LUND UNIVERSITY
School of Economics and Management

# The Size and Value effect of The Fama and French Three Factor Model

Do the variables remain meaningful or redundant? Evidence from the Swedish Stock Market 2007-2016

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**Abstract**

This thesis compared the explanatory power on excess return between the Capital Asset Pricing Model and the Fama and French Three Factor Model on the Swedish Market. Furthermore, an evaluation of the independent variables included in the Fama and French Three Factor Model was done. This was tested on a sample of 59 listed companies of the Stockholm Stock Exchange between 2007 and 2015. A total of 16 value weighted portfolios a year were constructed, which were constructed based on the characteristics of the individual companies. Regressions were performed on each portfolio which showed that the Fama and French Three Factor Model outperform the CAPM in explaining returns. Independently the SMB factor contributes the most in explaining excess return which was supported by the Goodness of fit and performed Students t-test. Hence the HML factor seem to be more redundant.

*Keywords: Asset Pricing Model, Capital Asset Pricing Model, Fama and French Three Factor Model, Portfolio Theory, Swedish Stock Market, Regressions, Students t-test*

# Contents

# 1 Introduction

The world's financial markets are becoming more and more interconnected, integrated and the total number of players in the stock market are growing. Everyday these investors make decisions on what to invest in and on what not to invest in on the public trading market. As every investor, private as well as institutional, seems to have one common goal – to maximize the rate of return – the crucial point of investing seems to be the prediction of the future rate of return.

With time the average investor has gained increasing opportunities to invest independently in the financial market due to simplifying technology, new models and strategies have been developed. Many of them guarantee that they will minimize risk, maximize return and beat the stock market. Nevertheless professors, businessmen and institutional managers constantly try to develop new models, techniques and algorithms that question the efficiency of already existing models.

In the 1960's an asset pricing model was developed by Sharpe, Lintner and Mossion (Fama and French, 2004). The model was the first of its kind and is called the Capital Asset Pricing Model (henceforth; CAPM). The model measures the relationship between expected return and the systematic risk, a relationship that is assumed to be linear (Berk and Demarzo, 2020). Divided opinions prevail about the model, since it has received a great deal of criticism while at the same time being used frequently in different contexts of financial calculations (Fama and French, 2004). The critics argue that the model doesn't explain a large part of the returns and that the assumptions of CAPM are unrealistic (Fama and French, 2004). According to the assumptions of the model, the risk of an asset is measured as relative between the asset's risk and the systematic risk (the risk on the market portfolio) (Fama and French, 2004). The market portfolio is a theoretical portfolio of investments including every asset available – including real estate, human capital and more (Fama and French, 2004). Bartholdy and Peare (2005) found that the CAPM seems to overestimate the cost of equity for high-beta stocks while it underestimates the cost of equity for stocks with low beta coefficients.

Although the amount of criticism to the model, CAPM is often the only asset pricing model taught in the investment courses of MBA (Fama and French, 2004). Furthermore, the model is described as the most widely used model in explaining the relationship between returns and risk (Fama and French, 2004).

Fama and French are two researchers who have built on the CAPM to receive the model to have a higher degree of explanatory power. In 1993 Fama and French constructed the model Fama and French Three Factor Model which is based on the CAPM with an addition of two new variables. The two variables are the firm size and the book-to-market equity ratio (BE/ME) which Fama and French found to explain a large part of an asset's return (Fama and French, 1993). The newly constructed model seemed to have a higher explanatory power than its predecessor according to empirical tests (Fama and French, 1993).

The expected return of an investment is the core regarding financial decisions. Hence, the calculation and thus the choice of model is central to financial decisions.

There are divided opinions about whether the models work in practice. However, the majority of empirical tests supports that the Fama and French Three Factor Model is superior to CAPM (Blanco, 2012; Kumar et al, 2020). Due to the dominance of research in the U.S, this has been particularly evident on that market. However, research has been done on the Swedish Stock market. Gustavsson and Gustafsson (2019) tested the model on the Swedish Market and came to the same conclusion - the Fama and French Three Factor Model is superior to CAPM. Schwert (2003) empirically shows that the effects of using the Fama and French Three Factor Model have disappeared after its publication. Fama and French (2015) found empirical evidence that one of the independent variables seems to have lost its effect in explaining returns. The empirical evidence that showed a superiority of the Fama and French Three Factor model have assumed that the variables work best together, which is in conflict with what has been established later on by Fama and French (2015) and Schwert (2003). This could be a problem when applying the model.

The purpose of this thesis is to test the CAPM and the Fama and French Three Factor Model to evaluate the contribution of the variables. This also allows the thesis to compare if the Fama and French Three Factor Model is the superior model in explaining returns. The tests will be performed on the Swedish Stock Market, where there is limited amount of research conducted. The limitation of research on the specific variables contribution and on the Swedish Market sparked my interest in this area. The questions that this thesis aim to answer are:

*''Is the Fama and French Three Factor model the superior model to CAPM in explaining returns on the Swedish Market?"*

*''Do the independent variables, HML and SMB, contribute in explaining returns on the Swedish Market, or are they redundant?"*

With these results I hope to provide managers with better knowledge of how to estimate returns. The thesis will generate more research on the Swedish market which may be useful for further investments in the Swedish Market. Furthermore, the results can be used for future research on asset pricing models.

The application of this thesis's is limited since it will be tested on the Swedish Stock market. As the stock markets varies in functions and efficiency the results obtained from this thesis should not be assumed to be applicable in other markets. Furthermore, the thesis is based on historical data during the years 2007-2015, which should be taken into consideration. The market and its efficiency are constantly changing, in which it should be assumed that these results are not necessarily applicable for other time periods.

This thesis will be based on the assumption that the market is semi-strong efficient according to the efficient market hypothesis (Byström, 2020). A semi-strong market is a market where it is not possible to make an excess return on historical data (technical analysis) nor on fundamental analysis. Moreover, it is assumed that all new publicly available information about the market itself or the company is reflected in the asset prices without any significant delay (Fama, 1970).

The results of this thesis provided evidence of that the variables included in the Fama and French Three Factor Model improves the explanatory effect. However it seems like the size factor has lost it's effect since it does not significantly improve the explanatory effect.

# 2 Previous research

Since the founding of the CAPM and the Fama and French Three Factor Model, there has been an enormous amount of research, tests and criticism of the models. The models have become important within finance to estimate returns and cost of equity.

The research on the model has mainly been used to empirically test the model to see if the model is durable or if it is violated in practice. This has mainly been tested on the US stock market because of natural causes due to the fact that it is the world's most developed stock exchange (Statista Research Department, 2021). Blanco (2012), Jackson (2020) and Gustavsson and Gustafsson (2019) are a few of the authors that have empirically applied the model. Blanco (2012) applied both the CAPM and the Fama and French Three Factor Model to the entire U.S market by using historically data. This to be able to draw a conclusion on which model has the highest explanatory power. Jackson (2020) choose to specify his test on a specific group of companies on the U.S market, lodging Real Estate Investment Trusts (REIT). This in order to be able to analyze whether the Fama and French Three Factor Model has a high degree of explanatory power on this specific type of asset. On the other hand, Gustavsson and Gustafsson (2019) chose to apply the CAPM and Fama and French Three Factor Model on the Swedish Stock Market in order to evaluate its performance. Blanco (2012) found that empirically the Fama and French Three Factor Model works better than the CAPM due to the fact that the Fama and French Three Factor Model explained more of the stock returns than the CAPM did. The single variable (Beta) of CAPM poorly described the portfolio return, while there exists evidence of how the characteristics related to the Book-to-Market and Size ratio explain the asset returns. This conclusion is shared with Gustavsson and Gustafsson (2019) who found that the Fama and French Three Factor Model produced significant coefficients and lower variance in the residuals. The low variance within the predicted residuals should be interpreted as a better fit of the predicted excess return (Gustavsson and Gustafsson, 2019). They found that the Fama and French Three Factor Model explained about 26% on average stock returns which is about eight times higher explanatory power than what they found CAPM to explain (2,98%) (Gustavsson and Gustafsson, 2019). Jackson (2020) used historical data of 33 U.S lodging REIT over a period of 20 years. Jackson (2020) found that lodging REITs that were significantly correlated with the three factors, had the greatest mean market capitalization (ME) and the greatest number of years on the stock market. Furthermore, it was statistically significant for firms listed on the US stock exchange for more than four years to be correlated with two or three factors (Jackson, 2020). Moreover, the authors find similarities on the model as the empirical results are reasonably consistent with the Fama and French (1993). Blanco (2012) found that the performance of the Fama and French Three Factor Model depends on how portfolios are constructed. If the model is going to be used, the portfolios have to be formed in a certain way in order to get the highest degree of explanatory power as possible (Blanco, 2012).

Additionally, extensive tests have been performed in emerging markets. The overall assessment of the tests performed is similar to what has been established before, that the

Fama and French Three Factor Model outperform the single factor model CAPM in explanatory power (Dolinar, 2013; Kumar et al, 2020). This evidence can be found in a paper by Kumar et al (2020). Where the authors applied the CAPM and the Fama and French Three Factor Model to a sample of non-financial companies from the main exchange of India, Bombay Stock Exchange 500. The results were consistent with previous empirical studies that advocate a superiority of the Three Factor Model over CAPM (Kumar et al, 2020). The same results are also found in a paper by Dolinar (2013). The author tests the Fama and French Three Factor Model and the CAPM on the stock exchange of Croatia, Zagreb Stock Exchange (ZSE). The result proved that the pricing models can be applied to the emerging market of Croatia. However, the results demonstrated that the success of the model in explaining risk return relation isn't as successful for the Croatian market as for developed market (Dolinar, 2013). Furthermore, Dolinar (2013) found that the B/M factor reveals a stronger common risk proxy in relationship to the size factor. Distinctly the Fama and French Three Factor Model was the superior model due to greater explanatory power than the CAPM (Dolinar, 2013). Dolinar (2013) like Achola and Muriu (2016) found that the Fama and French Three Factor Model face problems when it is applied to markets that aren't as the developed as the U.S Stock exchange. Achola and Muriu (2016) tested the model in the emerging market of Kenya on the Nairobi Securities Exchange (NSE). The authors found the problem to be non-liquid assets who violated the results of the models. Non-liquid assets occur when assets are nonfrequently traded (thin trading). This creates problems, since the prices and returns of the assets aren't true or effective ones. Unlike Dolinar the authors therefore adjusted the model for thin trading which shall be seen as proximation of risk in stock returns (Achola and Muriu, 2016). Furthermore, the authors found that after several trails and tests, the standard Fama and French Three Factor Model partially hold on the Nairobi Securities Exchange (Achola and Muriu, 2016). The study demonstrated that the variables of size and value premia are pervasive as per the conclusion of Fama and French. When the model was adjusted for thin trading, the model showed stronger evidence and they found that the returns of small firms and firms with high values of BE/ME-ratio outperforms big firms (Achola and Muriu, 2016). Furthermore, the Fama and French Three Factor Model has tried to be further developed. Fama and French (2015) found that by including two variables RMW (profability) and CMA (investments) the model can be developed even further. While the explanatory effect increased by adding these variables, they found an interesting phenomenon. The value factor (HML) seems to become redundant, as the factor did not contribute to a significantly higher degree of explanatory effect. Nagel (2013) found that using a Stochastic Discount Factor (SDF) the model can be improved. SDF is a stochastic model that derives the asset price by discounting the future cash flow with the help of a stochastic factor (Jagannathan and Wang, 2001). Nagel (2013) states that ''there is now little empirical justification for relaying on the Fama and French factors rather than a factor model that incorporates these other sources of cross-sectional return predictability as well" (2013, page. 193). Against the stated empirical evidence, the Fama and French Three Factor Model has been denied by researchers like Schwert (2003). Schwert (2003) demonstrated that the model (or specified, the factors) can no longer be used as an asset pricing model since the model is commonly known, hence it is incorporated in the market. Moreover Schwert (2003) refers to whether the model can be used, it must always be empirically proven. Empirically, this has failed to succeed (Schwert, 2003). Taken together, the majority of the previous research of the models demonstrate that the Fama and French Three Factor model is the superior model in explaining returns. Furthermore, it is also stated that for the model to work efficiently the assumptions must be met and the portfolios must be constructed in a consistent way. The disadvantage of the Fama and French Three Factor Model is the inferior performance on emerging markets and the large spread presented in the explanatory power. Beyond that there is also a huge amount of data and research on how the model can be developed further, by including a variable for thin trading and more advanced mathematical concepts like the Epstein-Zin Weil SDF.

# 3 Theoretical prerequisites

## 3.1 The Capital Asset Pricing Model (CAPM)

The Capital Asset Pricing Model was invented by Sharpe, Lintner and Moisson in the mid of 1960 (Fama and French, 2004). It is an asset pricing model that describes the relationship between the systematic risk and the expected return. The systematic risk (i.e., the market risk) is the inherent risk of the entire market, this shall be seen as a non-diversifiable risk. The opposite of the systematic risk is unsystematic risk, which is the risk associated with a specific company, industry or segment (Bodie, Kane and Marcus, 2014). The idea behind the assumptions and the model is that the unsystematic risk can be diversified away by adding stocks to the portfolio which diversifies away this risk. By adding enough stocks to the portfolio, the unsystematic risk can be completely diversified away (Meir Statman, 1987).

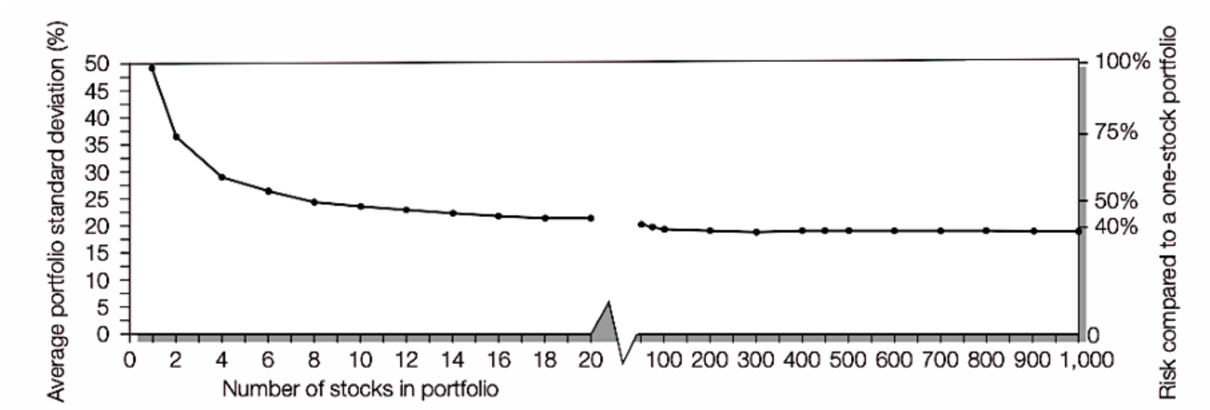


*Figure 3.1: Illustration of risk in a portfolio by adding more assets.Source: Meir Statman, ''How many Stocks Make a diversified portfolio", Journal of Financial and Quantitative Analysis (September 1987)*

Risk is usually measured from the data of the historical movements of the asset (Byström, 2020). The historical movements can be measured as the standard deviation ($\sigma$) which is referred to as the volatility of an asset (Byström, 2020). The higher the volatility – the riskier the asset, as the asset price tend to fluctuate more.

CAPM is based on this assumption, the higher the beta is – the higher the sensitivity to the systematic risk. The founders meant that, if one expects higher returns one has to take greater risk when choosing assets (Fama and French, 2004). The relationship between expected return and systematic risk is linear according to the model and can be illustrated through the Security Market Line (SML) with the intercept at a level with the risk-free interest rate (Berk DeMarzo, 2020).

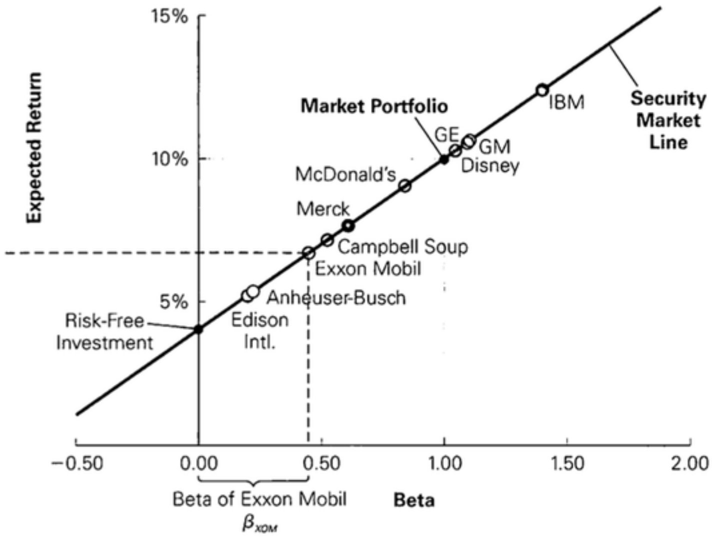


*Figure 3.2: Illustration of the Security Market Line with the intercept of the risk-free rate and expected returns as a function of the betas for different assets. Source: Berk and DeMarzo, 2020*

Furthermore, the expected return on the market portfolio is based on the assumptions of an effective market portfolio. This portfolio consists of risky assets and is diversified to the extent that it isn't possible to diversify further - only the systematic risk remains. When the portfolio is constructed to minimize the risk by diversifying with more assets this create a frontier that offers the highest expected return per unit of volatility ($\sigma$). The market portfolio is located on the efficient frontier as illustrated below (Berk and DeMarzo, 2020).

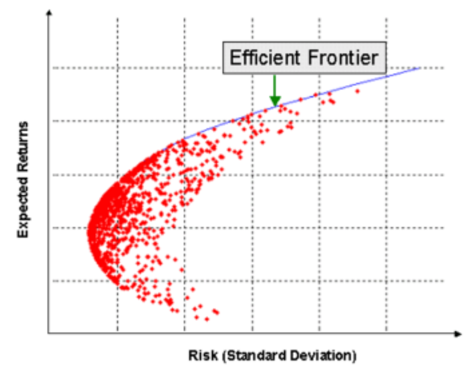


*Figure 3.3: Illustration of the efficient frontier when combining risky assets. The market portfolio is located on the frontier Source: Financetrain, 2021*

Furthermore, the Capital Asset Pricing Model is based on some assumptions, which of many are simplified assumptions. The assumptions are that all investors: (Corporate Financial Management, 2008):

1. Aim to maximize economic utilities
2. Are rational and risk-averse
3. Are broadly diversified across a range of investments
4. Are price takers, they cannot influence prices of stocks
5. Can lend and borrow unlimited amounts under the risk-free rate of interest
6. Trade without transaction or taxation costs

7. Deal with securities that are all highly divisible into small parcels
8. Have homogeneous exceptions
9. Assume all information is available at the same time to all investors

The model assumes as well that the risk of a stock should be measured as a relative to the market portfolio (M). The systematic risk can be measured as followed:

$$(Market\ Beta)\beta = \frac{(Cov(R_{\mathrm{i}}, R_{\mathrm{m}})}{Var(R_{\mathrm{m}})}$$

Where the covariance between a stock return and the return of the marker are divided by the variance of the market return, this ratio is called Beta ($\beta$). The Capital Asset Pricing Model combine this Beta-factor with the expected market return $E(r_m)$ the risk-free interest rate ($r_f$) to form:

$$E(r_{\mathrm{i,t}}) = r_f + \beta_i[E(r_m) - r_f]$$

The strength of the CAPM is that it's easy to use since it is a single factor model and that the beta coefficient is relatively straight forward to calculate. It is until today still widely used even though it has received a large amount of criticism. The criticism mainly focuses on the fact that the beta-value alone poorly explain the returns (Fama and French, 2004).

The critics have found that the returns can be increased by adding other variables. In 1992 Fama and French found evidence of effects based on size and book-to-market ratio that seem to have an explanatory effect in explaining returns. Stocks with low market values (size effect) tended to generate higher returns which wasn't covered in the CAPM. Stocks with high book-to-market equity ratio (BE/ME) had higher average returns than those with lower. Again, this was not covered by the beta variable in the CAPM (Fama and French, 1992).

## 3.2 The Fama And French Three-Factor Model

Fama and French found that, unlike the CAPM, two variables explain a large proportion of the average stock returns. The variables are book-to-market equity (BE/ME) and the size of the firm (ME). Fama and French (1993) included these variables (i.e. risk premiums) to the existing CAMP and constructed the Fama and French Three Factor Model. A risk premium is a compensation for investors who are at a higher risk by holding the specific asset (Berk and DeMarzo, 2020).

Size is defined as the market equity (ME) which can be calculated as the price of the stock times the number of outstanding stocks. Fama and French (1993) calculated this at the end of June at each year, t. The book-to-market equity (BE/ME) is defined as the book value of equity (BE) divided by the market value of equity (ME), both at the end of December at year t-1.

The stocks of the sample are divided into two groups depending on their independent size, the market equity. Which group each individual stock is placed in depends on its size compared to the sample. The groups are referred to as Small (S) and Big (B). Each year the median market equity of the sample is measured, the stocks that has a lower market capitalization is included in small (S) and the stocks with a higher market capitalization are included in the big (B).

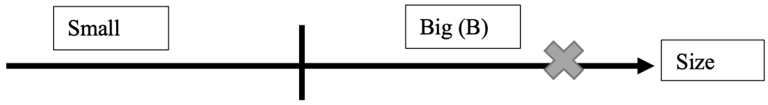


*Figure 3.4*

The second variable that Fama and French (1993) found explaining a large proportion of a stocks return is the book to market ratio (B/M). This ratio is derived by dividing the bookvalue by market capitalization as followed:

$$B/M = \frac{Book\ value}{Market\ capitalization}$$

Based on each firm's book-to-market ratio Fama and French (1993) divided the stocks into three additional groups. The groups consist of: Low (L), Medium (M) and High (H). The divisions are based on the percentiles of 30% and 70% where the low group has the lowest ratio. The stocks with lowest 30% BE/ME-ratio will be included in the low (L) group, the top 30% will be included in the high group (H) and the remaining 40% of the stocks will be included in the medium (M) group. Illustration of the division as below:

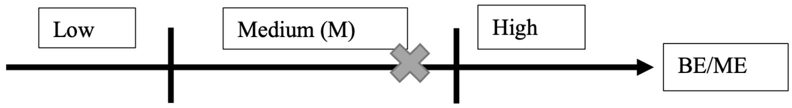


*Figure 3.5*

According to Fama and French (1992) the variable book-to-market equity ratio has a higher level of explanatory effect on the average stock returns than the risk factor Size. Fama and French took this into account when establishing the model and used two groups for market equity and three groups for book-to-market ratio. All companies of the sample are represented in both groups.

Fama and French (1993) constructed six portfolios out of this groups. The construction of the portfolios forms six different portfolios with different properties as followed: Big/Low (B/L), Big/Medium (B/M), Big/High (B/H), Small/Low (S/L), Small/Medium (S/M) and Small/Big (S/B). Illustration of the merge of figure X and X as below:

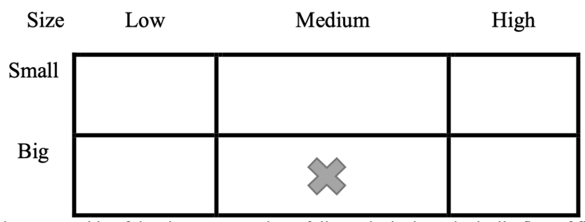


*Figure 3.6*

For each one of the six portfolios, the returns are calculated. Fama and French (1993) calculate the value-weighted monthly excess returns of each one of the portfolios. When the returns are obtained the explanatory variables SMB and HML can be derived.

According to Fama and French (1993) the risk linked to the firm's size is demonstrated by the SMB factor. It is the excess monthly average and value-weighted return of the small portfolios subtracting the excess monthly average and value-weighted return on the big portfolios as followed:

$$SMB = \frac{(R_{SL} + R_{SM} + R_{SH})}{3} - \frac{(R_{BL} + R_{BM} + R_{BH})}{3}$$

The risk factor in returns related to the book-to-market ratio is defined by the HML. It is the difference between the average return of two high portfolios and the average return of the two low portfolios (Fama and French, 1993):

$$HML = \frac{(R_{SH} + R_{BH})}{2} - \frac{(R_{SL} + R_{BL})}{2}$$

Consequently, the Fama and French Three Factor model is estimated as:

$$E(r_{\mathrm{i,t}}) - r_{\mathrm{f,t}} = \beta_{1,t}[E(r_{m,t}) - r_f] + \beta_{2,t}[SMB] + \beta_{3,t}[HML]$$

Where:

$$E(r_{i,t}) = Expected\,return\,on\,asset\,i$$

$$r_{f,t} = The\,risk - free\,interest\,rate$$

$$E(r_{i,t}) - r_{f,t} = Excess\,return\,on\,asseti$$

$$E(r_{m,t}) = Expected\,return\,on\,the\,market$$

$$[SMB] = Expected\,return\,on\,the\,size\,factor\,on\,the\,size\,factor$$

$$[HML] = Expected\,return\,on\,the\,BE/ME\,factor$$

$$\beta_{1,t}, \beta_{2,t}, \beta_{3,t} = Coefficient\,for\,the\,independent\,variables$$

Fama and French (1993) used the excess returns of 25 portfolios as the dependent variables when running the times-series regression. These portfolios are constructed in the same manner as the six portfolios mentioned above, the difference is that a 5x5 matrix is used instead of a 2x3 matrix (Fama and French, 1993). This is done to obtain the beta coefficients of the regressions. Fama and French (1993) run these regressions from July of year t to the last of June year t+1.

# 4 Data

To perform the test, the data will be collected mainly from Thomson Reuters Datastream and the Swedish house of Finance Research Data Center (SHoFDB) published by the Stockholm School of Economics. These are two well-established sites to gather information from within the field of Finance. Data on five variables will be gathered, the variables are: Market return, risk-free rate, stock returns, market capitalization and book-value.

The market portfolio will be defined as the SIX-Return Index (SIXRX) which is a weighted index of all stocks on the Stockholm Stock exchange (Fondbolagen, 2021). Thus, the market return will be the return on the SIX-Return Index, which will be gathered as the monthly return from Fondbolagen.se (2021).

The risk-free interest rate ($r_f$) will be defined as the one-month interest rate of Treasury Bills published by the Swedish state. Due to Sweden´s high credit rating and the relatively short time to maturity the systematic risk shall be seen as almost non-existent (Riksgälden, 2019). With regard to this we suppose that the interest rate is totally risk-free although in practice there is no totally risk free asset (Bodie, Kane and Marcus, 2019). The interest rate will be gathered from the database of Swedish House of Finance Research Data Center on a monthly basis. Worth noting is that a few observations have such low values that it is stated in the appendix as 0.00%, yet the real values are included in the calculations.

The data of the stock returns, market capitalization and book-value will all be gathered from Datastream. To calculate the monthly stock returns, data about the monthly stock prices will be obtained. The stock prices are adjusted for stock splits, reverse stock splits and changes. The formula $\frac{(P_{\mathrm{M,t}}-P_{\mathrm{M,t-1}})}{P_{\mathrm{M,t-1}}}$ will be used to calculate the monthly returns of each individual stock. The sample of stocks used, market returns and risk-free rates can be found in the appendix.

The data of the market equity and the Book-value are gathered from Datastream. After collecting these variables, it was conceivably to calculate the BE/ME quota. Simply by dividing the Book-Value by the Market Capitalization.

As stated before, Achola and Muriu (2016) found that thin-traded stocks violates the estimation of betas when running the regressions of The Fama and French Three Factor Model. Taking this into consideration, small stocks will be excluded in the sample. Hence the data will be based on the stocks included in the index OMXS Stockholm Benchmark (OMXSB). This index represents a wide majority of industries and consists of the most traded and largest stocks listed on the Stockholm Stock Exchange (Nasdaq, 2021). Thus, using this index, the risk of including stocks that are less-liquid is reduced. There is then a smaller risk for incorrect and inefficient pricing of the assets which otherwise would violate the tests (Amihud, Mendelson and Pedersen, 2013; Corporate Finance Institute, 2021). Despite the fact that the index contains frequently traded and large stocks some stocks will be excluded from the sample. This may be due to lack of information, delisting and bankruptcy since it isn't possible to obtain the variables for those companies, the sample use is to be find in the appendix. When removing delisted and bankrupt stocks from the sample, this creates a problem of survivorship bias. Survivorship bias is when stocks are removed from the sample, this may be due to lack of information (Linnainmaa, 2013). In this case it depends on that stocks are either delisted from the exchange or have gone bankrupt. However, stocks tend to do this when they perform poorly which is a problem (Elton et al, 1996). In other words, the sample consist only of stocks that have performed well enough. This skews the results upward and makes the performance looks better since the underperformers are removed (Katopol, 2017). However, stocks can also be removed from the sample due to lack of information and in order for a company to be included in the finale sample, the stock must have been on the market in January a year before 2007, at t-1.

In order to estimate the beta, the sample should consist of at least five years (Brooks, 2019). Previous research demonstrate that the true beta tends to fluctuate over time. The longer the time period – the higher probability it is that the estimation of beta will be incorrectly estimated (Bartholdy and Peare, 2005). Hence in order to estimate the true beta, it is optimal to use monthly data and use a shorter period (Brooks, 2019). This specific time period is also considered, due to the conditions prevailing during the time. Due to the financial crisis of 2007-2008 the market entered a broad bear market which lasted between mid 2007 to late 2008. The bull market began straight after the bear market and lasted until the end of the sample period.

# 5 Variables

## 5.1 Market Portfolio

When using the Fama and French Three Factor Model some of the factors do depend on which portfolio is being used as the market portfolio. According to Fama and French (2004) the market portfolio should include all assets including real estate, human capital and more. Such a portfolio is difficult in practice thus, this thesis will be based on a broad market index. The SIX Return Index (SIXRX) is a value-weighted index that contains all stocks on the Stockholm Stock Exchange (Fondbolagen, 2021). The SIX Return Index reflets the Swedish Stock Market in its entirety which is as close to the assumption as one comes. The estimation of the monthly market returns are compounded of the index as the difference between current and previous period divided by the previous period. The formula can be written as:

$$R_{\mathrm{M,t}} = \frac{(Index - value\,Current\,period - Index - value\,previous\,period)}{Index - value\,previous\,period} = \frac{(P_{\mathrm{M,t}} - P_{\mathrm{M,t-1}})}{P_{\mathrm{M,t-1}}}$$

## 5.2 SMB

To create the variable Small Minus Big (SMB) the companies that is included in our study are ranked on their size. The size of a company is defined as their market capitalization which can be calculated as the price of a stock by its total number of outstanding shares. This is in line with the definition of size by Fama and French (1993). The groups Small and Big are defined and based on the median value of market cap of all stocks. The stocks with a smaller value than the median will be placed in the small and the stocks with a higher value will be placed in the big. On this basis, two portfolios are created (small and big).

## 5.3 HML

To create the variable High Minus Low (HML) the companies of the sample must be ranked on their value of book-to-market ratio (BE/ME). Once these have been ranked, the two previous portfolios (small and big) are both divided into three new portfolios by the percentiles of 30% and 70%. The companies with the lowest 30% of BE/ME will be included in the Low, the companies with the highest 30% of BE/ME will be included in the High. The remaining companies has a percentile of 30-70% which will be included in the medium. This will result in a total of six portfolios:

After constructing the six portfolios it is possible to calculate their individual returns. This is done as a value-weighted return on a monthly basis. The first variable SMB is being constructed as the average and value-weighted returns for the three portfolios within the

| | Low | Medium | High |
|---|---|---|---|
| **Small** | S/L | S/M | S/H |
| **Big** | B/L | B/M | B/H |

*Figure 5.1*

small group minus the average and value-weighted returns for the three portfolios within the big group. This is calculated every year, as following:

$$SMB = \frac{(R_{SL} + R_{SM} + R_{SH})}{3} - \frac{(R_{BL} + R_{BM} + R_{BH})}{3}$$

The second variable (HML) will be constructed by taking the average and value-weighted returns of the portfolios within the high group minus the average and value-weighted returns of the portfolios within the low group. The medium portfolios are excluded from this calculation which is in line with Fama and French (1993).

$$HML = \frac{(R_{SH} + R_{BH})}{2} - \frac{(R_{SL} + R_{BL})}{2}$$

## 5.4 Dependent Variables

As stated before, Fama and French (1993) used the excess return of 25 portfolios (5 times 5) as their dependent variables. In this case Fama and French (1993) used stocks from the major stock exchanges NYSE, Amex and NASDAQ of USA. This resulted in Fama and French having significantly more stocks in their sample during their period of observations than this thesis will process. This has an important meaning since if the portfolios would be constructed in the same manner as Fama and French (1993) there is a risk that some portfolios will only consist of as few as one stock. This could possibly lead to inaccuracies of the beta estimations in the regressions. The portfolios will be designed as 4 times 4 which result in 16 portfolios a year as illustrated below. This approach has been tested before and it did not violate the result (Ajlouni and Khasawneh, 2017).

| | Low | 2 | 3 | High |
|---|---|---|---|---|
| **Small** | | | | |
| **2** | | | | |
| **3** | | | | |
| **Big** | | | | |

*Figure 5.2*

The excess return of the 16 portfolios will be the dependent variable in the time-series regression. The portfolios are constructed the last trading day of the year each year, t. Fama and French (1993) did the reconstruction in June each year, this was done as Fama and French wanted to be ensure that all the necessary information would be available at that date (Fama and French, 1993). Because all data is available in the last trading day of the year and the BE/ME does not change in a structural way, this should not be a problem.

All portfolio returns will be on a value-weighted basis. A portfolios value weighted return can be calculated in two steps (Byström, 2020):

$$W_i = \frac{Stock\, Market\, Equity}{Total\, portfolio\, Market\, Equity}$$

$$E(r_p) = \sum_{i=1}^{n} W_i * E(r_i)$$

Where:

$$W_i = Weight\, of\, asset\, i\, in\, portfolio$$

$$E(r_p) = Expected\, return\, on\, portoflio$$

$$n = Number\, of\, companies\, included\, in\, the\, portoflio$$

# 6 Methodology

## 6.1 Construction of the portfolios

The portfolios of the sample are constructed each year. The reconstruction of the portfolios will take place in the end of each year, at the last trading day of the year. The original paper by Fama and French (1993) reconstructs the portfolios in the first of June each year, this to ensure that all required information (i.g. book-value) is available. If the required information is not available, a lack of information arises which is called ''look-ahead bias" (DeFusco et al, 2015). If this problem occurs, it is not possible to use the model. Theoretically this chosen time for reconstructing the portfolios will not affect the final result to any great extent. This has been done by among others Månsby and Lindström (2017) who did not come to the conclusion that this had a negative effect.

The portfolios are reconstructed based and sorted on size (market capitalization) and the BE/ME factor. For each year the median of the market capitalization is calculated. The stocks with a higher value than the median are placed in the big group (B) while those with a smaller value are placed in the group small (S). The two portfolios are divided into three additional groups based on the B/E-ratio. The value-weighted returns of the portfolio are calculated from year t to t+1 each year. Each year six portfolios are constructed in order to calculate the explanatory variables HML and SMB.

## 6.2 Test of data

In addition to the necessary regression analyzes, other tests will be performed on the data. This is to ensure that the variables have an explanatory power and not only affected by the data itself. To ensure this, the data will first be tested with a unit-root test then multicollinearity, auto-correlation and heteroscedasticity (Brooks, 2019).

## 6.3 Stability condition

To be able to perform a regression on a time series data, we first have to perform a stationarity test. Since stationarity in the data is required for successful testing of the data (Fabozzi et al, 2014). To test this in a formal way a test called "Augmented Dickey-fuller (ADF) test" can be used. The ADF test states the null hypothesis: $H_0$: The variables have a unit-root, against $H_1$: The variables do not have a unit root. If the null is rejected then the stability condition holds and we can proceed with testing the other assumptions that are described below (Fabozzi et al, 2014).

## 6.4 Multicollinearity

Multicollinearity measures the interaction (correlation) of the independent variables. If there exists a high correlation between the independent variables used in the multiple regression it is called multicollinearity (or simply referred to as collinearity). The cause of its emergence depends on the fact that the independent variables in the regression contain common information and data (Fabozzi et al, 2014). If there exists presence of collinearity this can cause problem for the test since this can prevent the regressions from revealing the true contribution of each individual variable (Fabozzi et al, 2014). Multicollinearity can be detected by using a correlation matrix, this can be complimented with further testing using a test called Variance Inflation Factor (hereinafter; VIF) (Fabozzi et al, 2014).

## 6.5 Autocorrelation

Autocorrelation measures the relationship between error terms current value and their past values. If there is no autocorrelation this means that the test should not demonstrate any significant correlation between residuals. Autocorrelation can take any value between $-1 \leq p \leq 1$ where -1 is perfect negative correlation, 1 is perfect correlation and 0 means no correlation in the error terms and $p$ is the autocorrelation coefficient (Fabozzi et al, 2014). The presence of autocorrelation can cause problem if it is assumed that the observations are independent. Autocorrelation can also occur when the model is incorrectly specified. If for example testing the data as a simple linear relationship (e.g. OLS) but the true observations has a parabola graph, this will cause auto-correlation (Fabozzi et al, 2014). In order to detect autocorrelation "Breusch-Godfrey test" will be used. The null- and it's alternative hypothesis is (Brooks, 2019):

$$H_0 : p = 0$$

$$H_1 : p \neq 0$$

If the null is not rejected then there is no autocorrelation

## 6.6 Heteroscedasticity

It is of importance that the error terms are homoscedastic, this because the variance of the probability distribution of the error terms should not depend on the independent variables (Campbell, Lo and Mackinlay, 1997). If this condition is violated the error terms are heteroscedastic. Heteroscedasticity implies that for some observations the error terms are larger, which is an issue when the model is constructed, which can lead to invalid regression coefficient estimates. To test heteroscedasticity a test called "White's generalized heteroscedasticity test" (henceforth called ''whites test") is used. The issue of heteroscedasticity can be solved using a method called "weighted least squares estimation technique", which will correct the heteroscedasticity by weighing the observations coming from the population with larger variances, less weight, and the observations from observations with higher variance, more weight (Fabozzi et al, 2014). The hypothesis is:

$$H_0 : thereishomoscedasticity$$

$$H_1 : Unrestrictedheteroscedasticity$$

If the null hypothesis is not rejected there is no present of heteroscedasticity.

## 6.7 Regressions

To obtain the beta-coefficients of the three factors (Rm-Rf, SMB and HML), Ordinary Least Square (OLS) times series regressions will be used. The regressions will be performed on each one of the portfolios and equations listed below:

$$R_{\text{i,t}} - r_{\text{f,t}} = \alpha_i + \beta_1[R_{\text{m,t}} - r_f] + \epsilon_i$$

The CAPM Regression

$$R_{\text{i,t}} - r_{\text{f,t}} = \alpha_i + \beta_1[R_{\text{m,t}} - r_f] + \beta_2[SMB] + \epsilon_i$$

The CAPM+SMB Regression

$$R_{\text{i,t}} - r_{\text{f,t}} = \alpha_i + \beta_1[R_{\text{m,t}} - r_f] + \beta_2[HML] + \epsilon_i$$

The CAPM+HML Regression

$$R_{\text{i,t}} - r_{\text{f,t}} = \alpha_i + \beta_1[R_{\text{m,t}} - r_f] + \beta_2[SMB] + \beta_3[HML] + \epsilon_i$$

The Fama and French Regression

When performing the regressions, an intercept ($\alpha$) will be generated. The intercept will be referred to as Jensen's Alpha, this measures the abnormal return (Black et al, 1972). The alpha will generate p-values which will be tested against the critical value (5%).

According to the theory of the model the beta coefficients ($\beta$) should explain the portfolios return (Fama and French, 1993). If the model acts in this way in practice, Jensens Alpha ($\alpha$) should be statistically insignificant, and the degree of explanation ($R^2$) should be high (Brooks, 2019).

To assess and be able to compare the validity of the models in the different tests, the goodness of fit will be central. In order to measure this, the coefficient of determination ($R^2$) will be used. The $R^2$ coefficient measure how well the independent variables explain the dependent variable (Brooks, 2019). The coefficient can take value $0 \leq R^2 \leq 1$ where 1 means that the model fits the data perfectly and 0 means that the model do not fit the data at all (Brooks, 2019).

To test if there is a significant difference between the results of the different tests the Student's t-test (henceforward t-test) will be applied. T-test can be used to determine if there is a significant difference between the means of groups (Körner and Wahlgren, 2015). The null hypothesis and an alternative hypothesis will be set up:

$$H_0 : \mu_i = \mu_j$$

$$H_1 : \mu_i \neq \mu_j$$

If the null hypothesis is rejected, the evidence of a difference is strong and not due to chance, a critical value of 5% will be used.

# 7 Empirical analysis

## 7.1 Results

As stated before the stability condition must hold in order to be able to run the other tests successfully. The condition was tested against the null hypothesis: H0: The variables have a unit-root, against H1: The variables do not have a unit root. The Augmented Dickey Fuller Test was used, the result was that the H0 can be rejected since all p-values are lower than 5%. The variables do not have a unit root.

*Table 7.1: Augmented dickey fuller test (Unit root)*

| **Portfolios** | **t-value** | **p-value** |
|---|---|---|
| **S_L** | -4.07486 | 0.00171 |
| **S_2** | -3.93152 | 0.002113 |
| **S_3** | -3.0299 | 0.008501 |
| **S_H** | -6.15322 | 0.0001383 |
| **2_L** | -3.87016 | 0.002316 |
| **2_2** | -3.97193 | 0.00199 |
| **2_3** | -3.85648 | 0.002364 |
| **2_H** | -4.48361 | 0.0009548 |
| **3_L** | -3.19908 | 0.006517 |
| **3_2** | -4.05809 | 0.001752 |
| **3_3** | -3.21424 | 0.006359 |
| **3_H** | -4.31531 | 0.001209 |
| **B_L** | -6.48175 | 0.0001 |
| **B_2** | -6.44482 | 0.0001 |
| **B_3** | -6.33402 | 0.0001 |
| **B_H** | -5.78076 | 0.0001953 |

When the independent variables show high intercorrelation then this can create a problem. If this occurs the results risk to be misleading due to wider confidence intervals which in turn gives less accurate results. Test for multicollinearity in variables must be done after the models' significance has been determined (Fabozzi, 2014). To discover if multicollinearity exists the Variance Inflation Factor (VIF) is used. According to the test, values bigger than 10 may indicate a collinearity problem. As the test show no value larger than 10, we can assume that the data does not suffer from multicollinearity, as seen below.

*Table 7.2: Correlation matrix*

| **Variables** | **SMB** | **HML** | **RMRF** |
|---|---|---|---|
| **SMB** | 1 | 0,2666 | 0,313 |
| **HML** | | 1 | -0,0399 |
| **RMRF** | | | 1 |

*Table 7.3: Variance Inflation Factor*

| **Variable** | **VIF(j)** |
|---|---|
| **RMRF** | 1,129 |
| **SMB** | 1,214 |
| **HML** | 1,096 |

To detect if there exist any signs of correlation between the error terms the Breusch-Godfrey test will be used. The result from the Breusch-Godfrey test, the probability of chi2, can be interpreted by whether autocorrelation occurs. If the probabilities of chi2 are greater than the significance level used, 5%, then the null hypothesis cannot be rejected. In the results of the Breusch-Godfrey test presented in table 7.4 we can see that the probabilities of all portfolios lead to the null not being rejected, therefore there exists no autocorrelation in any model.

*Table 7.4: breusch godfrey (AUTO-CORRELATION)*

| **Portfolios** | **Chi2** | **prob>chi2** |
|---|---|---|
| **S_L** | 0.644455 | 0.422 |
| **S_2** | 2.413342 | 0.12 |
| **S_3** | 0.338395 | 0.561 |
| **S_H** | 0.124595 | 0.724 |
| **2_L** | 0.509931 | 0.475 |
| **2_2** | 1.355180 | 0.244 |
| **2_3** | 0.747401 | 0.387 |
| **2_H** | 1.157716 | 0.282 |
| **3_L** | 1.124137 | 0.289 |
| **3_2** | 0.936990 | 0.333 |
| **3_3** | 0.123064 | 0.726 |
| **3_H** | 0.997429 | 0.318 |
| **B_L** | 0.410228 | 0.522 |
| **B_2** | 0.886713 | 0.346 |
| **B_3** | 1.016484 | 0.313 |
| **B_H** | 0.292325 | 0.589 |

To test if the data is violated of heteroscedasticity the data was tested with the Whites test. The excess return of each one of the 16 portfolios was set as the dependent variable. The hypothesis:

$$H_0 : there\ is\ homoscedasticity$$

$$H_1 : Unrestricted\ heteroscedasticity$$

Results are presented in Table 7.5. The probabilities of all portfolios were higher than the critical value of 0.05 which implies that the null hypothesis cannot be rejected, and no heteroscedasticity was present in the portfolios.

*Table 7.5: Whites test*

| **Portfolios** | **Chi2** | **prob>chi2** |
|---|---|---|
| **S_L** | 4.344454 | 0.630170 |
| **S_2** | 4.186773 | 0.651417 |
| **S_3** | 7.708486 | 0.260248 |
| **S_H** | 7.818454 | 0.251708 |
| **2_L** | 8.086614 | 0.231826 |
| **2_2** | 8.159246 | 0.226667 |
| **2_3** | 4.697762 | 0.583119 |
| **2_H** | 6.847516 | 0.335179 |
| **3_L** | 4.487721 | 0.610978 |
| **3_2** | 6.386565 | 0.381307 |
| **3_3** | 8.432534 | 0.208096 |
| **3_H** | 2.601263 | 0.856967 |
| **B_L** | 8.968814 | 0.175340 |
| **B_2** | 7.232369 | 0.299892 |
| **B_3** | 8.104893 | 0.230519 |
| **B_H** | 6.147686 | 0.406851 |

Consequently, the results from all regressions follow, starting with CAPM then adding the independent variables.

*Table 7.6: CAPM 2007-2015*

| **Portfolio** | **Alpha** | **P-Value** | **RmRf** | $R^2$ |
|---|---|---|---|---|
| **S_L** | 0.0202403 | 0.0625 | 0.151206 | 0.080385 |
| **S_2** | 0.0260316 | 0.0357 | 0.278787 | 0.197865 |
| **S_3** | 0.0102995 | 0.4402 | 0.260128 | 0.120089 |
| **S_H** | 0.0102484 | 0.4047 | 0.310554 | 0.187489 |
| | | | | |
| **2_L** | 0.0234276 | 0.1553 | 0.394686 | 0.187081 |
| **2_2** | 0.0106629 | 0.5524 | 0.324225 | 0.103212 |
| **2_3** | 0.0110651 | 0.4729 | 0.225192 | 0.070784 |
| **2_H** | 0.00472783 | 0.7417 | 0.236835 | 0.086245 |
| | | | | |
| **3_L** | 0.0137336 | 0.1361 | 0.258764 | 0.243397 |
| **3_2** | 0.0174249 | 0.1187 | 0.287753 | 0.215934 |
| **3_3** | 0.0187004 | 0.2278 | 0.287753 | 0.215934 |
| **3_H** | 0.0117139 | 0.3922 | 0.255552 | 0.112289 |
| | | | | |
| **B_L** | 0.0137360 | 0.0840 | 0.0474137 | 0.015200 |
| **B_2** | 0.00449809 | 0.8530 | 0.470001 | 0.114293 |
| **B_3** | 0.00273880 | 0.9114 | 0.436848 | 0.097703 |
| **B_H** | 0.00180058 | 0.9387 | 0.462135 | 0.118107 |

If the P-value of the intercept is lower than the critical value (i.e $< 5\%$) the intercept is statistically significant from zero. The model then underestimates the return for those portfolios. Hence the model underestimates the return for portfolio S2. If the intercept's p-value is higher than the critical value (>5%), the model estimates the return correctly. The goodness of fit ranges from $0.07 \leq R^2 \leq 0.2434$.

*Table 7.7: CAPM+SMB 2007-2015*

| **Portfolios** | | **P-value** | **Rm-Rf** | **SMB** | $R^2$ |
|---|---|---|---|---|---|
| **S_L** | 0.0188838 | 0.1406 | 0.00901186 | 1.50720 | 0.882056 |
| **S_2** | 0.0233294 | 0.2535 | 0.126894 | 1.43058 | 0.720023 |
| **S_3** | 0.0248001 | 0.1942 | 0.0714686 | 1.76909 | 0.684524 |
| **S_H** | 0.00738642 | 0.2701 | 0.155494 | 1.45975 | 0.614087 |
| | | | | | |
| **2_L** | 0.0164323 | 0.2633 | 0.140871 | 2.36894 | 0.881607 |
| **2_2** | 0.0105454 | 0.2173 | 0.0156813 | 2.87284 | 0.947155 |
| **2_3** | 0.0175482 | 0.2716 | 0.0255545 | 2.34067 | 0.855634 |
| **2_H** | 0.0199859 | 0.0574 | 0.0125922 | 2.09668 | 0.778644 |
| | | | | | |
| **3_L** | 0.00722576 | 0.6054 | 0.139335 | 1.13167 | 0.708759 |
| **3_2** | 0.0131104 | 0.5524 | 0.161326 | 1.19614 | 0.590849 |
| **3_3** | 0.0130325 | 0.4811 | 0.164840 | 2.04583 | 0.747645 |
| **3_H** | 0.0237556 | 0.3169 | 0.0674843 | 1.76360 | 0.658467 |
| | | | | | |
| **B_L** | 0.0155497 | 0.1508 | 0.0205153 | 0.279794 | 0.071805 |
| **B_2** | 0.00609962 | 0.6477 | 0.126424 | 3.19540 | 0.670637 |
| **B_3** | 0.0167418 | 0.0649 | 0.100896 | 3.12519 | 0.624894 |
| **B_H** | 0.0112219 | 0.3305 | 0.108261 | 3.29018 | 0.746853 |

When the independent variable SMB is added to the CAPM model, there are no statistically significant portfolios. The Goodness of fit ranges: $0.0718 \leq R^2 \leq 0.9471$.

*Table 7.8: CAPM+HML 2007-2015*

| Portfolio | Alpha | P-Value | RmRf | HML | $R^2$ |
|---|---|---|---|---|---|
| **S_L** | 0.0243208 | 0.1341 | 0.159257 | 0.575667 | 0.120512 |
| **S_2** | 0.0336923 | 0.0642 | 0.289928 | 0.964942 | 0.277417 |
| **S_3** | 0.0235558 | 0.2328 | 0.276094 | 1.57334 | 0.342269 |
| **S_H** | 0.0225754 | 0.2098 | 0.325720 | 1.47233 | 0.342269 |
| | | | | | |
| **2_L** | 0.0298869 | 0.2302 | 0.404789 | 0.834297 | 0.213459 |
| **2_2** | 0.0172814 | 0.5308 | 0.334468 | 0.851631 | 0.128294 |
| **2_3** | 0.0292798 | 0.1869 | 0.245428 | 2.11250 | 0.301317 |
| **2_H** | 0.0264220 | 0.1665 | 0.260075 | 2.49084 | 0.439329 |
| | | | | | |
| **3_L** | 0.0212453 | 0.1208 | 0.269775 | 0.948724 | 0.355324 |
| **3_2** | 0.0259086 | 0.1190 | 0.299606 | 1.05443 | 0.316301 |
| **3_3** | 0.0197641 | 0.4016 | 0.389012 | 0.247634 | 0.188327 |
| **3_H** | 0.0264220 | 0.1665 | 0.260075 | 2.49084 | 0.439329 |
| | | | | | |
| **B_S** | 0.0223919 | 0.0443 | 0.0594149 | 1.07316 | 0.310185 |
| **B_2** | 0.0371361 | 0.1998 | 0.510436 | 4.65897 | 0.542585 |
| **B_3** | 0.0439623 | 0.1087 | 0.481651 | 5.20987 | 0.628704 |
| **B_H** | 0.0367846 | 0.2038 | 0.499939 | 4.32744 | 0.511632 |

When adding the independent variable HML to the CAPM model the portfolio BS is statistically significant from 0. The Goodness of fit ranges: $0.1205 \leq R^2 \leq 0.6287$.

*Table 7.9: Fama French Three-factor Model 2007-2015*

| ***Portfolio*** | ***Alpha*** | ***P-Value*** | ***RmRf*** | ***SMB*** | HML | $R^2$ |
|---|---|---|---|---|---|---|
| **S_L** | 0.0137016 | 0.0660 | 0.0137850 | 1.53831 | 0.175753 | 0.885676 |
| **S_2** | 0.0241728 | 0.0705 | 0.134806 | 1.37900 | 0.291339 | 0.727300 |
| **S_3** | 0.0122921 | 0.3793 | 0.0925521 | 1.63165 | 0.776325 | 0.720757 |
| **S_H** | 0.0135142 | 0.3572 | 0.178067 | 1.31261 | 0.831161 | 0.660303 |
| | | | | | | |
| **2_L** | 0.0131016 | 0.886763 | 0.131272 | 2.43151 | 0.353425 | 0.2388 |
| **2_2** | 0.00328847 | 0.6324 | 0.000719162 | 2.97975 | 0.603889 | 0.959529 |
| **2_3** | 0.0144182 | 0.1383 | 0.00325749 | 2.15285 | 1.06090 | 0.909128 |
| **2_H** | 0.0139103 | 0.1270 | 0.0561949 | 1.81245 | 1.60551 | 0.913491 |
| | | | | | | |
| **3_L** | 0.0139628 | 0.1714 | 0.151106 | 1.05494 | 0.433416 | 0.731789 |
| **3_2** | 0.0182804 | 0.1990 | 0.175303 | 1.10502 | 0.514660 | 0.614275 |
| **3_3** | 0.00463567 | 0.7402 | 0.142492 | 2.19151 | 0.822854 | 0.777762 |
| **3_H** | 0.0156671 | 0.2844 | 0.0940648 | 1.59033 | 0.978731 | 0.714481 |
| | | | | | | |
| **B_L** | 0.0217133 | 0.0851 | 0.0483562 | 0.0983095 | 1.02514 | 0.316391 |
| **B_2** | 0.0192222 | 0.2651 | 0.218527 | 2.59502 | 3.39138 | 0.878677 |
| **B_3** | 0.0273159 | 0.0861 | 0.210397 | 2.41139 | 4.03198 | 0.916039 |
| **B_H** | 0.0177110 | 0.2066 | 0.189132 | 2.76301 | 2.97779 | 0.917859 |

Running the Fama and French Three Factor Model there are no statistically significant portfolios. The Goodness of fit ranges: $0.2388 \leq R^2 \leq 0.9595$.

In table table 7.10 we can see that the mean of the $R^2$ increased as independent variables are added to the model. The biggest contribution seems to be the SMB variable since it increases the mean far more than the HML variable.

*Table 7.10: Descriptive statistics over $R^2$*

| | **Mean** | **N** | **Std. Deviation** | **Std. Error Mean** |
|---|---|---|---|---|
| **CAPM** | 0,13492094 | 16 | 0,063684196 | 0,015921049 |
| **CAPM + HML** | 0,34107831 | 16 | 0,144379722 | 0,036094931 |
| **CAPM + SMB** | 0,69897744 | 16 | 0,197473306 | 0,049368327 |
| **FF3FM** | 0,74264106 | 16 | 0,210608919 | 0,052652230 |

In order to compare the means of $R^2$, a paired samples t-test is used. This test is presented in table 7.11, which shows the difference of means between the pairs. Together with t-statistics and p-values used to determine whether there is a significant difference of means between the pairs.

*Table 7.11: Paired Samples Test*

| **Pairs** | | **Mean** | **t** | **df** | **p-value** |
|---|---|---|---|---|---|
| **Pair 1** | CAPM - CAPM + HML | -0,206157375 | -4,931 | 15 | 0,000 |
| **Pair 2** | CAPM - CAPM + SMB | -0,564056500 | -11,837 | 15 | 0,000 |
| **Pair 3** | CAPM - FF3FM | -0,607720125 | -10,574 | 15 | 0,000 |
| **Pair 4** | CAPM + SMB - CAPM + HML | 0,357899125 | 5,178 | 15 | 0,000 |
| **Pair 5** | FF3FM - CAPM + HML | 0,401562750 | 7,172 | 15 | 0,000 |
| **Pair 6** | FF3FM - CAPM + SMB | 0,043663625 | 0,852 | 15 | 0,407 |

## 7.2 Analysis

As mentioned above, in order for the models to estimate the excess return correctly, the intercept needs not to be significantly different from zero, which occurs when the p-value ¡ 5%. As we can see from the results the only models where this occurs is the CAPM and when combining the CAPM and the HML factor. When combining the CAPM and SMB factor, no portfolio shows an intercept with a positive significant. Consequently, the same results are obtained from the regressions of Fama and French Three Factor Model. These results indicate that the variable SMB is a better estimator of excess return than the variable HML. It also reveals that the Fama and French Three Factor Model is a better estimator on excess return than the CAPM model.

When comparing the results of the $R^2$ between the tests, it is possible to see that the independent variables (SMB and HML) contribute to explaining returns of the Swedish Stock market. This since the $R^2$ increases when adding these variables to the CAPM model. The range of $R^2$ when adding one variable ranges: $0.0718 \leq R^2 \leq 0.9471$ for CAPM + SMB to $0.1205 \leq R^2 \leq 0.6287$ for CAPM + HML. SMB seem to have a greater positive impact in explaining returns than HML, yet the interval of CAPM + SMB is wider than for CAPM + HML. To conduct if the SMB factor has a higher degree of explanatory effect or only a wider range, a t-test was performed. The t-test support the view that SMB have a greater impact of explaining average returns as the mean of the $R^2$ is greater for the CAPM + SMB factor.

In the paired sample test the p-values of the test between pair 1 through pair 3 is 0,000. The null hypothesis can with certainty be rejected and in summary adding variables to CAPM increases the mean of $R^2$. When looking at the comparison of means between pair 4 we can see that the p-value is lower than the significance level at 5%. This concludes that the mean of adding SMB as a factor to CAPM generates a higher mean of $R^2$ compared to when adding HML. However, when studying pair 6 a significant difference between means cannot be proven as the p-value is higher than the significance level at 5%. This further perpetuates the question of whether HML is a redundant variable to the Fama and French Three Factor Model. Furthermore, it is of importance to keep in mind that this study has a risk of survivorship bias as some stocks were removed from the sample. This tend to skew the result positively (i.e., increasing the explanatory power), hence the results should not be interpreted as exact values. However, I estimate the effect of this risk to be relatively small as the proportion of stocks excluded from the sample is less than 8%.

Furthermore, the values of the risk factors demonstrated that the returns have on average been higher for companies with low BE/ME-ratio than for those with higher BE/ME-ratio. This is interpreted by the values of HML as for each year is negative. Excluding the first two years (2007-2008) small companies outperformed big companies in average returns. This shall be interpreted from the positive values of the SMB factor.

To conclude the results of this thesis and answer the research questions. The results give strong evidence that the Fama and French Three Factor model is superior to its precursor, the CAPM. The independent variables contribute to explaining average returns, however, the HML factor contributes significantly less than the SMB. Including HML in the Fama and French Three Factor Model may not estimate average returns more accurate due to the fact that significant difference cannot be proven.

# 8 Discussion

The results of this thesis is in line with Dolinar (2013), Blanco (2012) and Fama and French (1993; 2015) came to conclusion. The Fama and French Three Factor Model is superior to CAPM in explaining average returns. However, the results are completely or partially different from other conclusions related to Schwert (2003) and Gustavsson and Gustafsson (2019).

Stated in the analysis of the results it was possible to see that the SMB factor seems to explain a bigger proportion of the returns than the HML factor did. Various authors have come to different conclusions. In line with Fama and French (2015) the value factor (HML) seems to be more redundant in describing returns. They found like, the result of this thesis, that the value factor does not undoubtedly improve the result of the explanatory effect. This questions whether the factor can be excluded or replaced. Before stating a conclusion whether the value factor can be excluded, it would be interesting to construct the factor with different percentiles. Commonly used in the academic literature is 30-40-30, to use e.g., 20-60-20 might affect the results. Moreover, the results of this thesis partially violate the conclusion of Schwert (2003). Schwert (2003) stated that since the model was published, investors are aware of this model and can include it in their financial analysis. The opportunity to generate returns by incorporating this model should therefore be gone. This conclusion is not supported by the results of this thesis since the explanatory power increased as variables were included. Schwert (2003) base these statements as he refers to fact that if these factors exist, it must always be possible to empirically prove it. Since the results of this thesis consist of a limited sample and a relative short time period, this can still be consistent with Schwert.

A distinct but frequently difference in the results of papers testing the models is the variation of explanatory power. Gustafsson and Gustavsson (2019) found that the Fama and French Three Factor Model explained, 26%, on average where Ji et al (2020) found that the model explained between 45% to 77% while this thesis resulted in an average of 74%. Selfsame phenomenon occurs in the analysis of CAPM. Despite similar methods and regard to time and place there is great variation in the results. The results are affected by the choice of index and sample. However, the variation seems greater than just due to those factors. This may be a confirmation of what Blanco (2020) stated, that if the model is to be used – the portfolios need to be constructed carefully in a certain way to achieve explanatory power.

If this result is to be used for investments. It is recommended to invest in portfolios focusing on smaller companies with lower book-to-market equity, due to the positive values of SMB and negative values of HML. However, the result indicate that stocks of bigger size generate a higher return during the financial crisis of 2007-2008. Thus, stocks of higher values can be used as a more defensive strategy. This is not in line with what Fama and French (1992) advocates for as they claim that stocks with high BE/ME-ratio outperform stocks with low BE/ME-ratio. One explanation for this difference in results may be due to the sample used in this thesis which contains of stocks from an index who contain only relatively large stocks. If one would use a sample from an index consisting of all stocks on the Stockholm Stock Exchange, the results might be different. The majority of the stocks used in the sample of this thesis is in comparison with smaller companies (i.e., small- and mid-cap stocks) relatively big. Larger companies tend to have a higher BE/ME-ratio than small companies, hence if smaller stocks were included - the construction of the portfolios would look different (Berk and DeMarzo, 2020). This could result in other values of the factor.

# 9 Conclusion

The CAPM and the independent variables SMB and HML have been tested in different combinations, finally the Fama and French Three Factor Model were tested. This was tested on a sample from the Stockholm Stock Exchange between 2007-2015. To summarize and answer the research questions, we can say that the Fama and French Three Factor Model outperform the CAPM. This because Fama and French Three Factor Model succeed in explaining average returns. Moreover, the results show that the factor SMB explain a larger amount of the return than the HML does. However, the Fama and French Three Factor Model is not sufficient to explain all of the excess returns. This result is valuable to future research as well for future investment strategies. For future investment strategies based on this result, stocks with lower market equity are to prefer.

Future studies can take its starting point in the literature reviewed combined with the results obtained from this thesis. Now when it is known that the Fama and French Three Factor Model outperform the CAPM and that the value factor does not contribute much to the explanatory effect. It would be as interesting as useful to replace the value factor with another factor that seems to explain average returns. These factors could be, but not limited to, high earning yields and high return on capital. Furthermore, it would be interesting to increase the size of the sample to evaluate how the result differs as more shares are included.

To investigate and further develop the model it would be interesting to combine other factors to the Fama and French Three Factor Model in order to increase its accuracy. In liaison with the COVID-19 pandemic the world's stock markets experienced strong turbulence. The relationship between the macroeconomic figures and the stock market seems to be interconnected. Maybe it is possible to achieve a higher degree of explanatory effect by taking macroeconomic figures like inflation, GDP-growth, public spending and exchange rates into consideration of the model.

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# 11 Appendix

*Returns of market portfolio:*

| | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** |
|---|---|---|---|---|---|---|---|---|---|
| **Jan** | 0,0326 | -0,1227 | -0,0566 | 0,0081 | -0,0117 | 0,0583 | 0,0550 | -1,6700 | 0,0710 |
| **Feb** | -0,0219 | 0,0343 | 0,0282 | -0,0052 | -0,0161 | 0,0630 | 0,0357 | 0,0606 | 0,0807 |
| **Mar** | 0,0557 | -0,0165 | 0,0145 | 0,0878 | 0,0227 | -0,0103 | 0,0091 | 0,0064 | 0,0002 |
| **Apr** | 0,0675 | 0,0491 | 0,2172 | 0,0422 | 0,0402 | -0,0015 | 0,0206 | 0,0190 | 0,0023 |
| **May** | 0,0195 | 0,0286 | 0,0285 | -0,0688 | -0,0054 | -0,0659 | 0,0214 | 0,0375 | 0,0122 |
| **Jun** | -0,0223 | -0,1398 | 0,0099 | 0,0145 | -0,0350 | 0,0304 | -0,0504 | -0,0135 | -0,0637 |
| **Jul** | -0,0150 | -0,0069 | 0,1036 | 0,0460 | -0,0469 | 0,0419 | 0,0717 | -0,0074 | 0,0500 |
| **Aug** | -0,0264 | 0,0125 | 0,0340 | -0,0317 | -0,1048 | -0,0222 | -0,0104 | 0,0064 | -0,0593 |
| **Sep** | -0,0040 | -0,1233 | 0,0062 | 0,0842 | -0,0589 | 0,0303 | 0,0407 | -0,0016 | -0,0443 |
| **Okt** | -0,0192 | -0,1777 | 0,0476 | 0,0004 | 0,0883 | -0,0141 | 0,0173 | 0,0155 | 0,0693 |
| **Nov** | -0,0649 | -0,0212 | -0,0001 | 0,0143 | -0,0141 | 0,0309 | 0,0227 | 0,0336 | 0,0363 |
| **Dec** | -0,0200 | 0,0369 | 0,0191 | 0,0586 | 0,0111 | 0,0206 | 0,0209 | 0,0106 | -0,0403 |
| **Average** | -0,0015 | -0,0372 | 0,0377 | 0,0209 | -0,0109 | 0,0135 | 0,0212 | -0,1252 | 0,0095 |

*Risk free interest rates:*

| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|
| Jan | 0.00255 | 0,00348 | 0,00138 | 0,00018 | 0,00112 | 0,00147 | 0,00091 | 0,00068 | 0,0001 |
| Feb | 0.00243 | 0,00325 | 0,00109 | 0,00018 | 0,00121 | 0,00145 | 0,00082 | 0,0006 | 0,00008 |
| Mar | 0,00278 | 0,00366 | 0,00061 | 0,00019 | 0,00155 | 0,00143 | 0,00089 | 0,00067 | 0 |
| Apr | 0,00268 | 0,00343 | 0,00084 | 0,00021 | 0,00141 | 0,0013 | 0,00085 | 0,00063 | 0 |
| May | 0,00285 | 0,00348 | 0,00035 | 0,00022 | 0,00155 | 0,00134 | 0,00085 | 0,00065 | 0 |
| Jun | 0,00273 | 0,00336 | 0,00042 | 0,00017 | 0,00152 | 0,00125 | 0,00081 | 0,00063 | 0 |
| jul | 0,00296 | 0,00355 | 0,00035 | 0,00025 | 0,00155 | 0,00112 | 0,00081 | 0,00061 | 0 |
| Aug | 0,00298 | 0,00366 | 0,00013 | 0,00031 | 0,00157 | 0,00125 | 0,0008 | 0,00022 | 0 |
| Sep | 0,00292 | 0,0036 | 0,00014 | 0,00034 | 0,00167 | 0,00125 | 0,0008 | 0,0002 | 0 |
| Okt | 0,00308 | 0,00384 | 0,00016 | 0,00048 | 0,00151 | 0,00097 | 0,00087 | 0,00022 | 0 |
| Nob | 0,00327 | 0,00292 | 0,00015 | 0,00088 | 0,00159 | 0,00105 | 0,00084 | 0,00002 | 0 |
| Dec | 0,00339 | 0,00272 | 0,00013 | 0,00097 | 0,00164 | 0,00106 | 0,00086 | 0,00005 | 0 |
| Avg | 0,00296 | 0,00341 | 0,00048 | 0,00037 | 0,00149 | 0,00125 | 0,00084 | 0,00043 | 0,00002 |

*Value-weighted returns of portfolios:*

| | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** |
|---|---|---|---|---|---|---|---|---|---|
| **S_L** | -0,0245 | -0,0213 | 0,0456 | 0,0197 | 0,0306 | 0,0151 | 0,0502 | 0,0233 | 0,0310 |
| **S_2** | 0,0032 | -0,0297 | 0,0616 | 0,0363 | 0,0071 | 0,0073 | 0,0389 | 0,0187 | 0,0679 |
| **S_3** | -0,0339 | -0,0506 | 0,0388 | 0,0470 | -0,0255 | 0,0087 | 0,0209 | 0,0138 | 0,0520 |
| **S_H** | 0,0208 | -0,0676 | 0,0651 | 0,0177 | -0,0089 | -0,0048 | 0,0162 | 0,0052 | 0,0228 |
| | | | | | | | | | |
| **2_L** | -0,0303 | -0,0525 | 0,0953 | 0,0244 | -0,0039 | 0,0246 | 0,0442 | 0,0181 | 0,0585 |
| **2_2** | -0,0511 | -0,0745 | 0,1018 | 0,0190 | 0,0029 | 0,0090 | 0,0225 | 0,0208 | 0,0189 |
| **2_3** | -0,0317 | -0,0784 | 0,0530 | 0,0319 | 0,0023 | 0,0132 | 0,0133 | 0,0269 | 0,0506 |
| **2_H** | -0,0260 | -0,0877 | 0,0328 | 0,0199 | -0,0133 | 0,0166 | 0,0251 | 0,0182 | 0,0375 |
| | | | | | | | | | |
| **3_S** | -0,0083 | -0,0342 | 0,0407 | 0,0381 | 0,0388 | 0,0069 | -0,0002 | -0,0037 | 0,0240 |
| **3_2** | 0,0088 | -0,0390 | 0,0567 | 0,0289 | 0,0006 | 0,0094 | 0,0016 | 0,0058 | 0,0603 |
| **3_3** | -0,0380 | -0,0360 | 0,0914 | 0,0244 | -0,0214 | 0,0237 | 0,0220 | 0,0090 | 0,0615 |
| **3_H** | -0,0166 | -0,0645 | 0,0425 | 0,0113 | -0,0082 | 0,0194 | 0,0170 | 0,0147 | 0,0688 |
| | | | | | | | | | |
| **B_S** | 0,0397 | -0,0180 | 0,0176 | 0,0078 | -0,0122 | 0,0087 | 0,0259 | 0,0209 | 0,0293 |
| **B_2** | -0,0122 | -0,1826 | 0,0491 | 0,0084 | -0,0113 | 0,0071 | 0,0151 | 0,0054 | 0,0417 |
| **B_3** | -0,0067 | -0,1854 | 0,0361 | 0,0188 | -0,0086 | 0,0161 | 0,0232 | 0,0116 | 0,0343 |
| **B_H** | -0,0264 | -0,1705 | 0,0532 | 0,0139 | -0,0112 | 0,0144 | 0,0220 | 0,0091 | 0,0411 |

*Sample:*

| **Name of the Stock** | Market |
|---|---|
| Boliden AB | Basic materials |
| Holmen AB ser. B | Basic materials |
| Lundin Energy AB | Basic Materials |
| SCA ser. B | Basic materials |
| Ericsson, Telefonab. ser. B | Communication |
| Millicom Intern. Cellular SDB | Communication |
| Modern Times Group MTG AB ser. A | Communication |
| Modern Times Group MTG AB ser. B | Communication |
| Tele2 AB ser. B | Communication |
| TeliaSonera AB | Communication |
| Bilia AB ser. A | Consumer goods |
| Electrolux, AB ser. B | Consumer Goods |
| HM AB, ser. B | Consumer Goods |
| Husqvarna AB, ser. B | Consumer Goods |
| Ica Gruppen | Consumer Goods |
| Nobia AB | Consumer goods |
| Swedish Match AB | Consumer goods |
| Volvo, AB ser. B | Consumer Goods |
| Industrivärden, AB ser. A | Financials |
| Industrivärden, AB ser. C | Financials |
| Investor AB ser. A | Financials |
| Investor AB ser. B | Financials |
| Lundbergföretagen AB, L E ser. B | Financials |
| Nordea Bank AB | Financials |
| SEB ser. A | Financials |
| SHB AB ser. A | Financials |
| Swedbank AB ser. A | Financials |
| Betsson B | Gambling |
| AstraZeneca PLC | Health care |
| BioGaia AB ser. B | Health care |
| Biotage AB | Health care |
| Elekta AB ser. B | Health care |
| Getinge AB ser. B | Health care |
| SECTRA AB ser B | Health care |
| Vitrolife | Health care |
| AAK | Industrials |
| ABB Ltd | Industrials |
| AF, AB. ser. B | Industrials |
| Alfa Laval AB | Industrials |
| Assa Abloy AB ser. B | Industrials |
| Atlas Copco AB ser. B | Industrials |
| Autoliv Inc. SDB | Industrials |
| Billerud AB | Industrials |
| Electra B | Industrials |
| Hexagon AB ser. B | Industrials |
| Indutrade AB | Industrials |
| JM AB | Industrials |
| Lagercrantz Group AB, ser. B | Industrials |
| NIBE Industrier AB ser. B | Industrials |
| Sandvik AB | Industrials |
| SKF, AB ser. B | Industrials |
| SWECO AB ser. B | Industrials |
| Trelleborg AB ser. B | Industrials |
| Balder Fastighets AB, ser. B. | Real Estate |
| Castellum AB | Real Estate |
| Catena AB | Real Estate |
| Fabege AB | Real Estate |
| Hufvudstaden AB ser. A | Real Estate |
| Kungsleden AB | Real Estate |
| Wallenstam AB, ser. B | Real Estate |
| Wihlborgs Fastigheter | Real Estate |