns of the test portfolios and risk factors are obtained from June 2001 to March 2016, for a period of 178 months. The t-statistic is given in brackets below the coefficient.

Table 10: Time-series regressions for the 5-factor model, using 16 value-weighted Size-Inv portfolios as a dependent variable.

$$R_{i,t} - RF_t = \alpha_i + \beta_i(RM_t - RF_t) + s_i * SMB_t + h_i * HML_t + r_i * RMW_t + c_i * CMA_t + \varepsilon_{i,t}$$

INV	Low	2	3	High		Low	2	3	High
	α					β			
	-0.04	0.24	0.57	0.98		1.22	0.99	1.01	1.13
Small	[-0.17]	[1.09]	[2.98]	[2.83]		[34.45]	[12.22]	[16.38]	[13.79]
	0.25	-0.08	-0.02	-0.33		0.99	0.9	0.88	0.97
2	[1.08]	[-0.59]	[-0.14]	[-2.81]		[28.34]	[22.57]	[31.90]	[24.65]
	0.48	-0.16	-0.1	-0.05		0.97	1.03	1.02	0.99
3	[1.25]	[-1.23]	[-0.86]	[-0.37]		[10.02]	[33.15]	[19.72]	[30.40]
	-0.15	0.03	-0.01	-0.03		0.85	1.09	1.01	1.07
Big	[-0.92]	[0.29]	[-0.05]	[-0.20]		[28.79]	[41.45]	[17.98]	[32.68]
	s					h			
	1.38	0.51	0.73	0.79		0.10	0.18	-0.11	-0.11
Small	[4.39]	[2.12]	[5.11]	[8.06]		[0.80]	[1.76]	[-1.09]	[-0.78]
	0.44	0.47	0.48	0.88		-0.1	0.09	-0.01	-0.05
2	[2.34]	[3.46]	[6.36]	[7.86]		[-1.33]	[1.32]	[-0.11]	[-0.78]
	-0.16	0.30	0.32	0.26		-0.16	-0.11	-0.09	-0.18
3	[-0.97]	[3.87]	[3.68]	[4.71]		[-1.22]	[-1.06]	[-1.27]	[-3.77]
	-0.45	-0.31	-0.33	-0.14		0.03	0.03	0.06	0.04
Big	[-3.99]	[-3.58]	[-2.60]	[-1.10]		[0.27]	[0.60]	[0.51]	[0.49]
	r					c			
	-0.32	-0.11	-0.21	-0.20		1.21	-0.10	-0.20	-0.72
Small	[-1.27]	[-0.73]	[-2.21]	[-0.93]		[3.54]	[-0.34]	[-1.24]	[-7.11]
	-0.02	-0.05	-0.04	-0.03		0.14	-0.15	-0.14	-0.65
2	[-0.17]	[-0.42]	[-0.43]	[-0.21]		[0.67]	[-0.62]	[-1.39]	[-10.51]
	-0.4	0.05	0.06	-0.07		-0.06	0.05	-0.08	-0.22
3	[-1.68]	[0.43]	[0.43]	[-1.24]		[-0.42]	[0.57]	[-0.86]	[-3.38]
	0.03	0.08	-0.02	-0.09		0.38	0.15	0.07	-0.42
Big	[0.16]	[1.43]	[-0.20]	[-0.92]		[5.31]	[3.31]	[0.56]	[-3.42]

The table shows the coefficients of each factor for every regression with differing test portfolios based on the market cap and the investment variable, based on the relative increase in the book value of assets. The test portfolios are created at the end of June every year from 2001 to 2015 and are created using the 25th percentiles of the market cap and book-to-market ratio as breakpoints. The excess returns of the test portfolios (Ri) are created using the 1-month Euribor as a risk-free rate (RF). The RM-RF, SMB, HML, RMW, CMA factors represent the market, size, value, profitability and investment risk factors, respectively. The excess returns of the test portfolios and risk factors are obtained from June 2001 to March 2016, for a period of 178 months. The t-statistic is given in brackets below the coefficient.

The coefficients estimated using the five-factor model with 16 test portfolios based on size and profitability in table 11 show significant alphas for portfolios with small cap and high profitability stocks. This is in contrast with Fama and French (2015), which finds very small and insignificant alphas when the test portfolios used are sorted on profitability. Furthermore, the profitability coefficients show an increasing level of sensitivity with increasing portfolio exposure to high profit stocks. Low profit portfolios have significantly negative coefficients and high profit portfolios have significantly positive coefficients. The largest market cap high profitability portfolio is an outlier, showing that a portfolio of stocks with the second highest quartile of profitability are more sensitive to the profitability factor than the highest profitability portfolio, with a coefficient of 0.35 for the lower and 0.26 for the higher profitability portfolio.

The overall result I draw from the time-series regressions made, is that compared to Fama and French, the sensitivities to the risk factors are not as pronounced, as many of the middle portfolios do not have a statistically significant coefficients and the extreme portfolios (smallest and largest market cap or lowest and highest book-to-market, profitability and investment portfolios) had coefficients which were not as large as those in previous research, possibly due to a smaller sample size both in time and in number of constituents. Furthermore, the alpha intercepts are larger in size than those estimated in Fama and Frenh (2015) and are more frequently statistically significant. Some of these differences are to be expected given the differences in sample size, time span and the use of 4 x 4 test portfolios instead of 5 x 5.

Table 11: Time-series regressions for the 5-factor model, using 16 value-weighted Size-Prof portfolios as a dependent variable.

$$R_{i,t} - RF_t = \alpha_i + \beta_i(RM_t - RF_t) + s_i * SMB_t + h_i * HML_t + r_i * RMW_t + c_i * CMA_t + \varepsilon_{i,t}$$

PROF	Low	2	3	High	Low	2	3	High
	α				β			
	0.01	0.32	0.6	0.67	1.22	0.96	0.99	1.11
Small	[0.03]	[1.03]	[1.38]	[2.72]	[18.97]	[18.37]	[20.28]	[19.90]
	-0.18	0.06	-0.31	0.15	0.92	0.96	0.9	0.96
2	[-0.69]	[0.49]	[-1.85]	[1.13]	[26.63]	[23.10]	[23.10]	[23.99]
	0.17	-0.11	0.02	-0.04	1.02	1.01	0.98	0.96
3	[1.00]	[-0.64]	[0.26]	[-0.25]	[21.32]	[13.28]	[27.87]	[20.50]
	0.21	0.05	-0.22	-0.17	0.87	0.97	1.02	1.04
Big	[1.20]	[0.35]	[-1.78]	[-1.96]	[14.00]	[29.16]	[36.44]	[41.44]
	s				h			
	1.53	0.77	0.71	0.79	0.04	0.06	0.00	0.33
Small	[5.00]	[5.65]	[5.68]	[4.93]	[0.25]	[0.66]	[0.01]	[5.80]
	0.83	0.39	0.6	0.6	-0.06	-0.14	0.06	-0.08
2	[2.90]	[3.50]	[6.12]	[6.85]	[-0.69]	[-1.63]	[0.36]	[-1.34]
	0.08	0.19	0.18	0.36	-0.23	-0.01	-0.04	-0.09
3	[0.60]	[2.25]	[3.18]	[4.61]	[-2.92]	[-0.09]	[-0.60]	[-1.02]
	-0.68	-0.36	-0.11	0.06	0.01	0.09	0.19	-0.13
Big	[-4.79]	[-1.92]	[-2.31]	[1.02]	[0.12]	[0.84]	[1.99]	[-2.19]
	r				c			
	-0.83	0.08	0.29	0.4	0.91	-0.2	-0.02	-0.26
Small	[-2.75]	[0.90]	[1.27]	[3.59]	[2.32]	[-1.07]	[-0.13]	[-2.27]
	-0.53	-0.26	0.2	0.3	-0.56	-0.2	-0.05	-0.21
2	[-3.52]	[-2.00]	[1.51]	[3.73]	[-3.36]	[-1.14]	[-0.42]	[-3.48]
	-0.62	-0.07	0.16	0.27	-0.04	-0.08	-0.1	-0.02
3	[-4.16]	[-0.65]	[2.36]	[2.71]	[-0.19]	[-0.84]	[-1.32]	[-0.38]
	-0.93	-0.19	0.35	0.26	-0.02	-0.24	0.01	0.16
Big	[-6.15]	[-1.42]	[3.32]	[4.35]	[-0.17]	[-1.44]	[0.15]	[2.37]

The table shows the coefficients of each factor for every regression with differing test portfolios based on the market cap and the profitability variable, based on the operating profit scaled by the book value of equity. The test portfolios are created at the end of June every year from 2001 to 2015 and are created using the 25th percentiles of the market cap and book-to-market ratio as breakpoints. The excess returns of the test portfolios (Ri) are created using the 1-month Euribor as a risk-free rate (RF). The RM-RF, SMB, HML, RMW, CMA factors represent the market, size, value, profitability and investment risk factors, respectively. The excess returns of the test portfolios and risk factors are obtained from June 2001 to March 2016, for a period of 178 months. The t-statistic is given in brackets below the coefficient.

6.2 Fama-Macbeth Regression

The coefficients estimated using the Fama-Macbeth regression in order to determine the risk premium awarded to the risk factors are found in table 12. I estimate them using the average excess returns of 4 x 4 test portfolios sorted based on book-to-market ratio, relative investment levels and operating profitability.

The first set of lambda coefficients from the regression uses the average returns of book-to-market test portfolios as dependents and shows clearly that a risk premium is awarded to the size risk factor with a coefficient of 0.61, indicating that if a portfolio increases its size factor coefficient by 1.0, the average excess returns of a portfolio should increase by 0.61%. This result for the size factor is robust for all test portfolios, regardless of how they are sorted. The premium also remains when the additional profitability and investment risk factors are added.

The value risk factor seems to have a very small risk premium awarded to it, which only falls within the 80 percent confidence range when estimated using the three-factor model coefficients with the average returns of portfolios sorted based on the book-to-market ratio. The same is also true when it is estimated using five-factor model coefficients and portfolios sorted on operating profitability.

Both the investment and profitability risk factors have insignificant risk premiums. The profitability risk factor even obtains a negative risk premium when the test portfolios are sorted on investment levels. This would indicate that during the time from which the sample is taken there are no possible significant excess returns obtainable as a result of investing in these factors. This corresponds with the average factor returns calculated in table 3 which shows that the profitability and investment factors have small and statistically insignificant returns.

6.3 GRS-test

The results of the GRS-test are placed in table 13 and show the GRS-statistic computed along with its significance level. The results indicate clearly that the alphas from the regressions using test portfolios double-sorted on the book-to-market ratio and market cap have alphas which are statistically insignificant and can therefore be regarded as equal to zero. The other tests using the alphas from the regressions with test portfolios based on investment level and profitability have a far larger GRS-statistic and are therefore rejected under 10% and 5% confidence levels. It can be concluded from these tests that the alphas are larger when using test portfolios created on the basis of investment level and profitability.

The effect of adding factors to the model and observing the size of the alpha helps in the determination of their effect on explaining excess returns. When adding the additional factors based on profitability, investment level and momentum to the model, the GRS-statistic increases and with it the significance level. For all test portfolio types the alphas do not decrease when adding the additional risk factors, which is in contradiction to the results of Fama and French (2015).

Table 12: Fama-Macbeth regressions to estimate the risk premium for every factor.

$$R_{i,t} - RF_t = \lambda_0 + \lambda_1 * \hat{\beta}_i + \lambda_2 * \hat{s}_i + \lambda_3 * \hat{h}_i + \lambda_4 * \hat{r}_i + \lambda_5 * \hat{c}_i + \varepsilon_{i,t}$$

	Coef.	S.E.	t-Stat.	Prob.	Coef.	S.E.	t-Stat.	Prob.
				B/M				
Const.	-0.14	0.25	-0.56	0.58	-1.44	0.94	-1.53	0.16
β	-0.94	0.23	-4.07	0.00	0.29	0.89	0.32	0.75
s	0.61	0.12	5.27	0.00	0.67	0.15	4.44	0.00
h	0.22	0.18	1.17	0.27	0.12	0.17	0.74	0.48
r					-0.06	0.76	-0.08	0.94
c					-0.20	0.27	-0.72	0.49
				PROF				
Const.	-0.91	2.16	-0.42	0.68	-0.94	1.73	-0.54	0.60
β	-0.20	2.15	-0.09	0.93	-0.19	1.68	-0.11	0.91
s	0.76	0.15	5.05	0.00	0.79	0.21	3.72	0.00
h	-0.17	0.55	-0.30	0.77	0.79	0.51	1.55	0.15
r					0.03	0.20	0.17	0.87
c					-0.09	0.51	-0.17	0.87
				INV				
Const.	-1.68	1.01	-1.66	0.12	-0.88	0.95	-0.93	0.37
β	0.79	1.01	0.79	0.45	-0.08	0.95	-0.09	0.93
s	0.63	0.14	4.38	0.00	0.59	0.16	3.74	0.00
h	0.06	0.34	0.17	0.87	-0.05	0.58	-0.09	0.93
r					-1.34	0.54	-2.49	0.03
c					-0.02	0.22	-0.11	0.92

The table shows the risk premium every risk factor receives using 16 test portfolios, based on 4 x 4 sorts on market cap and the book-to-market ratio, profitability and investment variables, as a dependent variable and the sensitivity to the factors from the previous regression time-series as an independent variable. Estimating the linear relationship between test portfolio returns and their factor sensitivities yields a coefficient which represents the risk premium. Increasing factor return coefficients with increasing test portfolio returns therefore indicate a risk premium.

Table 13: GRS-test for the significance of the alphas from the 16 time-series regressions. Each test includes the size factor SMB and the market factor Rm-Rf.

$$GRS = \frac{T-N-K}{N} * \left(1 + E(\boldsymbol{f})' * \widehat{\boldsymbol{\Omega}}^{\mathbf{-1}} * E(\boldsymbol{f})\right)^{-1} * \widehat{\boldsymbol{\alpha}}'\widehat{\boldsymbol{\Sigma}^{\mathbf{-1}}}\widehat{\boldsymbol{\alpha}} \sim F(N, T-N-K)$$

GRS-tests	GRS	Sig.	GRS	Sig.	GRS	Sig.
	B/M		PROF		INV	
HML	0.92	0.55	1.65	0.06	1.63	0.07
HML UMD	0.94	0.52	1.64	0.06	1.63	0.07
HML RMW	0.98	0.48	1.55	0.09	1.69	0.05
HML CMA	0.93	0.54	1.61	0.07	1.63	0.07
RMW CMA	1.04	0.42	1.60	0.07	1.76	0.04
HML CMA RMW	0.98	0.48	1.54	0.09	1.70	0.05

CHAPTER 7 Conclusion

This thesis answers the following research question: *Does the five-factor asset pricing model hold for European Equities?* It does so using the stocks listed on the S&P Euro index together with the market, size, value, investment, profitability and momentum risk factors as explanatory variables for stock returns. When regressing these factors on test portfolios with varying sorts, I find a monotonic relation for the size and value factors over the test portfolios as sensitivity increases for portfolios with small cap and value stocks. The sensitivities are lower and negative for large cap and growth stocks and the change in sensitivities over portfolios is robust. Adding the momentum factor does not seem to increase the explanatory power of the model. The profitability and investment factors also have monotonic relationships with test portfolios, but these are not as robust as the value and size factors, due to inconsistencies in the size, sign and significance of the coefficients. A number of coefficients are therefore outliers which disrupt the monotonic relation. These results combined with large alphas, estimated by both the time-series regressions and the GRS-tests, show a limited ability of the factors to explain portfolio returns. Furthermore, I find that risk premiums are only large and consistent for the size factor and that the value factor premium is small and not consistent. The risk premiums resulting from exposure to the investment and profitability risk factors seem non-existent, as their lambda coefficients are small and statistically insignificant.

I therefore conclude that the five-factor asset pricing does not hold for the 2000 to 2016 time period in the Eurozone, but that the three-factor model does hold even though the average returns and risk premiums for the value factor are relatively low. The most certain observation this thesis provides is the robustness of the size factor which is visible in every factor regression and has large average returns and risk premiums. This contradicts previous empirical research by Fama and French (2012) for European stocks, which finds no significant returns for the size factor and supports Malin and Veeraraghavan (2004), which finds a size effect in a number of European countries, but does not find a value effect.

A number of additional steps can be taken to improve upon the research done in this thesis. A larger sample size of European equities can be used to better estimate the cross-sectional variation of average returns. Obtaining the return data of these equities for a longer period of time would also limit any time-inconsistency of certain risk factors whose excess returns might be negligible in certain time periods and significant in others. Furthermore, the types of risk factor tests done on stocks in this thesis could also be applied to European fixed-income instruments, such as corporate bonds. There is already significant research done on the possible risk factor exposure of bonds to suggest that there may be an effect of profitability and investment on the risk levels and pricing of bonds.

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APPENDIX A Data Lists

Appendix Table A1: Constituents of the S&P Euro Index

Name	ISIN	GVKEY	Name	ISIN	GVKEY
ABERTIS INFRAESTRUCTURAS SA	ES0111845014	102629	HOCHTIEF AG	DE0006070006	100054
ABN-AMRO HOLDINGS NV	NL0000301109	15504	HOECHST AG	DE0005758007	100049
ACCIONA SA	ES0125220311	102712	HSBC FRANCE	FR0000047367	23904
ACCOR SA	FR0000120404	100001	HYPO REAL ESTATE	DE0008027707	156637
ACERINOX SA	ES0132105018	101529	IBERDROLA RENOVABLES SA	ES0147645016	287982
ACTIVIDADES CONSTR Y SERVICI	ES0167050915	222186	IBERDROLA SA	ES0144580Y14	100957
ADIDAS AG	DE000A1EWWW0	221244	INA-ISTITUTO NAZ ASSICURAZ	IT0001030268	30431
AEGON NV	NL0000303709	15598	IND DE DISENO TEXTIL SA	ES0148396007	245663
AENA SA	ES0105046009	319219	INFINEON TECHNOLOGIES AG	DE0006231004	132740
AGEAS SA/NV	BE0974264930	16447	ING GROEP NV	NL0000303600	15617
AGFA-GEVAERT NV	BE0003755692	228416	INTERTECHNIQUE SA	FR0000121766	102136
AIR FRANCE - KLM	FR0000031122	101475	INTESA SANPAOLO SPA	IT0000072618	16348
AIRBUS GROUP NV	NL0000235190	220833	ISTITUTO MOBILIARE ITALIANO	IT0001011268	29699
AKZO NOBEL NV	NL0000009132	15334	ITALCEMENTI SPA	IT0001465159	101143
ALCATEL-LUCENT	FR0000130007	101352	ITALGAS GROUP	IT0003049217	102863
ALITALIA SPA	IT0003918577	100936	JEFFERSON SMURFIT GROUP PLC	IE0031943644	100806
ALLEANZA ASSICURAZIONI	IT0000078193	15890	K&S AG	DE000KSAG888	100736
ALLIANZ SE	DE0008404005	15724	KBC GROUP NV	BE0003565737	15703
ALLIED IRISH BANKS	IE00BYSZ9G33	15505	KERING	FR0000121485	222379
ALMANIJ NV	BE0003703171	23899	KERRY GROUP PLC	IE0004906560	100801
ALPHA BANK SA	GRS015003007	62410	KLEPIERRE SA	FR0000121964	15936
ALSTOM SA	FR0010220475	218399	KLM-ROYAL DUTCH AIRLINES	NL0000009645	6305
ALTADIS SA	ES0177040013	101209	KONE CORP	FI0009013403	101023
ALTANA AG	DE0007600801	100004	KONINKLIJKE AHOLD NV	NL0010672325	23667
ALTICE NV	NL0011333752	317102	KONINKLIJKE DSM NV	NL0000009827	102454
AMADEUS GLOBAL TRAVEL DISTR	ES0109169013	232196	KONINKLIJKE KPN NV	NL0000009082	61440
AMADEUS IT HLDGS	ES0109067019	294508	KONINKLIJKE PHILIPS NV	NL0000009538	8546
ANGLO IRISH BANK CORP	IE00B06H8J93	15702	LA FONDIARIA ASSICURAZIONI	IT0001062097	15826
ANHEUSER-BUSCH INBEV	BE0003793107	241637	LAFARGE SA	FR0000120537	30807
APERAM SA	LU0569974404	296577	LAGARDERE (GROUPE)	FR0000130213	220997
ARCANDOR AG	DE0006275001	100479	LAHMEYER AG	DE0006056302	101804
ARCELORMITTAL SA	LU0323134006	65248	L'AIR LIQUIDE SA	FR0000120073	101202
ARGENTARIA CAJA POST BANC HP	ES0124207137	28255	LANXESS AG	DE0005470405	271763
ARKEMA	FR0010313833	277043	LEGRAND	FR0010307819	277039
ASML HOLDING NV	NL0010273215	61214	LEGRAND SA	FR0000120610	100116
ASSICURAZIONI GENERALI SPA	IT0000062072	15804	LINDE AG	DE0006483001	100037
ASSURANCE GEN DE FRANCE	FR0000125924	24052	LINOTYPE AG	DE0006490303	101920
ATLANTIA SPA	IT0003506190	102743	L'OREAL SA	FR0000120321	100581
AVENTIS SA	FR0000130460	13467	LUXOTTICA GROUP SPA	IT0001479374	20196
AXA SA	FR0000120628	63120	LVMH MOET HENNESSY LOUIS V	FR0000121014	14447
BA HOLDING AG	AT0000903331	15690	MAN SE	DE0005937007	100042
BAAN CO NV	NL0000336352	61385	MEDIASET SPA	IT0001063210	212577
BANCA COMMERCIALE ITALIANA	IT0000066198	15516	MEDIOBANCA SPA	IT0000062957	15593
BANCA FIDEURAM SPA	IT0000082963	16397	MERCEDES AKTIENGESELLSCHAFT	DE0006598600	27832
BANCA MEDIOLANUM	IT0004776628	212955	MERCK KGAA	DE0006599905	220301
BANCA MONTE DEI PASCHI SIENA	IT0005092165	24584	MERITA LTD	FI0009000053	15686
BANCA POPOLARE DI MILANO	IT0000064482	24564	METRO AG	DE0007257503	100746
BANCO CENTRAL HISPANO	ES0113260634	2000	METSO OYJ	FI0009007835	102345
BANCO COMERCIAL PORTUGUES SA	PTBCP0AM0007	23848	MLP AG	DE0006569908	205019
BANCO DE SABADELL SA	ES0113860A34	245436	MONTEDISON SPA - OLD	IT0001338620	13436
BANCO ESP DE CREDITO	ES0113440038	15515	MUNICH RE CO	DE0008430026	15677
BANCO ESPIRITO SANTO SA	PTBES0AM0007	31647	NATIONAL BANK OF GREECE	GRS003003027	30582
BANCO LARIANO	IT0000064748	15808	NAVIGATION MIXTE (COMPE DE)	FR0000121600	103165
BANCO POPOLARE	IT0005002883	225081	NIELSEN HOLDINGS NV	NL0000389872	100873
BANCO POPULAR ESPANOL	ES0113790226	15522	NOKIA CORP	FI0009000681	23671
BANCO SANTANDER SA	ES0113900J37	14140	NOKIAN TYRES OYJ	FI0009005318	211452
BANK OF IRELAND	IE0030606259	63590	NUMICO (KONINKLIJKE) NV	NL0000375616	100775
BANKIA SA	ES0113307021	297957	OMV AG	AT0000743059	102798
BANKINTER	ES0113679I37	15846	OPAP SA	GRS419003009	245672
BASF SE	DE000BASF111	17436	ORANGE	FR0000133308	220940
BAYER AG	DE000BAY0017	100080	ORANGE SA	FR0000079196	243787
BAYER MOTOREN WERKE AG	DE0005190003	100022	OSRAM LICHT AG	DE000LED4000	315541
BAYER SCHERING PHARMA AG	DE0007172009	101076	OTE - HELLENIC TELECOM ORG	GRS260333000	106815
BAYERISCHE HYPO- & VEREINSBK	DE0008022005	15537	PARIBAS SA	FR0004011534	15589

Name	ISIN	GVKEY	Name	ISIN	GVKEY
BAYERISCHE HYPOTHEKEN	DE0008020009	15599	PARMALAT FINANZIARIA SPA	IT0003121644	16382
BBVA	ES0113211835	15181	PECHINEY SA	FR0000132904	103159
BEIERSDORF AG	DE0005200000	100083	PERNOD RICARD SA	FR0000120693	101396
BEKAERT SA/NV	BE0974258874	100743	PETROFINA	BE0003564722	101289
BENETTON GROUP SPA	IT0003106777	15406	PEUGEOT SA	FR0000121501	101276
BIC SOCIETE	FR0000120966	100013	PHAROL SGPS SA	PTPTC0AM0009	31882
BNL-BANCA NAZIONALE LAVORO	IT0001254892	15726	PHILIPP HOLZMANN AG	DE0006082001	100411
BNP PARIBAS	FR0000131104	15532	PIRELLI & CO	IT0004623051	16262
BONIFICHE SIELE	IT0000070018	16213	PIRELLI SPA	IT0000088481	102346
BOUYGUES SA	FR0000120503	101097	PORSCHE AUTOMOBIL HOLDING SE	DE000PAH0038	102187
BRENNTAG AG	DE000A1DAHH0	269835	POSTNL NV	NL0009739416	112116
BRISA-AUTO-ESTRADAS PORTUGAL	PTBRI0AM0000	214839	PROMODES SA	FR0000121105	101285
CAIXABANK SA	ES0140609019	286879	PROSIEBENSAT.1 MEDIA SE	DE000PSM7770	205865
CAP GEMINI SA	FR0000125338	101944	PROXIMUS SA	BE0003810273	200384
CAPITALIA SPA	IT0003121495	25885	PRYSMIAN SPA	IT0004176001	284521
CARLSBERG A/S	DK0010181759	101130	PUBLICIS GROUPE SA	FR0000130577	101292
CARREFOUR SA	FR0000120172	100346	PUMA SE	DE0006969603	102175
CASINO GUICHARD-PERRACHON SA	FR0000125585	101173	QIAGEN NV	NL0000240000	63186
CASTORAMA DUBOIS INVESTISSEM	FR0000124208	103634	RANDSTAD HOLDINGS NV	NL0000379121	104761
CEPSA-CIA ESPANOLA DE PETROL	ES0132580319	100954	RAS HOLDINGS SPA	IT0000062825	15786
CHARGEURS INTERNATIONAL SA	FR0000130692	101170	RED ELECTRICA CORP SA	ES0173093115	234117
CHRISTIAN DIOR SE	FR0000130403	201260	RELX NV	NL0006144495	100075
CIE GEN DES ETABLIS MICHELIN	FR0000121261	101277	RENAULT SA	FR0000131906	210479
CIMPOR-CIMENTOS DE PORTUGAL	PTCPR0AM0003	105890	REPSOL SA	ES0173516115	15319
CIR-COMPAGNIE INDUSTR	IT0000080447	23586	RHEINELEKTRA AG	DE0007026007	101777
CNH INDUSTRIAL NV	NL0010545661	295786	ROLO BANCA 1473 SPA	IT0001070405	30543
COLRUYT SA	BE0974256852	101465	ROYAL DUTCH PETROLEUM NV	NL0000009470	9267
COMMERZBANK	DE000CBK1001	15575	ROYALE BELGE GROUP	BE0003560688	15635
COMPAGNIE DE SUEZ	FR0000130908	15569	RWE AG	DE0007037129	100953
CONTINENTAL AG	DE0005439004	100609	RYANAIR HOLDINGS PLC	IE00BYTBXV33	64835
CORPORATE EXPRESS NV	NL0000852861	100599	SACYR SA	ES0182870214	101553
CREDIT AGRICOLE SA	FR0000045072	24563	SAFRAN SA	FR0000073272	101305
CREDIT LYONNAIS SA	FR0000140071	15482	SAINT GOBAIN CRISTALERIA SA	ES0125030017	102335
CREDITANSTALT BANKVER	AT0000647953	15548	SAINT-GOBAIN (CIE DE)	FR0000125007	101811
CRH PLC	IE0001827041	15444	SAIPEM SPA	IT0000068525	101083
DAIMLER AG	DE0007100000	17828	SALZGITTER AG	DE0006202005	102259
DANONE	FR0000120644	17452	SAMPO PLC	FI0009003305	15773
DASSAULT SYSTEMS SA	FR0000130650	63169	SAN PAOLO-IMI SPA	IT0001269361	24589
DCC PLC	IE0002424939	222305	SANOFI	FR0000120578	101204
DE MASTER BLENDERS 1753 NV	NL0010157558	312871	SAP SE	DE0007164600	103487
DEGUSSA AG	DE0005421903	100061	SCHNEIDER ELECTRIC SA	FR0000121972	101336
DELHAIZE GROUP - ETS DLHZ FR	BE0003562700	100781	SEAT PAGINE GIALLE SPA	IT0005070633	213194
DEUTSCHE BANK AG	DE0005140008	15576	SES SA	LU0088087324	220562
DEUTSCHE BOERSE AG	DE0005810055	243774	SIEMENS AG	DE0007236101	19349
DEUTSCHE LUFTHANSA AG	DE0008232125	100103	SIRTI SPA	IT0003768261	101438
DEUTSCHE POST AG	DE0005552004	241456	SMURFIT KAPPA GROUP PLC	IE00B1RR8406	283184
DEUTSCHE TELEKOM	DE0005557508	221616	SNAM SPA	IT0003153415	249457
DEXIA FRANCE SA	FR0000130387	24995	SNIA SPA	IT0004239510	101174
DEXIA SA	BE0974290224	24596	SOC GENERALE DE BELGIQUE	BE0005200598	103016
DISTRIBUIDORA INTERNACIONAL	ES0126775032	298181	SOCIETE D EDITION DE CANAL P	FR0000125460	102647
DRESDNER BANK AG	DE0005350003	15577	SOCIETE GENERALE GROUP	FR0000130809	15784
E.ON SE	DE000ENAG999	100590	SODEXO	FR0000121220	102089
EBRO FOODS SA	ES0112501012	102019	SOLVAY SA	BE0003470755	101394
EDENRED SA	FR0010908533	294807	SONAE SGPS SA	PTSON0AM0001	208164
EDF	FR0010242511	220920	SONERA OYJ	FI0009007371	224817
EDISON SPA - OLD	IT0000072832	101395	STMICROELECTRONICS NV	NL0000226223	31142
EDP ENERGIAS DE PORTUGAL SA	PTEDP0AM0009	64910	STORA ENSO OYJ	FI0009005961	101020
ELAN CORP PLC	IE0003072950	4245	SUEZ	FR0000120529	100557
ELF AQUITAINE SA	FR0000120420	19364	SUEZ ENVIRONNEMENT SA	FR0010613471	289259
EM TV & MERCHANDISING AG	DE0005684807	216059	TECHNICOLOR SA	FR0010918292	125863
ENAGAS SA	ES0130960018	252465	TECHNIP SA	FR0000131708	30923
ENDESA SA	ES0130670112	15321	TELECOM ITALIA SPA	IT0003497168	19151
ENEL SPA	IT0003128367	201794	TELECOM ITALIA SPA-OLD	IT0001050696	101090
ENGIE SA	FR0010208488	220942	TELEFONICA SA	ES0178430E18	13683
ENI SPA	IT0003132476	61616	TELEKOM AUSTRIA AG	AT0000720008	141239
EPCOS AG	DE0005128003	124996	TELEVISION FRANCAISE 1	FR0000054900	104881
EQUANT NV	NL0000200889	112694	TENARIS SA	LU0156801721	151933
ERGO VERSICHERUNGSGRUPPE AG	DE0008418526	15681	TERNA SPA	IT0003242622	270451
ERIDANIA BEGHIN-SAY SA	FR0000120891	100810	TERRA NETWORKS SA	ES0178174019	126461

Name	ISIN	GVKEY	Name	ISIN	GVKEY
ERSTE GROUP BK AG	AT0000652011	214659	THALES	FR0000121329	13556
ESSILOR INTERNATIONAL SA	FR0000121667	101248	THYSSENKRUPP AG	DE0007500001	103176
EUROBANK ERGASIAS SA	GRS323003012	227537	TIM-TELECOM ITALIA MOBILE	IT0001052049	214259
EVN-ENERGIE-VERSORG NIEDEROS	AT0000741053	103133	TISCALI SPA	IT0004513666	232256
FERROVIAL SA	ES0118900010	271217	TNT EXPRESS NV	NL0009739424	297233
FIAT CHRYSLER AUTOMOBILES NV	NL0010877643	15172	TOTAL SA	FR0000120271	24625
FINANCIERE POLIET	FR0000120735	101439	TRACTEBEL SA	BE0003558666	101296
FINANZIARIA DI SVILUPPO	IT0000070331	15945	TUI AG	DE000TUAG000	100676
FINECOGROUP SPA	IT0003602155	200640	UCB SA-NV	BE0003739530	100751
FINMECCANICA SPA	IT0003856405	16267	UMICORE	BE0003884047	100773
FORTIS (NL) NV	NL0000300838	15584	UNIBAIL RODAMCO	FR0000124711	16383
FORTUM OYJ	FI0009007132	225597	UNICREDIT SPA	IT0004781412	15549
FPB HOLDING	DE0005772305	100597	UNILEVER NV	NL0000009355	10846
FRESENIUS MEDICAL CARE AG&CO	DE0005785802	212782	UNION FENOSA SA	ES0181380710	101330
FRESENIUS SE & CO KGAA	DE0005785604	202305	UNIONE DI BANCHE ITALIANE	IT0003487029	270266
GALP ENERGIA SGPS SA	PTGAL0AM0009	279448	UNIPOLSAI ASSICURAZIONI SPA	IT0004827447	15914
GAMESA CORP TECNOLOGICA SA	ES0143416115	241161	UNITED PAN-EUROPE COMMNS NV	NL0000389112	118284
GAS NATURAL FENOSA	ES0116870314	220586	UPM-KYMMENE CORP	FI0009005987	101718
GEA GROUP AG	DE0006602006	100368	USINOR SA	FR0000132607	206488
GEMALTO	NL0000400653	270243	VA TECHNOLOGIE AG	AT0000937453	64908
GENERALE DE BANQUE	BE0003652634	15592	VALENCIANA DE CEMENTOS SA	ES0182760019	102274
GENERALI DEUTSCHLAND HLDG AG	DE0008400029	15496	VALEO SA	FR0000130338	102523
GETRONICS NV	NL0000853091	102675	VALLOUREC SA	FR0000120354	101467
GIB GROUP (GB-INNO-BM)	BE0003576841	100884	VALMET CORP	FI4000074984	116961
GIST-BROCADES (KONINKLIJ) NV	NL0000354298	100752	VEOLIA ENVIRONNEMENT	FR0000124141	238616
GROUPE BRUXELLES LAMBERT	BE0003797140	21408	VIAG AG	DE0007626202	100679
GRUPO DRAGADOS SA	ES0127070110	101187	VINCI SA	FR0000125486	102296
GRUPO FERROVIAL SA	ES0162601019	228477	VIVENDI SA	FR0000127771	101264
GUCCI GROUP NV	NL0000359552	61658	VODAFONE AG	DE0006560303	100181
HAGEMEYER NV	NL0000355477	101840	VODAFONE TELECEL COM PESSOAI	PTTLE0AM0004	108468
HAVAS (AGENCE) SA	FR0000130106	101212	VOESTALPINE AG	AT0000937503	226156
HEIDELBERGCEMENT AG	DE0006047004	100373	VOLKSWAGEN AG	DE0007664039	100737
HEINEKEN HOLDING NV	NL0000008977	206493	VONOVIA SE	DE000A1ML7J1	315682
HEINEKEN NV	NL0000009165	104833	WARTSILA OYJ ABP	FI0009003727	101557
HENKEL AG & CO KGAA	DE0006048432	101942	WOLTERS KLUWER NV	NL0000395903	101361
HERMES INTERNATIONAL	FR0000052292	203053			

Appendix Table A2: Compustat Data Codes

Fundamentals		Securities	
Total Assets	AT	Close Price Daily	PRCCD
Total Common/Ordinary Equity	CEQ	Shares outstanding	CSHOC
Earnings Before Interest and Taxes	EBIT	Return Adjustment Factor	AJEXDI
Interest Expenses	XINT	Total Return Factor	TRFD

APPENDIX B Variable Summary Statistics

Appendix Table B1: Summary statistics of the stock variables.

B/M	Observations	Mean	Stnd. Dev.	Min.	Max.
Low	1,027	0.274	0.106	0.022	0.544
Neutral	1,363	0.597	0.197	0.266	1.337
High	1,012	4.488	38.342	.534	825.013

Shows the number of observations, mean, standard deviation, minimum and maximum of the yearly created value factor portfolios based on the book-to-market ratio using the top and bottom 30 percentiles as breakpoints.

Market Cap	Observations	Mean	Stnd. Dev.	Min.	Max.
Small	2,044	3640.298	2426.755	0.196	11715.500
Big	2,035	25488.310	23239.160	4820.953	250185.500

Shows the number of observations, mean, standard deviation, minimum and maximum of the yearly created size factor portfolios based on the market capitalization (price multiplied by shares outstanding) given in millions of euros, using the median as a breakpoint.

Investment	Observations	Mean	Stnd. Dev.	Min.	Max.
Conservative	1,010	-0.086	0.122	-0.899	0.099
Neutral	1,343	0.047	0.059	-0.095	0.263
Agressive	998	0.318	0.651	0.011	14.501

Shows the number of observations, mean, standard deviation, minimum and maximum of the yearly created investment factor portfolios based on the relative yearly change in total assets using the top and bottom 30 percentiles as breakpoints.

Profitability	Observations	Mean	Stnd. Dev.	Min.	Max.
Weak	1,116	-0.140	1.016	-26.852	0.152
Neutral	1,475	0.157	0.046	0.036	0.262
Robust	1,100	0.364	0.219	0.189	3.334

Shows the number of observations, mean, standard deviation, minimum and maximum of the yearly created profitability factor portfolios created by subtracting interest costs from earnings before interest and taxes and dividing the resulting amount by the book value of equity, represented by the book value of common and ordinary stock. The portfolios are created using the top and bottom 30 percentiles as breakpoints.

Momentum	Observations	Mean	Stnd. Dev.	Min.	Max.
Down	1,135	-0.019	0.029	-0.202	0.018
Neutral	1,509	0.008	0.017	-0.040	0.040
Up	1,121	0.035	0.026	-0.015	0.218

Shows the number of observations, mean, standard deviation, minimum and maximum of the yearly created momentum factor portfolios based on the average monthly returns for the past 12 months using the top and bottom 30 percentiles as breakpoints.