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Testing the Performance of the Capital Asset Pricing Model and the Fama-French Three-Factor Model

A study on the Swedish Stock Market between 2014 - 2019

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Abstract

The returns of potential investments are interesting for every investor. In this thesis we compared two financial models that are often used to predict expected returns of portfolios with different financial instruments. The studied models are *the Capital Asset Pricing Model*, CAPM, and *the Fama-French Three-Factor Model*, what we in this thesis call FF3. We did our research on the Swedish Stock Market between January 2014 and January 2019, a 5-year period of monthly observations. We constructed 6 portfolios, differentiated by size and book-to-market ratio. FF3 performed better than CAPM in terms of producing significant coefficients, having lower variance in the residuals and in the ability to estimate overall higher coefficient of determination. However, the effectiveness of FF3 diminishes while predicting the excess return for portfolios constructed of growth stocks.

Acknowledgement

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Sammanfattning

Möjligheten att kunna räkna ut avkastningen för potentiella investeringar är av interessant värde för alla investerare. I uppsatsen jämförde vi två finansiella modeller som förklarar portföljens avkastning innehållande olika finansiella instrument. De studerade modeller är *the Capital Asset Pricing Model*, CAPM, och *the Fama-French Three-Factor Model,* som vi i vår uppsats benämner FF3. Vi studerar den svenska aktiemarknaden under en femårig period med observationer baserade på månadsbasis. Perioden sträckte sig mellan Januari 2014 och Januari 2019. Vi har konstruerat 6 olika portföljer, differentierade med storlek samt förhållandet mellan det bokförda värdet och marknadsvärdet. Vårt resultat är att FF3 presterade bättre än CAPM i termer av signifikanta koefficienter, lägre varians i residualerna och förmågan att estimera hög förklaringsgrad. Däremot avtog FF3s förmåga att förutspå avkatningnen för portföljer konstruerade av tillväxt aktier.

TABLE OF CONTENT

LIST OF FIGURES:

Keywords: The Capital Asset Pricing Model, CAPM, The Fama-French Three-Factor Model, FF3, Market Returns, Significance, Swedish Stock Market

Vocabulary

CAPM - Capital Asset Pricing Model

FF3 - Fama-French Three-Factor Model

$R_m - R_f$ - Market risk premium

HmL - High minus Low (Book-to-market ratio)

SmB - Small minus Big (Market Capitalization)

$E(R_i)$ - Expected return from instrument i

$\sigma(R)$ - Risk level for individual portfolios

R_f - Risk-free interest rate

R_M - Market return

β_M - Systematic risk

α- Intercept of equations

R_P - Risk premium

B/M - Booked-to-market ratio

R^2 - R-squared (Stat. measurement of how close the data are to the fitted regression)

Mkt Cap - Market capitalization

Portfolios

S/H - Small Company High Value

S/M - Small Company Medium Value

S/L - Small Company Low Value

B/H - Big Company High Value

B/M - Big Company Medium Value

B/L - Big Company Low Value

1. Introduction

1.1. Background

The opportunity to account for the returns of potential investments is interesting for every investor. To anticipate the performance of a portfolio combined with different stocks on the market, several valuation methods are used. One of them is called the Capital Asset Pricing Model (CAPM) and this model was introduced by William F. Sharpe in 1964. Sharpe argues that the only way to increase the excess return is to increase the amount of risk you take with your investments. CAPM aims to quantify the systematic risk and unveil the link between the risk and the expected return (Capinski, 2014). Further development, led to an introduction of two additional factors, size, and book-to-market ratio. Eugene F. Fama and Kenneth R. French were the first who introduced this model to the public in 1993. Since the Fama-French Three-Factor Model was introduced, it has been a debated topic in academia. This new model was shown to be more accurate in the prediction of the expected excess return of portfolios than CAPM (Fama and French, 2004). Previous research have investigated this issue, with a deductive quantitative approach, but have not come to a definite conclusion. Therefore will this research examine the performance of the models' predictive ability of the portfolio excess return. The reliability of each model varies significantly depending on the data and method the model is applied to (Bartholdy and Peare, 2005). For this reason, we have chosen to conduct a deductive quantitative approach research over a five-year period with monthly observations that in previous studies have shown to produce the most consistent results for both models.

In recent times, there has been a further development of FF3 and the progress resulted in the Fama-French Five-Factor Model. We have chosen to investigate CAPM and FF3 which in this study suits our purpose and research questions. Although, similar research was conducted by Kilsgard and Wittorf (2010) on the Swedish Stock Market during the financial crisis in 2008 and it showed highly inconsistent estimates for all regressions. To conclude more recent studies needs to be performed.

1.2. Purpose

The purpose of this research is to study the performance of CAPM and FF3 and their prediction capacity of the excess return of listed companies on the Swedish Stock Market. We will also investigate the effectiveness of the theories and practices in real-world scenarios.

1.2.1. Research Questions

The research questions are as follows:

1. How well does the market risk premium explain the excess return of companies listed on the Swedish Stock Market?
2. How well does the market risk premium combined with the two additional factors size and book-to-market value explain the excess return of companies listed on the Swedish Stock Market?
3. Which model performs best at explaining the excess return of companies listed on the Swedish Stock Market?

1.2.2. Hypothesis

$$H_0: \beta = \beta_0 = 0$$

$$H_1: \beta \neq \beta_0 \neq 0$$

Testing our hypothesis on the significant coefficients and examine if the results are statistically different from zero. Our hypotheses are tested on the significance level of 10%, 5%, and 1%.

1.3. Limitations

One assumed limitation of this study is connected to the core problem of the models itself. The resulting estimate of our models is an outcome from the tradeoff between the observed frequency of the dataset and time. The value of the beta coefficients changes over time. Longer time intervals result in biased estimated coefficients thus the observed observations are skewed in their distribution. Shorter sample periods increase the volatility of the data which reduces the efficiency of the estimated coefficients and solves the skewed distribution. Another limitation regarding the models is the appraisal of the assets and the approximation

of the construction of the market index. The Estimated stock prices are a combination of intangible and tangible values traded on the stock market. The choice of equal or value weights index will affect the predictions of the models (Bartholdy and Peare, 2005; Fama and French, 2004).

1.4. Thesis layout

The study is divided into six chapters including the introduction. The study starts with an introductory chapter where the main research questions, background, purpose and limitations are presented. Followed by a presentation of previous literature that highlight the already existing studies conducted in the field. The third chapter includes the theory behind the two asset pricing models. The fourth chapter is dedicated to presenting valuable insight into the methods used for this study followed up with the fifth chapter that presents the results and analysis of the performance of the two models. The last part of the study is where we connect previous literature to the findings.

2. Literature Review

This chapter presents previously conducted studies in this field and is outlined in two subsections. The first section starts with global studies in the field of finance and the second section continues with research from Scandinavia. Each chosen article is important for the reader to get a broad understanding of the subject. The motivation for each selected research is stated at the end of each section.

2.1. Global Studies

The Capital Asset Pricing Model: Theory and Evidence written by Fama and French, published 2004 presents the theory and evidence for the Capital Asset Pricing Model (CAPM), and the development of the Fama-French Three-Factor Model (FF3). Behaviorist are critical to the Capital Asset Pricing Model's ability to explain the true covariance of market return according to Fama and French. They argue that the average return premium related to the FF3 model is misleading in terms of pricing. They explain the empirical evidence for the weak explanatory power of the CAPM, developed by Sharpe (1964) and Lintner (1965). In the late 1970s, the new variables price-ratios and size were found to have explanatory power on the return of portfolios. The work of Fama and French is a significant part of the field finance and the two models CAPM and FF3. Fundamentals of Fama and French findings influence the current global research when they showed that FF3 produced a better result of estimating average returns on portfolios than CAPM used on the international market (Fama and French, 2004).

Bartholdy and Peare (2005), compared expected returns between the performance of estimating individual stock returns using CAPM and FF3. The result of the study was shown to be limited in its explanatory power of the expected returns. On average CAPM explained 3% of the differences in return and the Fama-French model on average 5%. Testing different intervals, data frequencies and indexes to see what resulted in the best estimation it was found that monthly observations over a 5-year period were the best fit. Bartholdy and Peare (2005) found in their research that the models performed differently using different indexes. They identified that the best type of index used was the equal-weighted and not the more common value-weighted index. The analysis in their study was made on the New York Stock Exchange, the U.S. stock market. In conclusion, the writers present that none of the models produced high significance results and the explanatory power is too low to be useful for

estimating the cost of equity. The bullet point of this article is that CAPM and FF3 are imperfect models; by applying different datasets and particular periods, the model yields different outcome.

Suh (2009) conducted a time-series test on CAPM and FF3 for a specific estimation of the equity capital in a corporate investment decision-making perspective. The data was collected from a wide variety of stocks, over a 5-year period, conducted daily and monthly. The most consistent result of the study was the market risk premium. The results of the study were that the market risk premium, for individual stocks and portfolios, is significant in its results, and the two models worked as complements. CAPM was generally better at estimating the large-growth portfolio returns and was not able to provide a reasonable estimate for the small-value portfolios. On the other hand, FF3 showed better accuracy in estimating the small-value portfolios and less efficient at estimating the large-value portfolios. Furthermore, Suh supports the founding of the importance of the datasets from the previous study of Bartholdy and Peare (2005). The two financial models work as counterparts in the sense of explanation power.

The research by Grauer and Janmaat published 2010 studied the significance of CAPM compared to the market line using cross-sectional testing. It was shown that the expected return of portfolios that are unit-weight and the zero-weighted portfolios, both were tangents to the origin. The range of betas in the regression increased in significance when low-beta portfolios were replaced by short high-beta portfolios. Furthermore, the second part of the study was focused on testing the two pricing models on a real-life dataset. The second part of the study showed that the cross-sectional tests of the two models are both insufficient in explaining the expected return of portfolios, and the majority of the estimates showed a negative coefficient. As previously mentioned, the choice of a dataset has a great impact on the results of the models. Grauer and Janmaat (2010) show a dramatically different in datasets with and without zero-weights portfolios.

Zhang and Wihlborg (2010) investigate if CAPM applies in up and down markets on 6 European emerging markets. Emerging markets are characterized by high volatility and negative excess returns. Zhang and Wihlborg found that CAPM does not provide any sufficient results while including both developed and emerging markets. CAPM provides better predictions with a singular market category. The empirical results are based on

monthly observations testing CAPM. Results show that global events influence stock markets. One implication of the analysis is that a beta is a useful tool for portfolio managers considering investments in emerging markets. The concluding findings from this research are that stocks on emerging markets react more inconsistent exploiting CAPM to produce efficient results.

Manhoor (2017) conducted a comparison of the two models on 5 publicly listed firms in the Cement Industry of Bangladesh traded on the Dhaka Stock Exchange 2004-2014. The results of the cross-sectional regressions, first on the individual stocks for CAPM, and second combining a portfolio for the FF3, showed a higher adjusted R-squared for FF3 than for CAPM. The results state that the FF3 better explains variation in excess return. The conclusion of the study is in line with Fama and French (2004) and the more complex model FF3 include more explanatory variables but are more time affording to compute.

2.2. Scandinavian Research

In the paper of Ostermark (1991) CAPM was compared on the Swedish and the Finnish Stock Markets. Ostermark restructured his sample before running the regressions by neglecting extreme values, in terms of abnormal returns. It was found that Swedish data performed better, in terms of the stated coefficient of determination, and the standard error than the Finnish data. Furthermore, CAPM showed a higher significance of predicting the return on the Swedish stock market compared to the Finish Stock Market. This is a result of the interdependence between individual assets return on the Finnish Stock Market. One more conclusion made in the paper is that weekly observations and more extended periods for computing returns give better results in the purpose of CAPM. Ostermark (1991) concluded that CAPM performs better on the Swedish stock market compared to the Finish stock market.

Kilsgard and Wittorf (2010) conducted a similar study to Suh (2009) but chose to investigate the performance of the models of the decision-making perspective. The study was outlined to test the performance of the models on the Swedish Stock Market with companies Large and Mid-Cap size during the 2008 crisis. They constructed in a total of 16 different portfolios, for the period 2005-2010. Furthermore, to establish a difference in the two models, Kilsgard and Wittorf (2010) chose to analyze the R-squared and the P-values of the regressions. According

to their findings, the variance of R-squared estimates for all the regression was highly inconsistent. The volatility of R-squared was directly linked to the crises. However, the study concluded that FF3 outperformed CAPM on the Swedish Stock Market even in this specific period.

In recent times, there has been a further development of FF3 and the progress resulted in the Fama-French Five-Factor Model. The two new additional variables in the Fama-French Five-Factor Model are operating profitability and investments. Gruodis (2015) examines the performance of the Fama-French Five-Factor Model on the Swedish Stock Market, between 1991-2014. The findings of this study are that the five-factor model, on average, predicts absolute intercepts closer to zero compared to the intercepts predicted by the three-factor model. In the end, Groudis (2015) concludes that the additional variables raise the degree of the prediction with Swedish data.

To sum up, from the studies reviewed, data have a major impact on the performance of the models. This was mentioned in; Bartholdy and Peare (2005), Suh (2009), Grauer and Janmaat (2010), Kilsgard and Wittorf (2010). Furthermore, the results of the previous literature showed that CAPM and FF3 are weak in their ability to explain the excess returns. The implication of the models is as well true on the Scandinavian Stock Markets.

3. Theory

The single factor model known as the Capital Asset Pricing Model (CAPM) evolves from Portfolio Theory. The portfolio choice theory was developed by Markowitz (1959) and assumes that people are risk-averse. Moreover, recent studies show evidence that a big part of the variation in the expected return of historical data is not related to market beta. Prices of securities not only depend on expected cash flows but also the expected returns. Fama and French (1995) identified a covariance between the company's book-to-market ratio and size. This covariance is expressed as two additional variables, size and the book-to-market ratio. This led to the development of the Fama-French Three-Factor Model (Fama and French 2004).

3.1. Portfolio Theory

Investors are met by risky and non-risky investment opportunities. Investors combine the same risk tangency portfolio T with lending or borrowing at the risk-free rate. Risky assets, also known as the market assets, are weighed in the tangency portfolio as the total value of all outstanding assets divided by the total market value of all exceptional risky assets. According to the Separation Theorem, efficient portfolios are a combination of risk-free assets combined with the risky market assets. Every investor favors different exposure to risk. Exemplified in Figure 1 at point T, the investor invests in the "optimal" point where both the risk-free rate and risky security are tangent. In the optimal point of investment, T, the return is maximized and the volatility is minimized (Fama and French, 2004).

Investment Opportunities
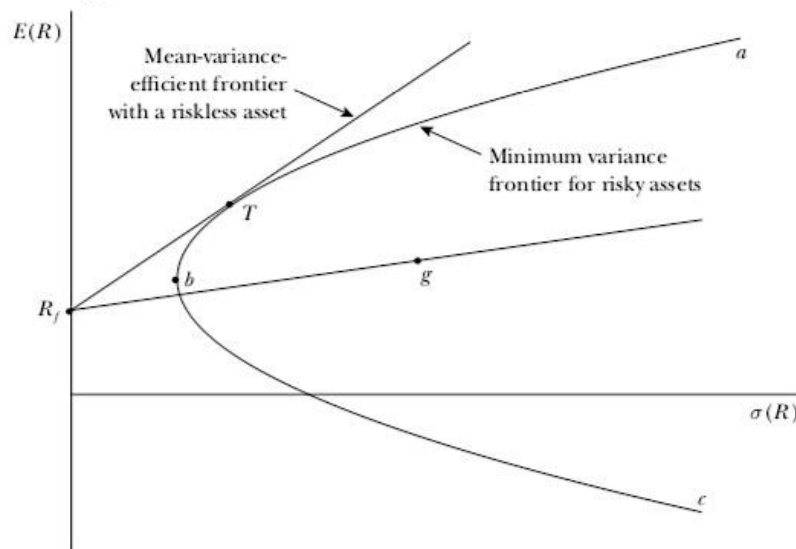
Figure 1: Visual description of investment opportunities (Fama and French 2004, p. 27).

As already mentioned, investors prefer different exposure to risk in a portfolio. The point R_f itself represents a zero-variance state where all assets are invested in the risk-free security. The minimum variance frontier for risky assets does not include any risk-free security. The risky investment curve represents combinations of risks and expected returns. Investors can minimize the return variance on certain levels of expected return by their own choice. In Figure 1, there is one example, point g represents a portfolio with a combination of investment in the risk-free security and in the risky assets but it is not an optimal investment point for the investor (Fama and French, 2004).

3.2. The Capital Asset Pricing Model

The Capital Asset Pricing Model, CAPM the single factor model, examines the relationship between portfolio risk and the expected return of the portfolio. Portfolio risk is measured by the standard deviation of the portfolio return, and the variance measurement traces the expected return. Identification of the efficient set of assets maximizes the expected return at minimum variance condition for risky assets, as described in section 3.1. The construction of each portfolio is based upon an individual's preferences of risk. Each asset is weighted according to the invested quantity and the size of the portfolio. These portfolios are called mean-variance-efficient (Fama and French, 2004).

Furthermore, Sharpe (1964) and Lintner (1965) stated two critical assumptions for the asset pricing models. These assumptions are a continuation of the work of Markowitz (1959). The

first assumption is complete agreement and the second assumption is homogeneity between the risk-free rate for all investors. With the complete agreement we argue that given the market prices at time *t-1*, investors agree that the returns on assets are made between period t-1 and the period *t*. This distribution is also known as the true joint distribution of asset returns. Assumption two states that the risk-free rate is the same for all investors and is independent of the amount borrowed or lent (Fama and French, 2004).

3.2.1. Sharpe-Lintner; Capital Asset Pricing Model Equation

$$E(R_i) \ = \ R_f \ + \left[E(R_M) \ - \ R_f\right]\beta_{iM} \qquad\qquad i = 1, \ ..., \text{N}$$

The equation of CAPM can be described as follow: the expected return is the risk-free rate plus a risk premium, times the premium per unit of beta risk. The difference between the expected market return and the risk-free rate is the risk premium of the assets invested. The interpretation of beta is a measure of the sensitivity of the return on different assets to variation in the market return. According to CAPM a linear relationship exists between the required return of a stock and its systematic risk, beta. In economic terms, the risk of each invested currency in the asset *i* is proportional to the contribution in the market portfolio. The risk-free rate does not contribute to the variance of the market return, the characteristic of the risk-free return is riskless and uncorrelated to the return of the market (Fama and French, 2004).

3.2.2. Time-Series Regression

$$R_{it} - R_{ft} = \alpha_i + \beta_{iM}(R_{Mt} - R_{ft}) + \varepsilon_{it} \qquad\qquad i = 1, \ ..., \text{N}$$

Jensen (1968) adds time to the equation and states the necessity to remove the risk-free interest rate from the predicted return to achieve the desired excess return. The additional time dependence improves the accuracy for multiple time regressions that increases the application of the equation. Testing the Sharpe-Lintner equation (1965) it was seen that the intercept on average is higher than the risk-free interest rate and the coefficient on beta is less than the average on the market return. Time-series regression concludes that the intercepts are negative for assets with high betas and positive for assets with low betas. Time-series and cross-section regressions test whether or not a particular proxy for the market portfolio is efficient the Sharpe-Lintner equation (1965) uses cross-section data to explain the expected return, e.g., the expected return on a portfolio is entirely explained by differences in the

market beta. According to previous research, is the Time-Series Regression improving accuracy for multiple time regressions but also develops the standard application of the equation (Fama and French, 2004).

3.2.3. Common Source of Variations

One critical assumption in CAPM is the estimation of the risk premium, the residual between the market return and the risk-free interest rate. In CAPM the risk-free interest rate is the starting point, and the coefficient beta describes the slope. According to Fama and French (2004) is the relationship between the intercept and the slope of CAPM, significant measurement errors were found. The residuals between the risk-free interest rate and the estimated market rate are often biased with a common source of variation. Fama and French (2004) describe one of the problems why CAPM produce more precise results when used on portfolios rather than individual securities.

Research shows evidence that a big part of the variation in the expected return of historical data is not related to market beta. Prices of securities do not depend on the expected cash flows but on the actual excess return. Market betas are not sufficient to explain the variation in expected stock returns. Book-to-market ratios and size are critical factors of the expected stock return (Fama and French, 2004).

3.3. The Fama-French Three-Factor Model

In the year 1995 Fama and French proposed a new model with additional factors that shown to be more precise in predicting the excess return of portfolios than the equation of Jensen (1968). They observe two additional factors in terms of market capitalization and book-to-market value (Sattar, 2017).

3.3.1. Description of the Equation of the Fama-French Three-Factor Model

$$R_{it} - R_{ft} = \alpha_i + \beta_{1i}(R_{Mt} - R_{ft}) + \beta_{2i}(SMB_t) + \beta_{3i}(HML_t) + \varepsilon_{it} \quad t = 1, \ldots, t_0.$$

Fama and French (1995) identified covariance between the company's book-to-market ratio and size. The covariance is expressed with two additional variables size and the book-to-market ratio. The return of large firm stocks has similar covariance with smaller firms. SmB is the return of a portfolio with a small market cap minus big market cap. HmL is the return

of a portfolio stock with high book-to-market value minus the return on a portfolio with stocks that have low book-to-market values (Bartholdy and Peare, 2005; Fama and French, 2004).

4. Method

This chapter will present the data collection and methods used to analyze our results. The first three sections present motives behind the chosen period, dataset and describe the construction of the portfolios. The section presents the analyzing tools that are based on previous studies. They provide the reader with the necessary description of our regressions.

4.1. Methodology

Testing the theory behind the effectiveness of CAPM and FF3 on predicting the excess return of portfolios is a deductive quantitative approach taken. This approach has been applied to previous research in this field. It tests a theory that is strongly related to the research proposal with new numerical data which develops into new hypothesis or support of already existing findings (Bryman and Bell, 2012).

4.2. Period of Observation

We are replicating the work of Fama and French, who conducted their research on the U.S. Stock Market but angled our research on to testing the performance of the models on the Swedish Stock Market. As mentioned in section 1.1 we have chosen to limit our research to a 5-year period, starting in January of 2014 and ending in January of 2019. Furthermore, the 5-year period with monthly observations was showed to produce a marginal improvement of the accuracy of the results (Bartholdy and Peare, 2005). Therefore, we conducted our research with the same proven methods and period of observation.

Our dataset consists of a subsequent period of 5-years with monthly observations, 60 observations in total. Starting from the first of January 2014 and ending on the first of January 2019. Monthly observations over a 5-year period are described by Bartholdy and Peare 2005 (p.412) to be: "the standard data frequency and time period used". In this period, we examine all of the companies registered on the Swedish Stock Market. There are in total of 409 different listed companies over the 5-year period. Information about the quantity of publicly traded companies between 2014-2019 will be presented in section 4.2.1.

Estimating beta wrong will produce a biased and inconsistent result and affect the efficiency of our estimates, therefore are the tradeoff between longer and shorter periods heavily

important for the results. In the study made by Bartholdy and Peare (2005), they conclude that the general recommendation of using 5 subsequent years of monthly data is reasonable when estimating the expected return of CAPM. The results are similar for the Fama-French Three-Factor Model.

According to the observed 5 subsequent years, interest rates fluctuate between 1% and negative 0.6%. The market risk premium is the weighted average of the monthly total returns from single stocks minus the risk-free rate. Different events in the economy affect the market risk premium for each individual portfolio as illustrated in Figure 2.
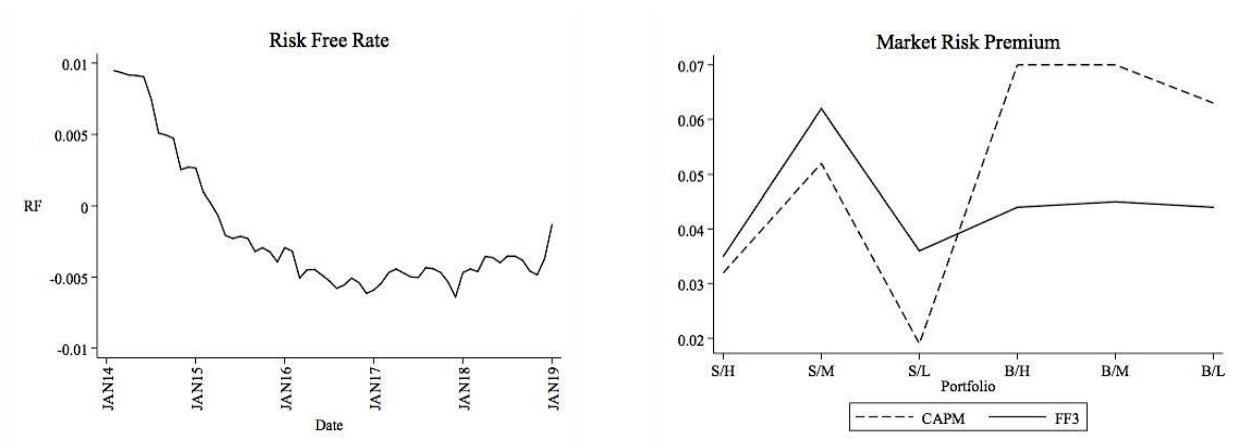
Figure 2: *Presents the risk-free interest rate over the observed period and the market risk premium for the six constructed portfolios.*

4.3. Dataset

The data will be collected through the Bloomberg terminal. The Bloomberg terminal is a broadly used, generally respected and trusted source in the field of finance. The first three points in the list below *(Total Equity, Market Capitalization, BE/ME)* are collected every year. The last two points (R_f, R_M) are collected monthly.

- Total Equity
- Market Capitalization
- Book-to-market ratio (BE/ME)
- Risk-free rate (R_f)
- Market return (R_M)

The risk-free interest rate is based on the Swedish short date Treasury Bill every 3-months. The Market return is collected through the Day-to-Day Total Return Index includes the market stock price and the market gross dividend.

A correlation analysis was made which showed us that the calculated variables correlate with French´s research (French, 2019) and AQR Capital Management database (AQR, 2019) with positive correlations, displayed in Figure 3. The correlation between our variables of interest and the compared variables shows low correlation values because of being constructed on different markets.

Figure 3: *Correlation between French. R. Kennedy, AQR and SAX index*

Correlation Table 1

	R_m-R_f	R_m-R_f (SAX)	SmB	SmB2	SmB3	HmL	HmL2	HmL3
R_m-R_f	1							
R_m-R_f (SAX)	**0.979*****	1						
SmB	-0.193	-0.194	1					
SmB2	0.150	0.167	**0.198**	1				
SmB3	-0.0980	-0.0766	**0.252**	0.0722	1			
HmL	0.0924	0.0665	-0.305	-0.0460	-0.113	1		
HmL2	0.110	0.0868	0.0193	0.166	0.0378	**0.0129**	1	
HmL3	0.153	0.162	-0.126	-0.0256	-0.123	**0.298***	0.0276	1
N	60							

Note: $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

***2 = French R. Kennedy

***3 = AQR Capital Management

R_m-R_f (SAX) = Swedish All-share Index (SAX index)

SmB = Small company's return minus Big company's return

HmL= High-growth potential company's return minus Low-growth potential company's return

4.3.1. Swedish Stock Market between 2014-2019

The amount of publicly traded companies on the Small-, Medium- and Large-Cap list varies throughout the observed period. In total there are 409 different companies, illustrated in Figure 13 found in Appendix but the amount of active companies per year are described in Figure 4. The portfolios are constructed of stocks traded during the observed 5 subsequent years and stocks that are not operating in these years are automatically overseen.

Year	Listed Companies
2013	279
2014	290
2015	308
2016	322
2017	345
2018	362

Figure 4: Presents the number of listed active companies on the market throughout the years.

4.3.2. Market Index

The appraisal constructed market index both includes intangible and tangible values. The choice of equal or value weights index will affect the predictions of the models. According to Bartholdy and Peare (2005) "The underlying theory for CAPM is quite specific in its recommendation of index; it specifies that a value-weighted index consisting of all the assets in the world should be used." (Bartholdy and Peare 2005, p. 412). Based on the theory supporting CAPM we use a value-weighted market index in our research.

The constructed index includes all firms listed every year on the Swedish Stock Market and the total amount over the 5-year period is 409 companies. The constructed market index deviates 2.1% from the SAX Index. The difference is displayed in the graph (Figure 5) and in the correlation table (Figure 3). The market index is motivated by the performance of the models with our universe of stocks.
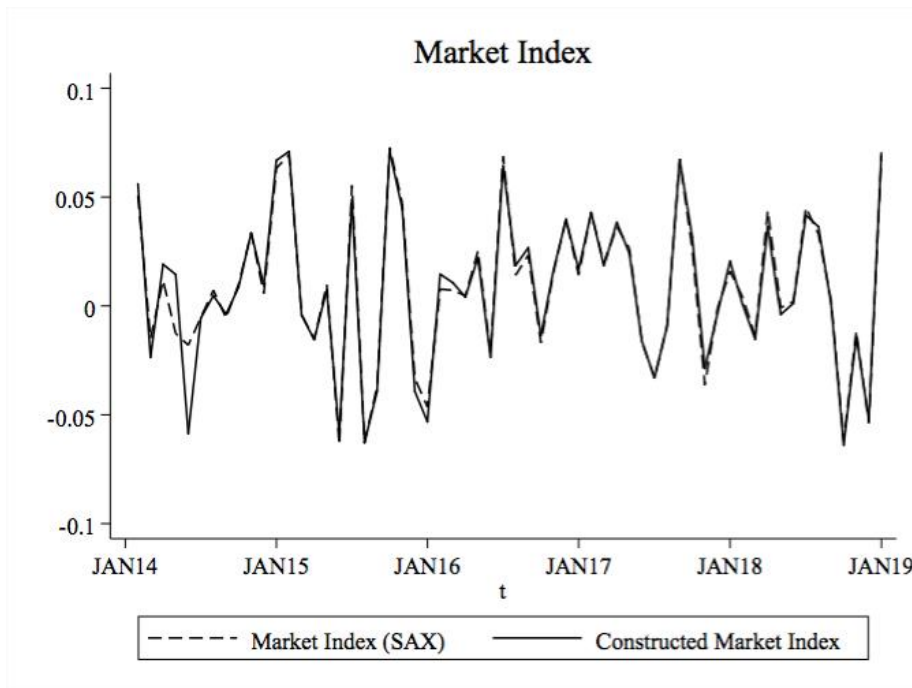
Figure 5: Presents the difference between our constructed market index compared to the SAX Index (All-Share).

4.4. Construction of Portfolios

Portfolios are constructed of combined conditions. The first condition divides the companies, from each year, by the median-value of the market capitalization. Companies with a market capitalization higher than the median (Market Capitalization > Median) are recognized as big companies of high-value and companies with a market capitalization lower or equal (Market Capitalization ≤ Median) to the median are labeled as small companies with high-growth potential.

The second condition divides the companies according to the book-to-market ratio (BE/ME). The book-to-market ratio is divided in High (BE/ME > percentile 7), Medium (percentile 7 ≥ BE/ME > percentile 3) and Low (BE/ME ≤ percentile 3) category, in the 10 percentile range. Combining both conditions lets us construct six portfolios with different criteria.

A company with a book-to-market ratio higher than the 7th percentile and with a *high* market capitalization is labeled "big high" (B/H). The percentile range for each book-to-market ratio determines if the company is labeled as a *high*, *medium* or *low*-value company. The book-to-market ratio that is higher than the 7th percentile is labeled *high*. Book-to-market values lower or equal to the 7th percentile and higher than the 3rd percentile are labeled *medium*

value companies. Lastly, the companies with a book-to-market ratio lower or equal to the 3rd percentile, are labeled as *low*-value companies.

Portfolio: Formed on size and book-to-market ratios (Bivariate)	Low Value	Medium Value	High Value
Small (High Growth potential) Company	S/L	S/M	S/H
Big (High Value) Company	B/L	B/M	B/H

Figure 6: Illustrates each portfolio and its label.

4.5. Regressions

4.5.1. Capital Asset Pricing Model Equation

$$R_{it} - R_{ft} = \alpha_i + \beta_{iM}(R_{Mt} - R_{ft}) + \varepsilon_{it} \qquad\qquad i = 1, \dots, N$$

We use the Time-Series Equation introduced by Jensen (1968) for all the CAPM regressions. The raw returns from the dataset are adjusted for the risk-free rate before executing our regressions in Stata. The regressions provide us with an coefficient estimate for the portfolios.

4.5.2. Fama-French Three-Factor Model Equation

$$R_{it} - R_{ft} = \alpha_i + \beta_{1i}(R_{Mt} - R_{ft}) + \beta_{2i}(SMB_t) + \beta_{3i}(HML_t) + \varepsilon_{it} \qquad t = 1,\dots,t_0.$$

We use the Fama-French Three-Factor Model (1995) for all FF3 regression. The same dataset is used as for the regression in section 4.5.1., with additional two variables; SmB and HmL that are explained in section 4.5.4.2 and down.

4.5.3. Dependent Variables

The results from calculating the monthly return of each portfolio are discounted for the risk-free interest rate in the final stage of the calculation. The dependent variable in the regressions is the monthly excess return of each portfolio.

4.5.4. Independent variables

4.5.4.1. Market Risk Premium ($R_m - R_f$)

The market risk premium is the weighted average of the monthly total returns from single stocks minus the risk-free rate. Excess returns are calculated by subtracting the risk-free interest rate from every individual stock's return. The risk-free interest rate is the 3-months Swedish Treasury Bill. Monthly return is calculated on a monthly basis for 5-years. Only the capital gain was considered for the calculation, and no price adjustment has been made for cash or stock dividends.

4.5.4.2. Small minus Big (SmB)

SmB is a variable accounting for the difference in return for companies of different size. The SmB variable is an average sum of our small portfolios minus the average of the big portfolios. The difference between the small and the big portfolio's returns is SmB, which is explained more in the section 3.3.

$$SmB = \frac{(R_{S/H} + R_{S/M} + R_{S/L})}{3} - \frac{(R_{B/H} + R_{B/M} + R_{B/L})}{3}$$

4.5.4.3. High minus Low (HmL)

HmL is a variable accounting for the difference in return between big and small companies book-to-market ratio. Summing up the portfolios with high values, e.g., high-growth potential stocks, and taking the average. The same is done for low-growth potential portfolios (in the same equation); thereafter we are taking the difference between them. Further explanations of the HmL variable is under the section 3.3.

$$HmL = \frac{(R_{S/H} + R_{B/H})}{2} - \frac{(R_{S/L} + R_{B/L})}{2}$$

5. Results and Analysis

This chapter presents our results from examining the performance of CAPM and FF3. The first part includes the results of the regressions using the two asset pricing models and the second part is dedicated to analyze coefficient estimates, R-squared, and the residuals supported by the literature from section 2.

5.1. Linear regression table results of CAPM and FF3

Figure 7: *CAPM Regression Results*

	Capital Asset Pricing Model (CAPM)					
	S/H	*S/M*	*S/L*	*B/H*	*B/M*	*B/L*
$R_m - R_f$	0.031	0.050	0.018	**0.069***	0.069	0.062
	(0.87)	(1.09)	(0.41)	**(1.82)**	(1.54)	(1.44)
Alpha (α)	0.001	**0.003***	0.002	0.001	-0.000	-0.001
	(1.28)	**(1.84)**	(1.55)	(0.45)	(-0.23)	(-0.67)
Obs.	60	60	60	60	60	60
R-Squared	0.015	0.022	0.003	0.056	0.043	0.040

Note: t-value in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

R_m-R_f = Market Risk Premium

Alpha (α) = Intercept of CAPM

Figure 8: *FF3 Regression Results*

Fama-French Three-Factor Model (FF3)						
	S/H	*S/M*	*S/L*	*B/H*	*B/M*	*B/L*
$R_m - R_f$	0.042	0.070	0.042	0.051	0.052	0.051
	(1.15)	(1.57)	(1.17)	(1.39)	(1.29)	(1.34)
SmB	0.192	0.261	0.192	**-0.754***	**-0.845***	**-0.755***
	(0.91)	(1.03)	(0.88)	**(-3.43)**	**(-3.44)**	**(-3.56)**
HmL	-0.406	**-1.097**	**-1.767***	**-0.741**	**-1.149***	**-1.380***
	(-1.18)	**(-2.28)**	**(-5.43)**	**(-2.12)**	**(-2.88)**	**(-3.58)**
Alpha (α)	0.001	0.003	**0.002***	**0.003**	0.002	0.001
	(0.91)	(1.62)	**(1.87)**	**(2.03)**	(1.39)	(1.09)
Obs.	60	60	60	60	60	60
R-Squared	0.076	0.196	0.414	0.258	0.281	0.334

Note: t-value in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

R_m-R_f= Market Risk Premium

SmB = Small company's return minus Big company's return

HmL= High-growth potential company's return minus Low-growth potential company's return

Alpha (α) = Intercept of CAPM

Figure 7 and 8 presents the regression table of CAPM and FF3, both models include regressions on six portfolios (S/H, S/M, S/L, B/H, B/M, B/L). The regressions provide us with estimated coefficients for each model and each portfolio including the R-squared, the coefficient of determination. Two coefficients are estimated for every CAPM-portfolio; Alpha, and $R_m - R_f$. In FF3 two additional factors are estimated; SmB and HmL. Each

independent variable in the regressions is described in section 4.4.4. Regression analysis is done with a level of significance of 10%, 5% and 1%. Significant results are illustrated with numbers superscript with either one, two or three stars and bold text.

5.2. Regression CAPM and FF3

5.2.1. Coefficient of Estimation

The alpha coefficient for the S/M portfolio and the only significant market risk premium of both models is B/H, showed to be significant at 10 % level in CAPM. The other four portfolios show no significant coefficients which means that they fail to reject the null hypothesis and we are not able to conclude anything about their size or effect on the predicted excess return of those portfolios. In case of the significant estimates, we can state that all reject the null hypothesis and an increase of one unit would mean that the predicted excess return for the S/M portfolio would increase with 0.3%, respectively for the B/H portfolio, an increase with one unit would mean an increase of 6.9% in the excess return of that portfolio. Furthermore, can we see that the t-values differs between (-0.67)-1.84. The two significant coefficients' (B/H market risk premium; S/M Alpha) have a close variation (1.82, 1.84) compared to the sample mean. The estimated market risk premium coefficient for the B/H portfolio, is 0.02 units closer to the true market value.

Further analysis of the results in Figure 8 we can observe that the Alpha coefficient for S/L and B/H portfolio showed to be significant at the 10% respectively 5% for the B/H portfolio. The other four portfolios showed no significant Alpha or market risk premium coefficients, which means that they fail to reject the null hypothesis and we are not able to conclude anything about their size or effect on the predicted excess return of those portfolios. In case of the significant estimates, we can state that all reject the null hypothesis and an increase of one unit change in the beta of Alpha, would mean that the predicted excess return for the S/L portfolio, would increase with 0.2%. Similar the estimated Alpha coefficient for the B/H portfolio would affect the prediction of the excess return with 0.3% with an increase with one unit change in the return of the stocks included in the portfolio. Furthermore, comparing the t-values of the significant shared coefficients can we state that the difference in significance level is visible in terms of the t-value estimates. The t-value of S/L is 1.87 and for B/H is 2.03 this means that the B/H portfolios estimated coefficient variation in terms of standard error

average compared to the sample mean. The estimated alpha coefficient for S/L portfolio is therefore 0.15 units closer to the true market value.

Continuing the analysis of the two additional factors of FF3 (Figure 8), SmB and HmL, showed at least one significant estimated coefficient for five out of six portfolios. The S/H portfolio showed insignificant coefficients which means that they fail to reject the null hypothesis and we are not able to conclude anything about their size or effect on the predicted excess return of those portfolios. In case of the significant estimates, we can state that all reject the null hypothesis and an increase of one unit in HmL, would mean that the predicted excess return for the S/M portfolio, would decrease 1.097. Ceteris paribus, one unit change in the S/L portfolio, would decrease 1.767, the predicted excess return for the S/L portfolio. The significant SmB coefficient estimates varied between (-0.845)- (-0.754) that means one unit change for the SmB-variable, in predicting the excess return for an example the B/M portfolio (highest significant SmB-coefficient), would decrease the excess return with -0.845. Ceteris paribus, all estimated coefficients for the high-value firms was significant at 1% level. Moreover, the coefficients vary between (-1.380)- (-0.741) and means that one unit change for the HmL-variable for B/H portfolio (highest significant HmL-coefficient), would decrease the excess return with 0.741. To sum up, FF3 showed to produce highly significant coefficient for all of the high-value companies for both of the additional variables SmB and HmL. However, no significant SmB estimates were produced for the growth portfolios but showed to produce highly significant estimates for the high-value companies with a significance of 1% level. Before stating which of the variables showed the highest significance in each portfolio, we compare the t-values of the significant coefficients. The t-values varies between (-5.43)- (2.12) for the significant estimates. The highest observed t-value of SmB (-3.56) and HmL (-5.43) are significant in 1% level, statistically different from zero. The t-value, explain the variation of the relationship to the sample data. The estimates for the same level of significance, are differentiated with higher or lower t-values. The estimate with the lowest t-value in the same level of significance is potentially closer to the true market value. The B/H portfolio has the lowest t-value and highest significance level (-3.43) for SmB and B/M portfolio (-2.88) for HmL.

Further observation of the results is that FF3 perform better than CAPM in terms of the quantity of significant coefficients. We can observe that the market risk premium, that is measured by both models, loses the single significant coefficient from the CAPM-regression.

This could possibly be an effect from what the behaviorists argue, the two additional variables do not add any additional significance for the asset pricing (Section 2.1.) This phenomenon is illustrated in Figure 8, none of the estimated market risk premium variables are significant in FF3.
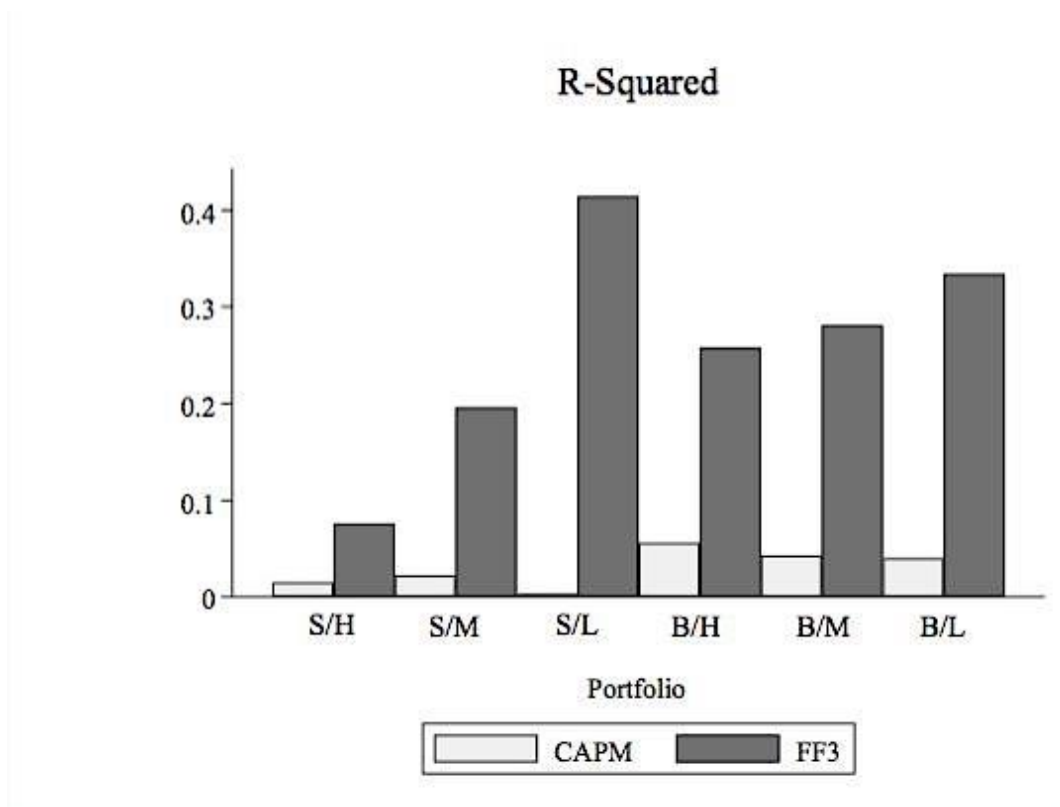
5.2.2. Coefficient of Determination

Figure 9: Illustrates the predictions of R-Squared for both CAPM and FF3 for each portfolio.

By analyzing the R-squared values in Figure 7, 8 and 9 we observe that the R-squared is overall low for both regressions that make us argue the estimated beta coefficients do not fit the linear regression in both models. Comparison of R-squared in Figure 7 (CAPM) and 8 (FF3) can identify that FF3 presents higher R-squared for all of the six portfolios. However, none of the observed R-squared estimates are higher than 0.414 that mean our estimated coefficients have a high variation in relation to the linear regression. Furthermore, the highest R-squared (FF3) is for the S/L portfolio (0.414). We have two significant coefficients (Alpha and HmL) and the second highest estimated R-squared (0.203) is as well located in the FF3 regression for B/H portfolio. This portfolio showed the highest significance level and the lowest t-value for the 1% significance level for SmB and include three out of four possible significant coefficients. The lowest R-squared for FF3 is 0.076 (S/H) that is higher in comparison to all R-squared estimates acquired for CAPM. This low explanation degree of portfolio S/H is reasonable by the definition of the stocks included in the portfolio. The portfolio (S/H) consist of growth stocks that are generally known as high risk investments

26

with high growth potential. The same phenomena were observed in the study of Suh (2009), that went on to test CAPM and FF3 on the International Stock Markets. Suh (2009) argued that CAPM showed a weak prediction capability of the growth-portfolios.

Presented in our results is that CAPM on average explains less than 3% (0.0298) of the differences in return and FF3 explains on average 26% (0.260). This difference in explanatory power of the two model were found on the U.S. Stock Market by Bartholdy and Peare (2005) that is presented in the literature review in section 2.1. Bartholdy and Peare (2005) found that CAPM explained 3% of the differences in return and FF3 on average 5 %. In continuation to the research of Manhoor (2017), found that by comparing the adjusted R-squared from his sample, constructed of companies listed on the Stock Market of Bangladesh, that FF3 has a higher degree of explanation than CAPM. Furthermore, Kilsgard and Wittorf (2010) found that the variance of R-squared estimates of all the regression was highly inconsistent in their study during crisis and concluded that FF3 outperformed CAPM on the Swedish Stock Market. Following this line of literature, we can observe that FF3 has a higher R-squared than CAPM and that both models shows the same amount of significant coefficients by only comparing the shared variables ($R_m - R_f$ and Alpha) for our 6 portfolios.
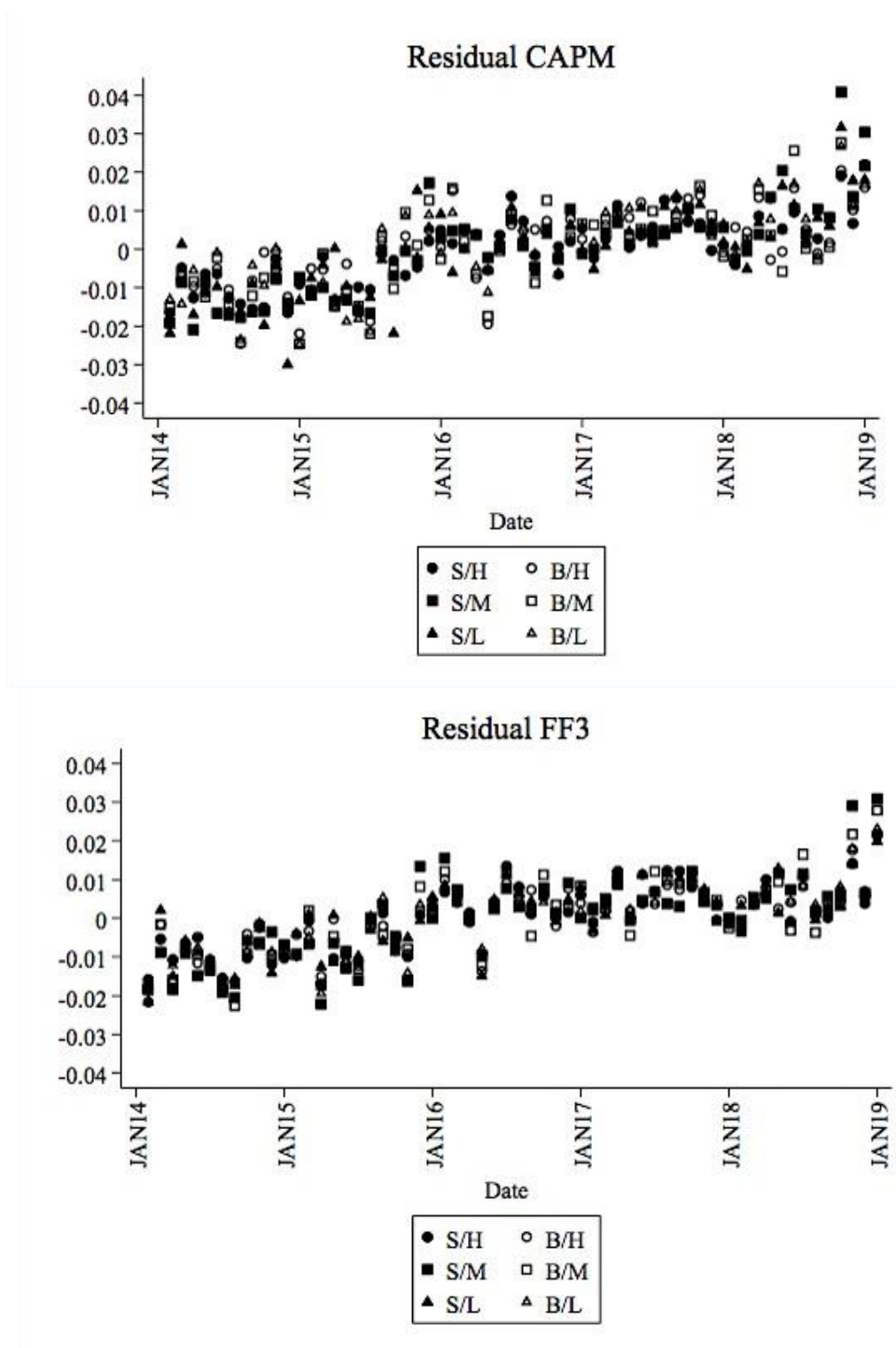
5.2.3. Residuals

Figure 10: *Illustrates the monthly predictions of the residuals between January 2014 and January 2019 for CAPM and FF3 for each portfolio.*

CAPM and FF3 shows a similar pattern according to the predicted excess return across the 5 subsequent years but we can indicate that CAPM illustrates a higher variation in the predictions. Furthermore, we can spot a positive time trend that could be a result of multicollinearity of the data. This problem will be addressed in section 5.3.1.

In continuation, we observe that both models have residuals close to zero for 2016. Before 2016 we observe negative residuals and after 2016 we observe positive residuals. These observations are limited in their external validity because we observe a trend in the data. We can indirect state that 2016, which is in the middle of our observed period, is illustrating the most correct predictions of the excess return according their low spread from zero. Therefore, the observed trend does not allow for a comparison of each separate year for the predicted residuals of the models. Detrending the data would allow us to observe the true causal effect of the predicted residuals but this is not the purpose of this thesis. Detrended residuals are presented in Appendix (Figure 14).

5.3. Validity of the results

5.3.1. Multicollinearity

The results of our explanatory variables in Figure 11 makes us able to conclude that our dataset do not suffer from multicollinearity, based on the fact that none of the variables shows a correlation higher than 0.5. Multicollinearity is a factor that may cause problems in time series regressions and therefore are we testing our correlation of the explanatory variables correlation. High correlated explanatory variables causes irregular changes in the results.

Figure 11: *Correlation between the explanatory variables.*

<div align="center">

Correlation Table 2

</div>

	$R_m\text{-}R_f$	SmB	HmL
$R_m\text{-}R_f$	1		
SmB	-0.193	1	
HmL	0.0924	-0.305[*]	1
N	60		

Note: [*] $p < 0.05$, [**] $p < 0.01$, [***] $p < 0.001$

$R_m\text{-}R_f$ = Market Risk Premium

SmB = Small company's return minus Big company's return

HmL= High-growth potential company's return minus Low-growth potential company's return

6. Conclusion

The performance of CAPM and FF3 is limited in their capability of predicting the excess return on the Swedish Stock Market. We found that FF3 performed better than CAPM in terms of producing significant coefficients, having lower variance in the residuals and in the ability to estimate overall higher coefficient of determination. As mentioned in the analysis, lower variance in the predicted residuals is a sign of a better fit of the predicted excess return in relation to the fitted regression line. However, the effectiveness of FF3 shown to diminish while predicting the excess return for portfolios constructed of growth stocks.

We found that both of the additional variables showed to work better for estimating significant coefficients for all of the value constructed portfolios and showed less effectiveness for growth portfolios. Thus, comparing the shared significant coefficients, both models produce the same amount of significant coefficient ($R_m - R_f$ and Alpha) for our six portfolios. Continuing our findings, the S/H portfolio showed insignificant coefficients and generally low R-squared vales for both models. The S/H portfolio is constructed of growth stocks that are known for high potential profitability and high risk. The research conducted by Suh (2009) shared the same ineffectiveness in predicting the excess return of growth portfolios, constructed of growth stocks from the International Stock Market. To conclude, CAPM explained less than 3% (0.0298) and FF3 26% (0.260) on average of the dependent variable in our results. Kilsgard and Wittorf (2010) identified that the variance of R-squared of all the regressions was highly inconsistent, during crisis, and concluded that FF3 outperformed CAPM on the Swedish Stock Market (Section 2.2).

According to the residuals in Figure 10, FF3 produce estimates with lower variation compared to CAPM. The pattern of the predicted residuals showed a similar but not identical spread, of predicted residuals across the observed period. However, both models showed inconsistent results of the market risk premium, SmB and HmL therefore we can not state a definite answer to the question of which model is the best at explaining the excess return of companies listed on the Swedish Stock Market.

6.1. Future Research

For future studies it would be interesting to add the additional two factors including in the Fama-French Five-Factor Model over the same period on the Swedish Stock Market. Another contribution to this field could be to include the Arbitrage Pricing Theory (APT) to the comparison of CAPM and FF3.

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Electronic Library Information Finder: "Supersok" Goteborgs Universitetsbibliotek (2019-04-15)

Appendix

Portfolio	Description of the portfolio construction
S/H	Represent the group of portfolios that is *small* in size and have a *high* book-to-market value (Market Capitalization $\leq$ Median; $BE/ME >$ percentile 7).
S/M	Represent the group of portfolios that is *small* in size and have a *medium* book-to-market value (Market Capitalization $\leq$ Median; percentile $7 \geq BE/ME >$ percentile 3).
S/L	Represent the group of portfolios that is *small* in size and have a *low* book-to-market value (Market Capitalization $\leq$ Median; $BE/ME \leq$ percentile 3).
B/H	Represent the group of portfolios that is *big* in size and have a *high* book-to-market value (Market Capitalization $>$ Median; $BE/ME >$ percentile 7).
B/M	Represent the group of portfolios that is *big* in size and have a *medium* book-to-market value (Market Capitalization $>$ Median; percentile $7 \geq BE/ME >$ percentile 3).
B/L	Represent the group of portfolios that is *big* in size and have a *low* book-to-market value (Market Capitalization $>$ Median; $BE/ME \leq$ percentile 3).

Figure 12: Presents a description of each label for the portfolios

Figure 13: Tickers of the used 409 Companies (SS Equity)

|								
1294047D	ARIONSDB	BEIAB	BRINB	COOR	HMB	INTRUM	LIAB	MSABB
AAK	ARISE	BEIJB	BTSB	COREA	HMS	INVEA	LIFCOB	MSONA
ABB	ARJOB	BELE	BUFAB	COREB	HNSA	INVEB	LIME	MSONB
ACAD	ARP	BERGB	BULTEN	CRADB	HOFI	INWI	LOOMB	MTGA
ACANB	ASP	BESQ	BURE	CSN	HOLMA	INVUO	LUC	MTGB
ACAPA	ASSAB	BETCO	CALTX	CTM	HOLMB	IPCO	LUG	MTRS
ACAPB	ATCOA	BETSB	CAMX	CTT	HPOLB	IS	LUMI	MULQ
ACTI	ATCOB	BHG	CANTA	CYBE	HTRO	ITABB	LUMISDB	MVIRB
ADDTB	ATIC	BILIA	CAPIO	DEDI	PROB	SCAA	SPOR	THULE
AEROB	ATORX	BILL	CAST	DGC	PROEB	SCAB	SRNKEB	TIETOS
AFB	ATRE	BINV	CATA	DIOS	PROFB	SCST	SSABA	TIGO
AGRO	ATRLJB	BIOAB	CATB	DOM	PXXSSDB	SCVA	SSABB	TOBII
AHSL	ATT	BIOGB	CATE	DORO	QLINEA	SCVB	SSM	TRACB
ALFA	AVAILO	BIOT	CBTTB	DUNI	QLRO	SEBA	STARA	TRAD
ALIFB	AVEGB	BMAX	CCC	DURCB	RADH	SEBC	STARB	TRELB
ALIG	AXFO	BOL	CCORB	DUST	RAIL	SECTB	STEA	TRENT
ALIV	AXIS	BONAVA	CEVI	EAST	RATOA	SECUB	STEFB	TRI
ALNX	AZA	BONAVB	CHERB	EDGE	RATOB	SEMC	STER	TRMO
AM1S	AZN	BONEX	CLAB	EKTAB	RAYB	SENS	STRAX	TROAX
AMBEA	B3	BONG	CLASB	ELANB	RECIB	SHBA	STWK	TWW
ANODB	BACTIB	BOOZT	CNTA	ELEC	REJLB	SHBB	SWECA	TWWSDBA
ANOT	BALCO	BORG	COIC	ELOSB	RESURS	SHELB	SWECB	TWWSDBB
AOI	BALDB	BOUL	COLL	ELTEL	RNBS	SHOT	SWEDA	UFLXB
AQ	BEFSDB	BRAV	COMH	ELUXA	RROS	SINCH	SVEDB	WALLB
ARCM	BEGR	BRGB	CONSB	ELUXB	RSOFB	SINT	SVIK	VBGB
FPAR	HUFVA	IVSO	LUNDB	MYCR	RTIMB	SKAB	SWMA	VICPA
FPIP	HUFVC	JM	LUPE	NCAB	SAABB	SKFA	SWOLB	VICPB
G5EN	HUM	KABEB	MAG	NCCA	SAGAA	SKFB	SYSR	WIHL
GARO	HUSQA	KAHL	MCAP	NCCB	SAGAB	SKISB	TEL2A	WISE
GETIB	HUSQB	KARO	MCOVB	NDA	SAGAD	SMF	TEL2B	VITB
GHP	IARB	KDEV	MEABB	NDX	SAND	SNTC	TELIA	VITR
GRNG	IBTB	KINDSDB	MEDAA	NETB	SANION	SOBI	TETY	
GUNN	ICA	KINVA	MEKO	NETIB	SAS	SOFB	TFBANK	
GVKOB	ICTA	KINVB	MELK	NEWAB	ZETA	NOKIASEK	VOLVA	
HANDI	IFSA	KLED	MIDWA	NGQ	PEABB	NOLAB	VOLVB	
HEBAB	IFSB	KLOVA	MIDWB	NGS	PENGB	NOMI	VRGB	
HEMB	IMMNOV	KLOVB	MIPS	NIBEB	PLAZB	NOTE	VSSABB	
HEMF	IMMU	KNOW	MMGRB	NILB	PNDXB	NP3	WTX	
HEMX	INDT	LAGRB	MOB	NMAN	POOLB	NSPB	XANOB	
HEXAB	INDUA	LAMMB	MOMENT	NNB	PREC	NTEKB	XVIVO	
HIQ	INDUC	LATOB	MQ	NOBI	PREVB	NUE	VNESDB	
HLDX	INSTAL	LEO	MRG	NOBINA	PRICB	VOLO	VNVSDB	
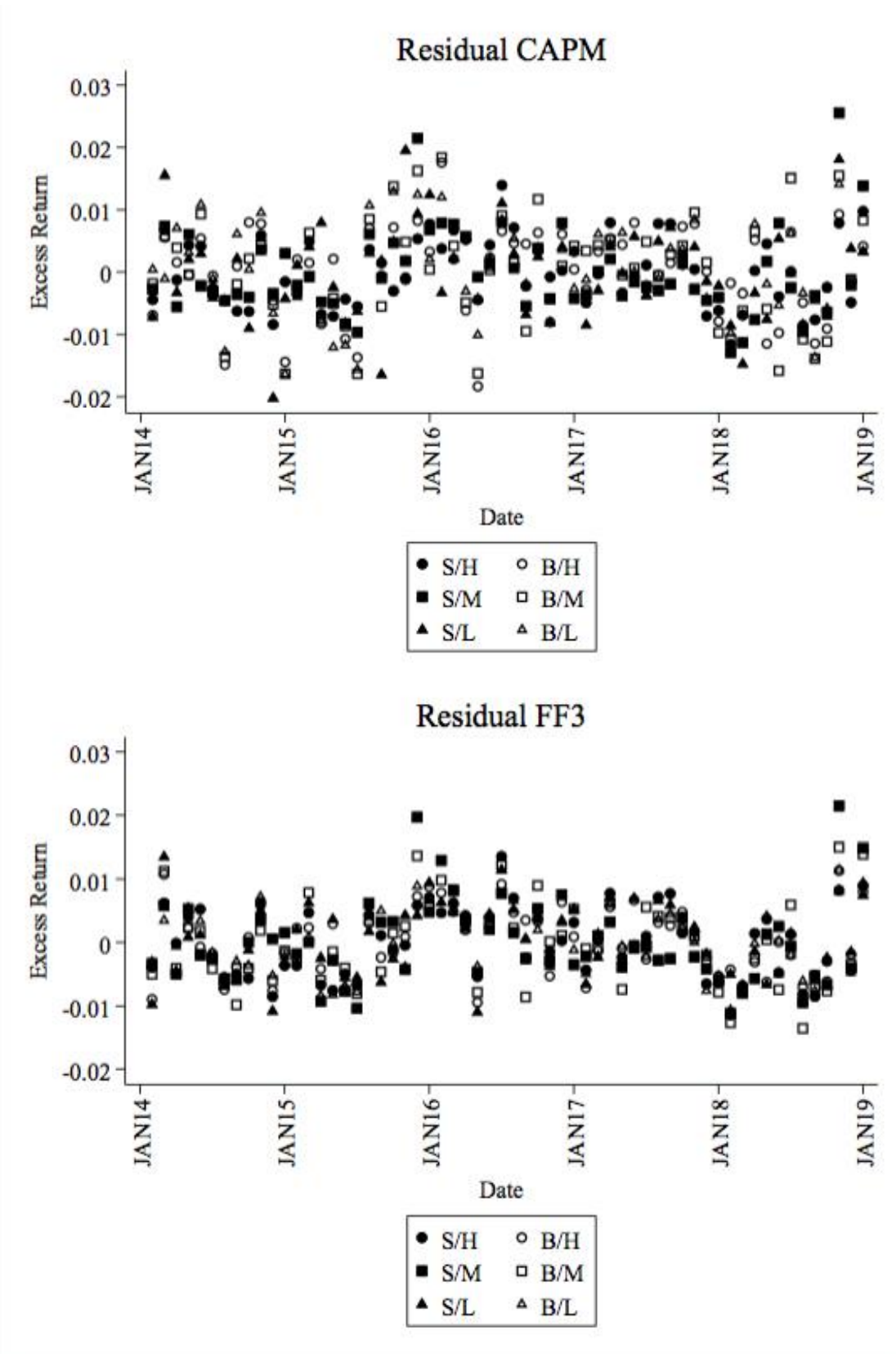
Figure 14: *Presents detrended residuals for both CAPM and FF3.*