*At the Department of Finance*

UNIVERSITY OF GOTHENBURG
**SCHOOL OF BUSINESS, ECONOMICS AND LAW**

# A Study of the Size and Value effect on the Stockholm Stock Exchange

*Are there pricing anomalies present on the Stockholm Stock Exchange?*

*Bachelor's Thesis*

*By*

*Milan Arif and Daniel Bezaatpour*

*Spring 2019*

*Supervisor: Charles Nadeau*

# Abstract

This thesis evaluates the financial performance of Swedish small cap stocks over the period 2000-2016. By applying CAPM and the Carhart four-factor model, we find no evidence for a size or a value effect. Furthermore, the results are inconsistent when conducting two-sided t-tests with Sharpe and Treynor ratios adjusted for asymmetrical return distributions. These findings strengthen our belief that the results in previous studies covering the same topic lack robustness. Finally, we find no evidence for the non-market risk to be attributed to any of the additional risk factors in the Carhart four-factor model.

# Acknowledgements

We would like to thank Charles Nadeau for providing well needed guidance in writing our thesis.

We would also like to thank the Department of Finance for providing access to Bloomberg's Terminal.

# Table of Contents

# List of Tables

# List of Figures

# 1. Introduction

## 1.1 Background

The assumption that financial markets are efficient has for a long time played a central role in economic and financial research. The assumption is based on the hypothesis that all market participants have access to the same information and that therefore, asset prices fully reflect all available information (Fama, 1970). The theory of an efficient market has for a long time induced a great number of research papers as it has captured the attention of many researchers. The majority appear to agree that the market, at least in the long run, is efficient to a certain extent. Price discrepancies when examining short-term asset price changes are expected as it is nearly impossible for all information to reach all investors simultaneously and due to psychological factors. The assumption of efficient markets raises a more controversial question. If the market is to be considered efficient, stock picking should by logic be considered futile as all available information is already incorporated in the asset prices. Therefore, both fundamental and technical analysis should fail to improve an investor's portfolio returns, eliminating potential abnormal returns (alphas).

Later studies have through empirical studies, found consistent asset price discrepancies through empirical studies (Banz, 1981 and Fama and French, 1992). The "small firm effect" refers to the theory which states that shares of firms with a smaller market capitalization often outperform their larger counterparts when comparing risk-adjusted returns. Multiple researchers have tried to make sense of the additional risk factors by identifying potential causal links. Some have argued that the small firms are subject to additional risk factors that have not been included when pricing assets in the past. Similar to the small firm effect, the "value effect" has also been found to perform higher than expected for their systematic risk (Fama and French 1992 and Rosenberg, Reid and Lanstein, 1985). The name refers to firms with a low book-to-market equity ratio (value firms), which have also proven to generate higher risk-adjusted returns. A typical value firm can be described as a firm that has a low market value due to poor performance and difficult financial situations, increasing the risk in the case of potential market contractions.

## 1.2 Research Question

Previous studies covering the use of multifactor models as an underlying investment strategy have predominantly focused on U.S and European stock markets. We intend to use a similar method in our research. More specifically, our research will differ from previous papers in its segmentation of stocks and creation of different portfolios. The focus will be aimed at firms listed on the large cap and small cap lists of the Stockholm Stock Exchange rather than a division of the market based on relative firm size.

*We intend to test the following null hypotheses:*

1. There is no statistically significant Jensen's alpha for investment in the equally weighted small cap portfolio.

2. There are no consistent statistically significant difference in risk-adjusted returns for the small firm portfolio and the value based portfolios.

3. The, by CAPM, unexplained risk in the portfolios cannot be attributed to the additional risk factors in the Carhart four-factor model.

The first null hypothesis will be tested using the capital asset pricing model (CAPM) (Sharpe, 1954). This is to determine if we can concur with the results of previous research arguing that CAPM overlooks certain risk factors. If there is a small firm effect or a value effect, we expect our regressions to return statistically significant intercepts. As to our second hypothesis, we intend to examine if our small cap portfolio performs significantly better than our large cap counterpart after adjusting for risk. We will use different risk measures and statistical tests to verify our results. The last hypothesis is mainly included for two reasons. First, we want to determine if the characteristics of our different portfolios will have an effect on the coefficients of the risk factors. Second, we want to determine if potential differences in returns can be explained by the four-factor model.

## 1.3 Purpose of Study

The purpose of our study is twofold. First, we want to examine how our portfolios have performed since the turn of the millennium to determine if the results are consistent with current financial theory. By testing the small cap stocks and comparing the results with large cap stocks we intend to examine small cap stocks' ability to achieve risk-adjusted returns. Second, we want to examine the performance of CAPM and Carhart's four-factor model to determine if the additional market factors help improve estimations.

## 1.4 Assumptions and Delimitations

In our paper we assume frictionless trading, i.e. there are no trading costs and all orders can be filled. We only consider common stocks. We also assume evenly distributed financial information.

## 1.5 Results

We find that statistically significant Jensen's alpha cannot be achieved consistently when solely basing ones investment strategy on the firm size effect and value effect. When comparing risk-adjusted returns we find no single strategy to consistently perform better than the other. Lastly, when testing Carhart's four-factor model we are unable to assign the risk of the portfolios to any of the three additional market factors.

## 1.6 Disposition

Following this page we provide a literature review of previously made studies of the pricing anomalies we intend to study. It is followed by a theory review in which the underlying theory and the different models are presented. This is followed by an explanation of the data and methodology used to reach our conclusions. Lastly, we present our results before finishing with conclusions and a critical evaluation.

# 2. Literature Review

This thesis makes use of multiple papers regarding the subjects of market efficiency, abnormal returns, and the “size effect” along with other asset pricing anomalies. Although multiple researchers argue that CAPM does not incorporate all relevant risk factors, the sources of these additional risks are not as widely agreed upon.

Based on prior research of relevant factors of asset pricing, Banz (1981) investigated the relationship between return and market value of common stocks. Historically CAPM had been used for asset pricing, postulating a simple linear relationship between expected return and market risk of a security. Using data from common stocks quoted on the NYSE between 1926 and 1975, the empirical study aimed at examining the relationship between returns and total market value.

Using 25 equally weighted portfolios on the basis of market value and beta, with groupings of five for each variable, Banz found large firms to generate a lower return than similar small firms. The greatest unexpected returns where found in very small firms, with medium sized and large firms not showing a statistically significant difference.

Banz emphasized the fact that although he found there to be a non-linear relation between firm size and returns after adjusting for risk, there was no theoretical foundation for such an effect. In his conclusion Banz referred to previous research on the subject, such as the findings of Klein and Bawa (1977). They found that investors avoided holding securities of which there was insufficient information due to the risk of estimation errors. As there was often more information about larger firms this could therefore be a potential reason for the size effect.

The same conclusion was reached by Arbel, Carvell and Strebel (1983). In their study, portfolios where created on the basis of size and institutional ownership to investigate the effect of large institutional holdings with regards to returns. In addition to the beta coefficient from CAPM, risk adjustments where made with respect to the Sharpe index (risk per unit of total risk) and the Treynor index (returns per unit of systematic risk) when comparing risk adjusted returns.

Their findings showed that institutionally neglected firms did in fact generate higher returns compared to firms intensively held by institutions. Although, their results showed an increase in total risk for the neglected firms, the risk adjusted earnings where more than double or quadruple depending on which of the two risk measurements was used. When looking at the difference in returns depending on size, the size effect was apparent for the data set as a whole but insignificant when comparing within each group based on institutional ownership. The conclusion was therefore that the size effect was a reflection of the neglected firm effect and not the other way around. As to why this effect existed, Arbel, Carvell and Strebel interpreted it as being due to the institutions role in gathering information and lowering the risk of estimation errors due to insufficient information.

In a later paper, Chan, Chen and Hsieh (1985) investigated the small firm effect through a model based on multiple factors. Market returns, the monthly growth rate of industry production, inflation and an adjustment for risk are included in the model. The market returns where based on the equally weighted NYSE index. The monthly growth rate of industrial production (IPI) was used for industry production and served as a proxy for real market activity. Real market activity was included since it was regarded as an indicator of the current state of the economy. Inflation was included to eliminate its effect on the cash flows. Finally, the adjustment for risk was based on the risk premium originating from the marginal trade-off between risky investments and consumption in different economic states. In a state of low consumption, higher returns are necessitated for maintaining the levels of investments and vice versa.

The study was based on the period 1953-1977 and twenty portfolios where created based on firm size. Using the return data from the twenty portfolios and the market factors above, cross-sectional regressions where used to obtain the different betas. Chan, Chen and Hsieh concluded that there was a size effect and that it was due to changing business conditions which where reflected in the changing risk premium. As smaller firms fluctuate more with business cycles, the higher returns are justified by the additional risks borne in an efficient market. Therefore, one could argue that markets are in fact efficient and the small size effect is due to risks intrinsic to investments in small firms.

Furthermore, Rosenberg, Reid, and Lanstein (1985) found a statistically significant abnormal performance of two different strategies. The first strategy intended to buy stocks with a high book-to-market equity ratio (BE/ME) and the second strategy was built upon the theory of mean reversal. The main strategy was to invest in stocks that had a relatively negative performance the prior month and short the stocks that had a relatively positive performance. Although both strategies generated abnormal returns, the latter was found to be much less efficient if the investor faced trading costs as it required more active trading.

In one of Fama and French's (1992) most heeded articles, "The cross-section of expected returns", the researchers examined the returns of American firms during the period 1963–1990. Their research was to a great extent based on prior research of the size effect made by Stattman (1980) and the effect of price-to-book-multiples (P/B) conducted by Rosenberg, Reid and Lanstein (1985). In their paper, the duo evaluated the joint roles of market beta, size, leverage and book-to-market ratio.

They found that market beta, as pointed out by earlier articles, contained little information regarding the average returns during the research period. However, they concluded that the size effect and book-to-market ratio captured a great part of the variation in stock returns. Their conclusion was that a portfolio constituted of small firms with a high book-to-market ratio performed better than other portfolios. They noted, however, that the feasibility of using their results depended on the future validity of their results and if the pricing of the securities where rational or irrational.

In a later paper, Fama and French (1996) found that the risk-return relation of their three-factor model (1992) was a good model for the returns of portfolios formed by size and book-to-market ratio. It was also documented that the Fama and French three-factor model explained the strong patterns in returns observed when portfolios where formed on earnings/price, cash flow/price, and sales growth.

Although asset pricing anomalies have been found in multiple empirical studies, it is not possible to assume that the same anomalies will be present in the future. One of the greatest drawbacks of empirical studies is the fact that if one looks hard enough, patterns and correlations may be found in the data even though they may be completely random. This should however not be interpreted as if empirical studies do not bear any weight, but rather that the results should be evaluated as time goes by. Empirical studies of the pricing anomalies have been criticized for using similar data sets and evaluating multiple possible causalities with the same data set, known in statistics as "data mining" (van Dijk, 2011).

In another paper, van Holle et al. (2002) evaluated the returns of investment strategies based on firm size and book-to-market ratio. Furthermore, the focus of the paper was aimed at the evaluation of the robustness of the findings.

A large size premium was observed when the investment strategy based on firm size was evaluated. However, the size premium was found to only be present in the cross-section of the whole European market. Hence, van Holle et al. concluded that the size premium was high and significant if stocks where selected on a European basis and not on a country-by-country basis. As for the value premium, the investment strategy based on book-to-market ratio was not found to be profitable. The stocks where divided into two equally weighted portfolios of value stocks and growth stocks. Initially, a significant value premium of 7% per annum was observed. However, the premium was found to be explained by the size effect.

In an earlier paper, Berk (1996) examined whether there was a significant cross-sectional relation between average returns and four non-market measures of firm size. The four measures used where all highly correlated with firm market value and consisted of book value of assets, value of property, plant and equipment, annual sales, and number of employees. However, Berk failed to find evidence to support his hypothesis and concluded that there was no evidence that the size effect was due to the existence of a relation between expected return and firm size.

Berk based his conclusion on the theory that a firm's market value depends on the discount rate since it is endogenously determined in equilibrium as the discounted value of expected future cash flows. He claimed that expected returns will always be negatively correlated with firm market value. Furthermore, Berk argued that the traditional interpretation of the empirical relation between market value and average return might be flawed. Rather than evidence of a size effect, the relation might have been due solely to the endogenous inverse relation between the market value and discount rate of firms.

# 3. Theory Review

In our theory review we describe the evolvement of asset pricing theory over time that has led to the factor model used primarily in our thesis, the Carhart four-factor model. These include, the efficient market hypothesis, the modern portfolio theory, the capital asset pricing model and the Fama and French three-factor model.

## 3.1 The Efficient Market Hypothesis

The efficient market hypothesis asserts that security prices fully reflect all available information and that stock prices react immediately to any new information. This makes it impossible to "beat the market", i.e. generate a positive alpha. If the efficient market hypothesis holds, it implies that neither technical nor fundamental analysis can generate positive alpha consistently and only inside information can result in risk-adjusted excess returns. Furthermore, there are three versions of the efficient market hypothesis (EMH);

*Weak-form EMH*
The weak-form efficient market hypothesis states that stock prices already reflect all information contained in the history of past trading that can be derived by examining market trading data such as the history of past prices, trading volume, or short interest.

*Semi strong-form EMH*
The semi-strong-form efficient market hypothesis asserts that stock prices reflect all publicly available information regarding the prospects of a firm.

*Strong-form EMH*
The strong-form efficient market hypothesis argue that stock prices reflect all relevant information, including information only available to company insiders.

## 3.2 Modern Portfolio Theory

Markowitz established his modern portfolio theory in an essay in 1952. It is, in combination with the assumption of market efficiency, considered to form the foundation for what would later be known as the Capital Asset Pricing Model. When forming his theory, Markowitz assumed that the goal of investors is to maximize returns given the level of risk in their portfolio. It asserts the idea that owning a diversified portfolio is less risky than owning only one financial asset. The key insight of the theory is that an asset's risk should not be assessed by itself, but that its contribution to the portfolios overall risk and returns should instead be the deciding factor. The most efficient portfolios together constitute the efficient frontier (Figure 3.1), a curve illustrating the relationship between risk and expected return. In his model, Markowitz uses the standard deviation of returns as a proxy for risk.

**Figure 3.1: CML and Efficient Frontier**

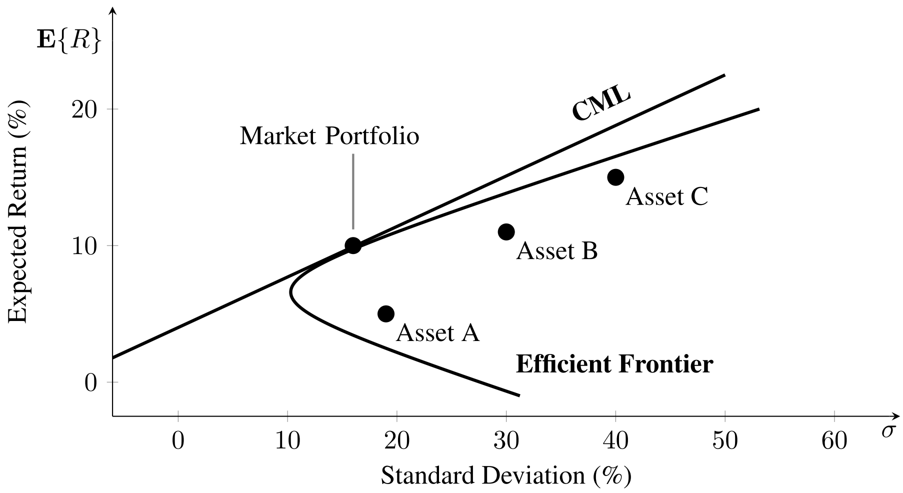



*Table 3.1: CML is derived from CAPM with its intercept representing the risk-free rate. The efficient frontier represents efficient combinations of portfolios. The market portfolio represents a portfolio with a beta of 1.*

## 3.3 Capital Asset Pricing Model

With the work of Markowitz, Sharpe (1964), Lintner (1965) and Mossin (1966) independently developed a model known as CAPM. The model illustrates that the expected return of an portfolio, at market equilibrium, depends on the sensitivity of the expected excess portfolio returns to the expected excess market returns. Thus, the model assumes that the market is efficient and that investors construct their portfolios in accordance to Markowitz's portfolio theory. The model can be illustrated by a linear function (Figure 3.1), known as "the Capital Market Line" (CML). As the model assumes that only systematic risk should be undertaken, an optimized portfolio should therefore lay on the CML. The point at which CML equals the efficient frontier represents the market portfolio.

CAPM states that:

$$R_{i,t} - R_{f,t} = \alpha_i - \beta_i(R_{m,t} - R_{f,t}) + \epsilon_{i,t} \tag{3.1}$$

where

| | |
|---|---|
| $R_{i,t}$ | = The expected return of portfolio *i* at time *t* |
| $R_{f,t}$ | = The risk-free rate at time *t* |
| $\alpha_i$ | = Jensen's alpha for portfolio *i* - risk adjusted return for portfolio *i* |
| $R_m$ | = Return of the market at time *t* |
| $R_{m,t} - R_{f,t}$ | = The excess return of the market |
| $\epsilon_{i,t}$ | = Error term for portfolio *i* at time *t* |

## 3.4 Fama and French – Three-Factor Model

Fama and French's extensive work in examining additional risk factors resulted in two additional explanatory variables for calculating expected returns; market capitalization and book-to-market equity ratio (Fama and French, 1995). According to Fama and French, their research results clearly indicated that these two factors constitute additional systematic risk which should be compensated for and therefore be included in the pricing models.

Their model has received criticism for being developed using market data ex-ante (van Dijk, 2011). It means that the data used for developing the model has been gathered after the fact and therefore, if one looks hard enough, will find patterns and relationships in the data set. These result might have been able to explain in-sample results but may not be good estimators when looking at out of sample data. This in turn means that the although the model was able to explain previous returns, it lacks the ability to work as a predicting model for future returns.

In their research, Fama and French argued that in addition to CAPM, two additional factors where to be included. The first factor denoted "small minus big" or SMB for short, represents what has in previous research been described as the small firm effect. The factor is made up of the returns from a portfolio consisting of small firms subtracted by a similar portfolio made up of large firms. Fama and French distinguished between the two by dividing the market in question into two parts with an equal number of stocks in each. The half containing the small firms was denoted small firms and the other half was by default the large firms. They chose to include the firm size as a factor due to their findings which showed that small firms bear risks other than the ones explained by CAPM.

The duo also included a factor based on book-to-market equity ratio, "high minus low" (HML). Similar to how the SMB portfolio is specified, the HML factor represents the difference in returns of firms with a high book-to-market ratio and firms with a low book-to-market ratio (BE/ME). The reason for this additional factor was the, according to Fama and French, historical return data showing firms with a high BE/ME consistently outperforming firms with a low BE/ME.

## 3.5 Carhart – Four-Factor Model

In his paper *"On persistence in Mutual Fund Performance"* (Carhart, 1997), Carhart built on Fama and French's three-factor model. In addition to the size effect and book-to-market equity ratio, Carhart also included an additional factor that captured Jegadeesh and Titman's one-year momentum anomaly (Jegadeesh and Titman, 1993). Some years prior, the two researchers had examined what they called the momentum effect. By buying stocks that had performed well in the past and selling stocks that had performed poorly, they were able to generate significant positive returns over a shorter period of three to twelve months. They found that this effect was however short-lived but that it was not due to increased systematic risk or delayed stock price reactions. Although the momentum effect is not in the scope of our thesis, its potential significance could help in determining relevant future studies. Additionally, its inclusion should theoretically not have an effect on the original model produced by Fama and French (1995) except potential lowering of endogeneity.

When estimating pricing errors, Carhart found that the three-factor model improved on the errors from CAPM. Although the errors where strongly negative for the previous year's loser stock portfolios, and highly positive for the winner stock portfolios. This confirmed the conclusion that Jegadeesh and Titman reached four years prior. Therefore, he included the momentum effect in the regression and found that the average pricing errors were reduced. The momentum effect is represented by "MOM" in the factor model and is calculated by subtracting the average returns of the lowest performing firms from the average returns of the highest performing firms. The model is otherwise based on much of the work of Fama and French and their evolvement of the CAPM. The small firm effect explained earlier is accounted for in SMB (small minus big). HML (high minus low) accounts for the value effect, and the momentum effect (MOM), is the difference between winners and losers.

The Carhart four-factor model states that:

$$R_{i,t} - R_{f,t} = \alpha_i - \beta_{1,i}(R_{m,t} - R_{f,t}) + \beta_{2,i}SMB_t + \beta_{3,i}HML_t + \beta_{4,i}MOM_t + \epsilon_{i,t} \quad (3.2)$$

where

| | |
|---|---|
| $R_{i,t}$ | = The expected return of portfolio *i* at time *t* |
| $R_{f,t}$ | = The risk-free rate at time *t* |
| $\alpha_i$ | = Four-factor alpha for portfolio *i* - risk adjusted return for portfolio *i* |
| $R_m$ | = Return of the market at time *t* |
| $R_{m,t} - R_{f,t}$ | = The excess return of the market |
| $SMB_t$ | = Fama-French's risk premium capturing size effects at time *t* |
| $HML_t$ | = Fama-French's risk premium capturing book-to-market effects at time *t* |
| $MOM_t$ | = Jegadeesh and Titman's risk premium capturing momentum effects at time *t* |
| $\epsilon_{i,t}$ | = Error term for portfolio *i* at time *t* |

## 3.6 Jensen's Alpha

Jensen's alpha, also known as "Jensen's measure", represents the average risk-adjusted return of a portfolio or investment, above or below the return predicted by the capital asset pricing model. A positive alpha value indicates that the investment has generated an abnormal return inconsistent with the systematic risk undertaken and that the market is inefficient. Contrary, a negative alpha value indicates abnormal losses, while an alpha value of zero indicates market efficiency. Thus, the market is deemed to be inefficient if a non-zero alpha is observed. Furthermore, in the Carhart four-factor model, the intercept represents Jensen's alpha and is referred to as the "four-factor alpha" (Low and Tan, 2016).

## 3.7 Sharpe Ratio

The Sharpe ratio measures the risk-adjusted return of a portfolio by dividing the excess return with the total risk of the portfolio. Thus, the Sharpe ratio gives the investor the incremental return she may expect for every $1\%$ increase in the portfolio standard deviation, i.e. a measure of the reward per unit of risk (Sharpe, 1994). It's link to Markowitz's portfolio theory decades earlier can be seen in its use of standard deviation as a risk measure (Markowitz utilized portfolio variance as a proxy).

The Sharpe ratio is defined as follows:

$$Sharpe\ Ratio = \frac{R_i - R_f}{\sigma_i} \tag{3.3}$$

$R_i$ = Return of portfolio *i*
$R_f$ = The risk-free rate
$\sigma_i$ = Standard deviation of portfolio *i*'s excess return

### 3.7.1 The Sharpe ratio, statistical assumptions and limitations

An important assumption beside others when using Sharpe ratios for comparison is the normality assumption. However, portfolio returns are often characterized by fat-tailed distributions and the normality cannot always be fulfilled. Numerous adjusted ratios have later been developed with the investors quadratic utility function (Sharpe, 1994) in mind as they penalize negative extreme events without weighing positive events equally. However, we do not intend to take the investors marginal utility into consideration, and we therefore utilize an adjusted ratio that weighs both positive and negative extreme events. One such adjusted ratio has been developed by Christie (2005). However, as it is cumbersome to use, we therefore intend to use Opdyke's (2007) simplification. The model differs from Sharpe's in the way the standard error is calculated. These standard errors will be used if the variance of returns is found to differ significantly between the compared portfolios.

The estimated standard errors, as specified by Opdyke, are specified as follows:

$$\widehat{SE(\widehat{SR})} = \sqrt{\left[1 + \frac{\widehat{SR}^2}{4}\left(\widehat{\frac{\mu_4}{\sigma^4}} - 1\right) - \widehat{SR}\,\widehat{\frac{\mu_3}{\sigma^3}}\right] \Big/ (T-1)} \tag{3.4}$$

$\widehat{SR}$ = Estimated Sharpe ratio
$\widehat{\frac{\mu_3}{\sigma^3}}$ = Estimated skewness of the distribution
$\widehat{\frac{\mu_4}{\sigma^4}}$ = Estimated kurtosis of the distribution

## 3.8 Treynor Ratio

The Treynor ratio measures the risk-adjusted return of a portfolio by dividing the excess return with the systematic risk of the portfolio, i.e. the portfolio beta. Thus, the Treynor ratio is a measure of excess returns per each unit of market risk (Treynor, 1965).

The Treynor ratio is defined as follows:

$$Treynor\ Ratio = \frac{R_i - R_f}{\beta_i} \tag{3.5}$$

$R_i$ = Return of portfolio *i*
$R_f$ = The risk-free rate
$\beta_i$ = Beta of portfolio *i*

## 3.9 Idiosyncratic Risk

When creating the portfolios used in this thesis, the selection of stocks are limited to the lists in question, i.e. the small cap and large cap lists. According to modern portfolio theory (Markowitz, 1952), this should theoretically diversify the portfolios. In an effort to account for all risk measures idiosyncratic risk is also included.

We define idiosyncratic risk as follows:

$$1 - R^2 = 1 - \frac{Explained\,Variance}{Total\,Variance} \tag{3.6}$$

According to Markowitz, only systematic risk should be undertaken as all other risk increases the portfolio's risk in an inefficient manner. In CAPM the systematic risk is explained by the beta. Thus, any variance in portfolio returns not attributed to beta is by definition due to idiosyncratic risk.

# 4. Data

## 4.1 Equity screening in Bloomberg Terminal

The monthly return data used in this thesis is collected from the Bloomberg terminal. The equity screening process starts by screening for common stocks on the Stockholm Stock Exchange, as our study only covers stocks on said exchange. We continue by screening for market capitalization to differentiate between large and small cap stocks. To obtain large cap stocks we screen for firms with a market capitalization over EUR 1 billion, and for small cap stocks we screen for firms with a market capitalization under EUR 150 million. In addition to the two portfolios based on market capitalization, we also screen by P/B ratio and create four additional portfolios. Two of the portfolios contain small cap stocks, one with stocks that have a above median P/B multiple and one that has a below median P/B multiple. Two similar portfolios are then created based on large cap stocks from the Stockholm Stock Exchange. We do not require returns data over the whole period, only for twelve consecutive months as the portfolio will be rebalanced annually. Also, equity for firms going bankrupt during the period are included as such information would not have been available when rebalancing the portfolio ex-ante.

## 4.2 The CAPM Market Factors

The market portfolio is constructed in Bloomberg with all common stock on the Stockholm Stock Exchange included to reflect the market performance. The portfolio is equally weighted and rebalanced annually. Thereafter, a backtest is conducted in Bloomberg to obtain total returns during the period, corresponding to the method used when constructing the aforementioned portfolios.

For the risk-free rate we use the Stockholm Interbank Offered Rate (STIBOR). The rate is based on the arithmetic mean of the interest on borrowing and lending between Sweden's largest banks. As the interest rates are yearly rates we have transformed them on a monthly basis by using the twelfth square root of the monthly observations.

## 4.3 House of Finance Reasearch at Stockholm School of Economics

All factors used in our model, apart from the market risk premium, are based on data from The House of Finance at the Stockholm School of Economics, Sweden's national research center in financial economics. The factors are calculated using the same method as Fama and French used when developing their three-factors model (1995). The portfolios from which the market factors are derived are equally weighted to match the portfolios we created for our thesis and prior research. All returns include dividend and capital gains.

### 4.3.1 Method for calculating market factors

The method used for calculating the SMB and HML factors is the same as Fama and French used in their 1995 paper. Six equally weighted portfolios are constructed yearly by forming two groups by market equity, and then further dividing those two groups into three groups each, based on BE/ME.

For the first grouping, the median ME (price times shares outstanding) on the Stockholm Stock Exchange is used to group the stocks into ”Small” and ”Large”. Then these two groups are further divided into three smaller portfolios based on BE/ME. The breakpoints are the top 30th percentile (value), the bottom 30th percentile (growth) and the 40 percentiles in between (neutral).

$$\begin{aligned} SMB = {} & \frac{(Small\ Growth + Small\ Neutral + Small\ Value)}{3} \\ & - \frac{(Big\ Growth + Big\ Neutral + Big\ Value)}{3} \end{aligned} \tag{4.1}$$

As the equation above states (Equation 4.1), the SMB is the average return of the small portfolios less the average return of big portfolios. When calculating the average, the arithmetic mean is used without any correction for differing market equity between the different portfolios. Thus, SMB represents the difference between returns on small-stock and big-stock portfolios.

$$HML = \frac{(Small\ Value + Big\ Value)}{2} - \frac{(Small\ Growth + Big\ Growth)}{2} \tag{4.2}$$

The HML factor is constructed by calculating the arithmetic mean returns of the portfolios with a high BE/ME ratio, and subtracting the arithmetic mean returns of the portfolios with a low BE/ME ratio. Like the SMB factor, returns are equally weighed for the HML factor as well.

# 5. Methodology

## 5.1 Econometric Analysis

Using the screening requirements specified in section 4.1 we perform a backtest, a method used for examining how well a trading strategy would have done ex-post. We rebalance the portfolios the last day of June each year. This is to avoid the ”January effect” and dividend periods, along with other factors that could affect the outcome (Fama and French, 1992). By rebalancing, we exclude the stocks which do not fulfill the capitalization requirements and include the stocks which meet the requirements.

$$Monthly\ Return = \frac{1 + R_{i,t}}{1 + R_{i,t-1}} - 1 \tag{5.1}$$

Using the Portfolio function in Bloomberg we obtain the total returns including dividends. The returns generated are total returns and we therefore convert the data into monthly returns to make it compatible for statistical testing with the data gathered from The Swedish House of Finance, which is based on monthly data (Equation 5.1).

In our thesis we make use of CAPM (Equation 3.1) as several of our risk measurements require the portfolio beta attained from the model. Carhart's four-factor model (Equation 3.2) is used for testing our third hypothesis; to determine its ability to explain potential price discrepancies. The regressions are run for the whole period using the statistics software Stata.

## 5.2 Sharpe Ratio

As the Sharpe ratio is the only risk measure not dependent on the systematic risk obtained from CAPM, it will be calculated seperatly. The ratios are calculated using the portfolio's excess returns and volatility (Equation 3.3). Before calculating the ratio, the Shapiro-Wilks test is used for determining the skewness and kurtosis of the return data, to be used in the calculation of our adjusted standard errors (Equation 3.4). The ratio is then, together with the other risk measures, used to identify potential differences in risk adjusted returns between the portfolios.

## 5.3 Statistical Test

As the data is of time series characteristics, we test the data for time trend, seasonality and serial correlation. The test for time trend is performed by running a regression of the return data on a time variable with a delta of one month. If time is a statistically significant explanatory variable, it would indicate the presence of a time trend. For seasonality, a dummy variable is created for 11 months of the year (to avoid multicollinearity by using 12 dummies) and tested for joint significance.

$$Monthly\,return = \beta_0 + \beta_1 t + \beta_2 Feb + \beta_3 Mar + ... + \beta_{12} Dec + \epsilon \tag{5.2}$$

The test for serial correlation is performed using the Breusch-Godfrey test. The null hypothesis of the test is that there is no serial correlation. We therefore examine the p-values and utilize Newey-West standard error if a p-value below 0.05 is obtained. Newey-West standard errors are to be used with an appropriate number of lags depending on the level of correlation. A higher correlation factor requires correction for a greater number of lags.

Multicollinearity occurs when there is a near perfect linear relation between two regressors. It can lead to inflated standard errors and inconsistent coefficients. To determine if our model suffers from multicollinearity, we calculate the variance inflation factor (VIF) in STATA. VIF gives us the ratio of our model with all factors included divided by the variance that would've been obtained if only one factor was being used. Although an acceptable VIF-ratio is not always agreed upon, the consensus is that a VIF ratio over 10 is too high.

Finally, the White test for heteroscedasticity is performed to determine if we have heteroscedasticity in the error terms. The White test establishes whether the variance of the error term is constant, whereas a non-constant variance would indicate heteroscedasticity.

## 5.4 Robustness

To determine the robustness of our findings, an alternative market portfolio and an alternative risk-free rate will be used. The data will be gathered from the Swedish House of Finance. By using these additional factors, we can better determine the robustness of our results.

# 6. Empirical Results

## 6.1 Descriptive Statistics

We produce a summary table of our data to get an overview. Studying the table, we observe some interesting properties about our data. Although the period for our analysis includes two major financial downturns, arithmetic mean returns from our small cap portfolio are marginally greater than returns from our large cap portfolio. We can however also see that the standard deviation is higher for our small cap portfolio, which is expected as described earlier in our thesis.

**Table 6.1: Descriptive Statistics**

| Variables | Mean | Median | Std. Dev. | Min | Max | Number of Observations |
|---|---|---|---|---|---|---|
| Small Cap | 0.011 | 0.003 | 0.098 | -0.276 | 0.608 | 203 |
| Small Cap (Low P/B) | 0.005 | 0.005 | 0.060 | -0.185 | 0.277 | 203 |
| Small Cap (High P/B) | 0.010 | 0.006 | 0.074 | -0.190 | 0.319 | 203 |
| Large Cap | 0.010 | 0.014 | 0.055 | -0.160 | 0.242 | 203 |
| Large Cap (Low P/B) | 0.013 | 0.013 | 0.059 | -0.169 | 0.288 | 203 |
| Large Cap (High P/B) | 0.003 | -0.003 | 0.076 | -0.217 | 0.283 | 203 |
| Market | 0.010 | 0.015 | 0.057 | -0.188 | 0.233 | 203 |
| SMB | -0.003 | -0.010 | 0.056 | -0.439 | 0.238 | 203 |
| HML | 0.007 | 0.005 | 0.044 | -0.250 | 0.139 | 203 |
| MOM | 0.003 | 0.009 | 0.067 | -0.316 | 0.272 | 203 |

*Table 6.1: All statistics are based on monthly data from Feb 2000 - December 2016. Means are calculated as arithmetic means. Market factors are obtained from The Swedish House of Finance. Small cap represents the returns from a portfolio with equal holdings in all firm stocks with a market capitalization below 150 million euros. Similarly, the Large Cap portfolio is equally weighted between all firm stocks with a above 1 billion euro market capitalization. High P/B represents all stocks with an above median P/B ratio and Low P/B represents all stocks with a below median P/B ratio.*

When analyzing our return data, we find there to be only one instance of a linear time trend and three instances of seasonality. A linear time trend is also present in the risk-free rate. Further investigation into the matter has led us to find that the risk-free rate has steadily declined over the period, except for some shorter rebounds. All linear time trends and forms of seasonality are adjusted for by using the residuals from a regression with a month count and eleven of the years months as the sole explanatory variables. Further details on the results from the tests of linear time trends and seasonality can be found in the appendix (Table 8.1 and 8.2).

Following our corrections for time trends, tests for serial correlation and heteroscedasticity were conducted. There were multiple cases of heteroscedasticity and serial correlation. However, as explained in section 5.3, Newey-West standard errors have been implemented in all such cases.

**Figure 6.1: Total Returns (Small Cap vs Large Cap)**

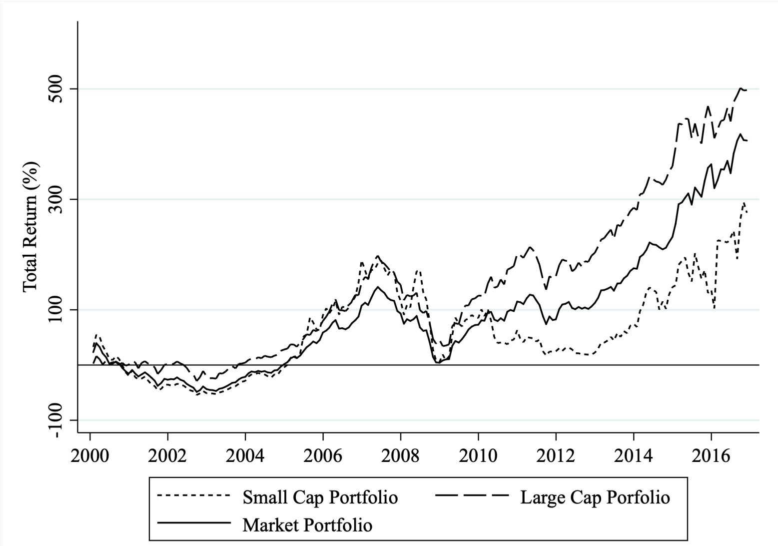



*Figure 6.1: Gross returns for equal investments in all stocks with a market capitalization under 150m euros (Small cap portfolio) and all stocks over 1 billion euros (Large cap portfolio). Market Portfolio represents all stocks on the Stockholm stock exchange.*

Figure 6.1 shows the total returns for the small cap and large cap portfolios in addition to the market portfolio from February of 2000 through 2016. Due to the dotcom crash, the returns are negative up until 2004 when the portfolios start to generate positive returns. In 2007, we observe a negative development again, due to the financial crisis of this period. Since that crash, the returns have steadily increased with the large cap portfolio performing better than the small cap portfolio.

The same observations can be made in figure 6.2, although at a different scale. When dividing the portfolios based on P/B, a great difference in the large cap portfolios appears, with the low P/B portfolio achieving much greater returns. These results are more consistent with earlier findings of Rosenberg, Reid and Lanstein (1985).

Figure 6.3 represents the monthly returns and is included to illustrate the difference in volatility for the the three portfolios. Although it is difficult to distinguish between the market portfolio and the large cap portfolio, the fluctuations of the small cap portfolio are apparent. Despite the fluctuations for the most part staying between positive 20% and negative 20%, there is a 60% positive return in February of 2016. This extreme event is unique by the fact that it is not matched by a similar movement in the other two portfolios. Nor can we find any potential reasons for it when researching the matter. The differences in return volatility are not as significant for the four additional portfolios constructed by both market capitalization and P/B ratio. (Appendix figure 8.3)

Examining figure 6.4 it becomes apparent the large cap portfolio has not only outperformed the

**Figure 6.2: Total Returns (Value Portfolio vs Growth Portfolio)**

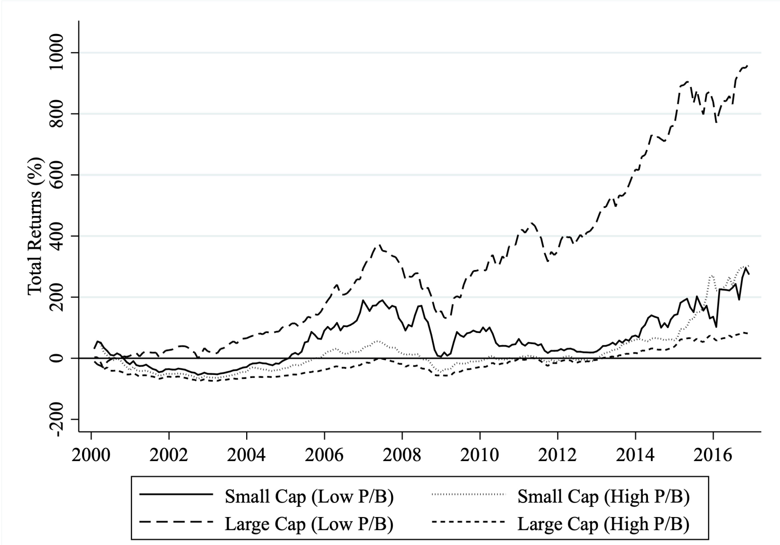



*Figure 6.2: Gross returns for equal investments in all stocks with a market capitalization under 150m euros (Small cap) and all stocks over 1 billion euros (Large cap). Low P/B represents all stocks with a below median P/B ratio and High P/B represents the half of the market with a above median P/B ratio.*

**Figure 6.3: Monthly Returns**

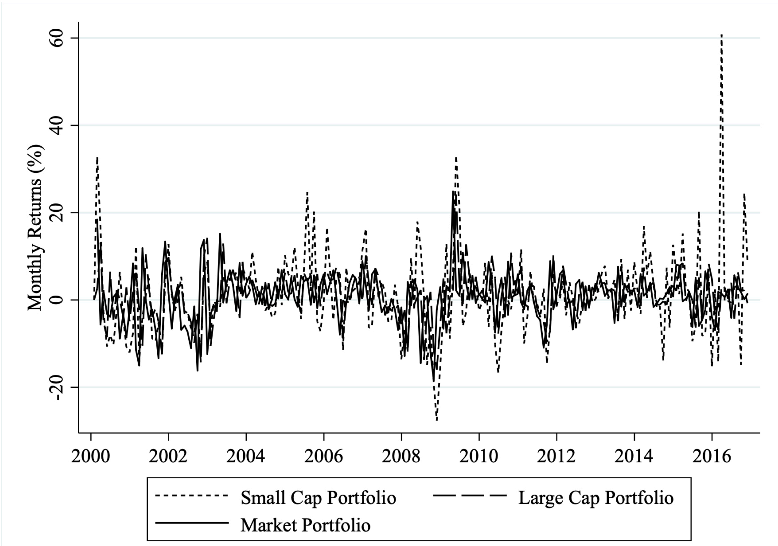



*Figure 6.3: Monthly returns for equal investments in all stocks with a market capitalization under 150m euros (Small cap portfolio) and all stocks over 1 billion euros (Large cap portfolio). Market Portfolio represents all stocks on the Stockholm stock exchange.*

small cap portfolio during financial crises. Post the 2007-2008 financial crisis, the difference in return between the two portfolios has increased up until 2016. Chan, Chen and Hsieh (1985) claimed that the higher risk in small cap firms is partially due to its covariance with real market activity. Since labor has steadily moved from the production sector to the service sector since their paper was released in 1985, we have examined indices for both sectors. The service production has steadily increased over time whilst industry production has stagnated post 2010 (Appendix table 8.1). We have not identified any substantial differences in allocation between the sectors for the two portfolios, which would help explain the difference in returns.

**Figure 6.4: Difference in Portfolio Total Returns (Firm Size)**

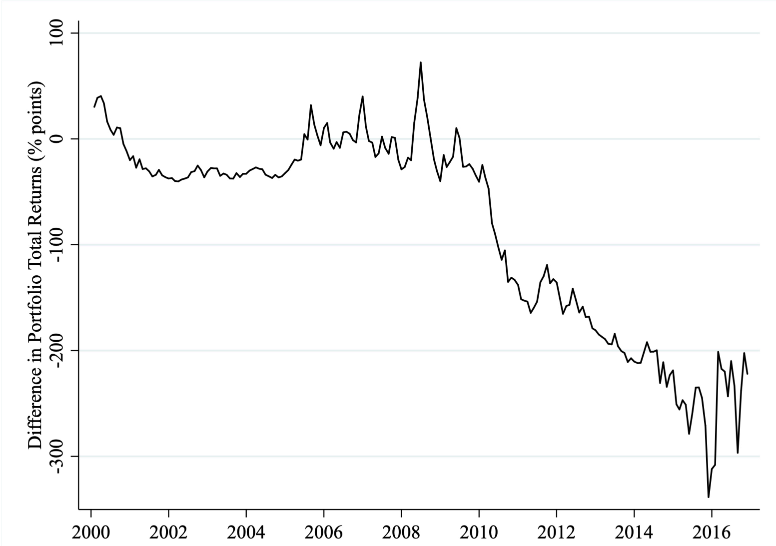



*Figure 6.4: The data for the table is produced by subtracting the total return of the large portfolio (all stocks with market capitalization above 1 billion euros) from the total return of the small portfolio (all stocks with a market capitalization below 150 million euros. Negative values indicate higher returns in the large cap portfolio.*

Another potential explanations for the large cap portfolios relatively high returns could be the relatively low interest rate. As mentioned in section 6.1, the risk-free rate has steadily declined. As interest rates decrease, the yield on 5-year and 10-year Swedish treasury bonds have also declined steadily (Appendix table 8.2). According to Sharpe (2008), depending on the investors utility curve i.e. preferences, when returns on investments change, so will the investors preferred asset allocation. As safe investments have a lower pay-off due to lower interest rates and yields, investors with a decreasing marginal utility curve will move money from risky investments to less risky investments. Thus, the divergence of portfolio returns could be explained by a reallocation from more risky small cap investments to less risky large cap investments. An increased supply of small cap stocks would without an equal increase in demand lower asset prices, and vice versa.

As illustrated below, the results from the portfolios constructed on size and P/B are seem more consistent with the cited theory (Rosenberg, Reid and Lanstein, 1985) (Figure 6.5). However, the higher returns could be due to higher portfolio risk, lowering the risk-adjusted returns. To confirm that these results are consistent with the finding of Fama and French (1992) and Carhart (1997), risk-adjustments are necessary and will be conducted in the following sections.

**Figure 6.5: Difference in Portfolio Total Returns (P/B)**


*Figure 6.5: The data for the table is produced by subtracting the arithmetic mean total return of the two portfolios with a above median P/B from the arithmetic mean total return of the two portfolios with a below median P/B.*

## 6.2 Hypothesis 1 - Is there a statistically significant Jensen's alpha for size effect and value effect?

**Table 6.2: Capital Asset Pricing Model (Size Based Portfolios)**

| Variables | Small Cap | Large Cap |
|---|---|---|
| Jensen's Alpha | -0.0008 | 0.0023 |
| | (0.0049) | (0.0019)$^n$ |
| Market | 1.2301** | 0.8361** |
| | (0.0857) | (0.0838)$^n$ |
| $R^2$ | 0.5064 | 0.7686 |
| Number of Observations | 203 | 203 |

*Table 6.2: Jensen's alpha is specified in section 3.6. The data used in the regressions are specified in chapter 3. Small Cap represents a portfolio made out of all stocks of firms with a market capitalization below 150 million euros. Large cap represents a portfolio made out of all stocks of firms with a market capitalization above 1 billion euros. All holdings are equally weighted.*
*** = Significant at a 1% significance level*
** = Significant at a 5% significance level*
*n = Newey-West standard errors reported*

In Table 6.2 the results from running OLS regressions on the small cap and large cap portfolios using CAPM are presented. Although the focus of the hypothesis is to examine whether investments in small cap stocks generate a positive alpha, the large cap portfolio is included for comparison. We can observe that none of the portfolios achieve a statistically significant alpha. Furthermore, the small cap portfolio shows a greater systematic risk than the large cap portfolio. The reason for its relatively poor performance could potentially be explained by high level of idiosyncratic risk (Sharpe, 1954). Almost half of the variance in the portfolio's excess returns cannot be explained by its covariance with the market portfolio (see equation 3.6).

Our results contradict earlier research on the subject, and there are several potential reasons for it. When Fama and French (1992) conducted their empirical tests, they partitioned the market into 10 different portfolios based on market capitalization. By doing so they could test smaller groups of stocks with a very low market capitalization. The same method was used by Banz (1981) and Carhart (1997). To asses if this difference in methodology could potentially explain our differences in results, we constructed an additional portfolio out of the 25th percentile ranked by firms size at any given rebalance date, and kept all else equal. We found this additional portfolio to perform even worse and with a much higher level of idiosyncratic risk. Another potential explanation for the discrepancy could also be due to the exclusion of additional risk factors e.g. the value effect (Fama and French, 1992). This will be tested in hypothesis 3.

**Table 6.3: Capital Asset Pricing Model (Value Based Portfolios)**

| **Variables** | **Small Cap (Low P/B)** | **Small Cap (High P/B)** | **Large Cap (Low P/B)** | **Large Cap (High P/B)** |
|---|---|---|---|---|
| Jensen's Alpha | -0.0078** | -0.0098** | -0.0073 | -0.0057 |
| | $(0.0024)^n$ | $(0.0027)^n$ | $(0.0037)^n$ | $(0.0037)^n$ |
| Market | 0.8059** | 1.0185** | 0.6420** | 0.5891** |
| | $(0.0618)^n$ | $(0.0605)^n$ | $(0.1933)^n$ | $(0.0659)^n$ |
| $R^2$ | 0.6708 | 0.6968 | 0.3781 | 0.2196 |
| Number of Observations | 203 | 203 | 203 | 203 |

*Table 6.3: Jensen's alpha is specified in section 3.6. The data used in the regressions are specified in chapter 3. Small cap represents all stocks with a market capitalization below 150 million euros. Similarly, the Large Cap portfolio is equally weighted between all firm stocks with a above 1 billion euro market capitalization. High P/B represents all stocks with an above median P/B ratio and Low P/B represents all stocks with a below median P/B ratio.*
*** = Significant at a 1% significance level*
** = Significant at a 5% significance level*
*n = Newey-West standard errors reported*

When dividing each portfolio into two additional portfolios based on P/B, we obtain drastically different results, with both small cap portfolios having achieved a statistically significant negative alpha. Our results also emphasize the teachings of Markowitz's modern portfolio theory (1952). When reconstructing our two initial portfolios into the four new ones, their risk characteristics change despite being constructed from the same sample of stocks. Additionally, the systematic risk is reduced in all four portfolios, however the same cannot be said about the idiosyncratic risk. A decrease in the idiosyncratic risk of the small cap portfolios is observed in contrast to an increase in the large cap portfolios.

Our results presented in table 6.3 are quite peculiar. Despite a seemingly low negative alpha for the two small cap portfolios, when accumulated over 203 periods its effect is much more drastic. This could help explain their relatively poor performance despite a low level idiosyncratic risk. To achieve a more complete analysis of the returns in relation to the risk, and compare the results, we have to make use of additional risk-to-return calculations. These will be conducted in the following section.

## 6.3 Hypothesis 2 - Is there a statistically significant difference in risk-adjusted returns for the portfolios?

The purpose of testing this hypothesis is to examine the two investment strategies' effect on the risk-adjusted returns. We achieve this by calculating risk-adjusted returns for each portfolio and then conducting a two-sided t-test.

For testing the size effect we examine the difference between the small cap portfolio and its large cap counterpart. Similar to the findings of Chan, Chen and Hsieh (1985), we find the small cap portfolio to have a higher level of total risk (standard deviation). However, We find that there is no statistically significant difference in risk-adjusted returns when considering total risk (Sharpe ratio). This tells us that although the risk increases, the increased risk is not compensated. Additionally, when testing for differences in systematic risk (Treynor ratio), we find there to be a significant difference. In contrast to the finding of Banz (1981), we find the large cap portfolio to outperform the small cap portfolio with regard to returns adjusted for systematic risk. Although we find the small cap portfolio to have significantly higher idiosyncratic risk, the Treynor ratio only considers systematic risk.

As for the value effect, the results are less explicit. In contrast to earlier findings, when dividing the small cap portfolios based on P/B the portfolios with a lower ratio have a lower level of volatility in their returns. For the small cap portfolios, the portfolio with a higher P/B outperforms the low P/B portfolio with regard to both total and systematic risk. Also, no significant difference in idiosyncratic risk was observed. However the effect of the idiosyncratic risk is ambiguous as its effect on portfolio returns could be drastically different. Additionally, on average the small cap portfolio with a low P/B ratio does not manage to generate excess return.

Lastly, the difference in risk-adjusted performance between the large cap portfolios is partially consistent with the findings in the cited literature regarding the value effect. The portfolio with a low P/B ratio outperforms its counterpart drastically and at a statistically significant level. The discrepancy in results are in the risk of the portfolios. The portfolio with a relatively low P/B ratio has a higher level of total risk than the portfolio with a high P/B. We can therefore not draw the conclusion that the higher returns are due to overcompensated additional risk due to the value effect (Fama and French, 1996).

**Table 6.4: Additional Risk-adjusted Return measures**

| Variables | Small Cap | Large Cap | Small Cap (Low P/B) | Small Cap (High P/B) | Large Cap (Low P/B) | Large Cap (High P/B) |
|---|---|---|---|---|---|---|
| Excess Return | 1.93% | 1.11% | -5.27% | 0.17% | 4.89% | -7.65% |
| Standard Deviation | 34.20% | 19.26% | 20.96% | 25.97% | 20.63% | 26.45% |
| Portfolio Beta | 1.2066 | 0.5819 | 0.8267 | 1.0185 | 0.6754 | 0.5928 |
| Sharpe Ratio | 0.0562 | 0.0571 | -0.2583 | 0.0071 | 0.2322 | -0.3004 |
| Treynor Ratio | 0.1755 | 0.4687 | 0.0818 | 0.2499 | 0.6236 | -0.0814 |
| Idiosyncratic Risk | 0.4936 | 0.2314 | 0.3292 | 0.3032 | 0.6219 | 0.7804 |
| t-statistic (Sharpe) | -0.03 | | -5.49 | | 11.04 | |
| t-statistic (Treynor) | -5.71 | | -3.50 | | 14.64 | |
| t-statistic (Idiosyncratic Risk) | 5.11 | | 0.54 | | -3.29 | |
| df | 318 | | 386 | | 381 | |
| p-value (Sharpe) | 0.976 | | <0.001 | | <0.001 | |
| p-value (Treynor) | <0.001 | | <0.001 | | <0.001 | |
| p-value (Idiosyncratic Risk) | <0.001 | | 0.588 | | <0.001 | |

*Table 6.4: Small cap represents the returns from a portfolio with equal holdings in all firm stocks with a market capitalization below 150 million euros. Similarly, the Large Cap portfolio is equally weighted between all firm stocks with a above 1 billion euro market capitalization. High P/B represents all stocks with an above median P/B ratio and Low P/B represents all stocks with a below median P/B ratio. Excess returns and standard deviation are annualized. The t-test conducted is a two-sided t-test and variance is not assumed equal. The small cap portfolio has been tested against the large cap portfolio. The two low P/B portfolios have been tested against the corresponding high P/B portfolio. A significant positive t-statistic (p-value below 0.05) indicates that the small or low P/B portfolio has outperformed its large or high P/B counterpart.*

## 6.4 Hypothesis 3 - Can the non-market risk be attributed to any of the additional risk factors in Carhart's four-factor model?

**Table 6.5: The Carhart Four-factor Model (Size Based Portfolios)**

| **Variables** | **Small Cap** | **Large Cap** |
|---|---|---|
| Four-Factor Alpha | -0.0004 | 0.0010 |
| | (0.0051) | $(0.0017)^n$ |
| Market | 1.2033** | 0.8713** |
| | (0.0820) | $(0.0547)^n$ |
| SMB | -0.0230 | 0.0502 |
| | (0.0959) | $(0.0418)^n$ |
| HML | -0.0378 | 0.1787 |
| | (0.1183) | $(0.1090)^n$ |
| MOM | 0.0034 | -0.0296 |
| | (0.0765) | $(0.0234)^n$ |
| $R^2$ | 0.5291 | 0.7871 |
| Number of Observations | 203 | 203 |

*Table 6.5: Four-factor alpha is specified in section 3.6. The data used in the regressions are specified in chapter 3. Small cap represents the returns from a portfolio with equal holdings in all firm stocks with a market capitalization below 150 million euros. Similarly, the Large Cap portfolio is equally weighted between all firm stocks with a above 1 billion euro market capitalization.*
*** = Significant at a 1% significance level*
** = Significant at a 5% significance level*
*n = Newey-West standard errors reported*

As can be see in table 6.5, there is no evidence for a statistically significant four-factor alpha in our small cap portfolio. Furthermore, none of the additional market factors are significant despite a higher volatility for the returns of the small cap portfolio (table 6.4). This implies that there is no evidence for a size or value effect for our small cap portfolio, nor for a momentum effect. The same is to be said about our large cap portfolio. We can draw the conclusion that the additional market factors as specified by Carhart (1997), have not provided a significant additional explanation for our portfolios' returns. These results are further strengthened by the results of van Dijk (2011) as he argued that the results of Fama and French (1992, 1995, 1996) lacked robustness. The additional tests for robustness using an alternative risk-free rate and market portfolio generated similar results (Appendix table 8.4 and 8.5).

Except for one instance of a significant momentum effect, the market factors in Carhart's four-factor model do not provide any further information for the risk in the additional portfolios constructed by P/B ratios (Table 6.6). As explained in section 6.2, this could potentially be explained by the differences in methodology when constructing portfolios. However these results suggest a less than perfect robustness for the four-factor model as it also performed poorly when testing the additional portfolio with an even lower market capitalization limit (Table 8.3). Another potential reason for the models poor performance could potentially be alternative sources of the idiosyncratic risk. The portfolios are not constructed to represent whole subgroups of the market. There could potentially be more optimal combinations or weightings of the constituent stocks in each portfolio.

**Table 6.6: The Carhart Four-factor Model (Value Based Portfolios)**

| **Variables** | **Small Cap (Low P/B)** | **Small Cap (High P/B)** | **Large Cap (Low P/B)** | **Large Cap (High P/B)** |
|---|---|---|---|---|
| Four-Factor Alpha | -0.0073* | -0.0089** | 0.0050 | -0.0066 |
| | $(0.0029)^n$ | (0.0028) | $(0.0032)^n$ | $(0.0034)^n$ |
| Market | 0.8229** | 1.0069** | 0.7037** | 0.6176** |
| | $(0.0587)^n$ | (0.0449) | $(0.1398)^n$ | $(0.0449)^n$ |
| SMB | 0.0177 | 0.0994 | 0.0793 | -0.0246 |
| | $(0.0343)^n$ | (0.0524) | $(0.0437)^n$ | $(0.0829)^n$ |
| HML | 0.0639 | -0.0675 | 0.2889 | 0.1328 |
| | $(0.0543)^n$ | (0.0647) | $(0.1746)^n$ | $(0.1318)^n$ |
| MOM | -0.0440 | 0.0052 | -0.0092 | -0.1156* |
| | $(0.0468)^n$ | (0.0419) | $(0.0415)^n$ | $(0.0581)^n$ |
| $R^2$ | 0.7871 | 0.7302 | 0.4695 | 0.2670 |
| Number of Observations | 203 | 203 | 203 | 203 |

*Table 6.6: Four-factor alpha is specified in section 3.6. The data used in the regressions are specified in chapter 3. Small cap represents all stocks with a market capitalization below 150 million euros. Similarly, the Large Cap portfolio is equally weighted between all firm stocks with a above 1 billion euro market capitalization. High P/B represents all stocks with an above median P/B ratio and Low P/B represents all stocks with a below median P/B ratio.*
*** = Significant at a 1% significance level*
** = Significant at a 5% significance level*
*n = Newey-West standard errors reported*

As for the question in the section title, we have to conclude that it cannot. Although there was a significant momentum effect in one of the portfolios, SMB and HML are not significant in any of the portfolios. These are important as the portfolios are created based on firm size and P/B ratios. Additionally, the negative alphas obtained in CAPM are still present as they could not be attributed to any of the factors in Carhart's model, (Carhart, 1997).

## 6.5 Critical Evaluation of Empirical Results

There are a few critical aspects worth pointing out in this thesis. We do not consider trading costs although ex-post we know that it would not have changed the conclusions of the thesis if one expects small cap stocks to have at least as high of a trading cost as large cap stocks. We also assume that any trading order can be filled when constructing the portfolios and when rebalancing.

As for the method, we do not replicate the methods for portfolio creation used by Fama and French (1992,1995,1996,1998) or Carhart (1997). This lowers the thesis' comparability with their results. We cannot claim that their results are right out false, however we can criticize the robustness of their findings.

As for the choice of data, a study of funds rather than portfolios based on all stocks on the market could potentially removed some of the unnecessary risk in the portfolios making it easier to draw conclusions in section 6.3, hypothesis 2.

# 7. Conclusion

In the beginning of this thesis, we introduced the size effect and the value effect as these investment strategies had been found to generate alpha. Our aim was therefore to evaluate whether these strategies could generate alpha in a more recent time period on the Swedish stock market using alternative portfolio allocations. Our main approach has been to utilize the CAPM to identify potential Jensen's alphas. In the cases where Jensen's alpha has been observed, further regressions were conducted using the Carhart four-factor model. The purpose of this strategy has been to examine whether the risk-adjusted returns could be attributed to the additional market factors of the model. In addition to regressions based on CAPM and Carhart's four-factor model, we have also conducted tests for differences in risk adjusted returns (Section 6.3).

In our research, we found that the portfolio with a low P/B ratio significantly outperformed the portfolio with a high P/B. However, these results were not consistent as the same results could not be observed for our small cap portfolios. We found more discrepancies to Fama and French's results (1992) when investigating the risk characteristics of the portfolios. Unlike their claim of a increased sensitivity to market movements for value portfolios, we found it to be true only for the large cap portfolio. As for the higher sensitivity of small cap stocks to real market activity (Chan, Chen and Hsieh, 1985), we found no evidence for this claim. Industry production has steadily increased throughout our the period with the exception for a small decrease in 2009. We have speculated that it could be due to the small cap portfolios higher sensitivity to the service sector, although we find no significant difference in the allocation between the two as both portfolios seemed relatively balanced between the industry and service sector.

In the cases where significant risk-adjusted returns have been identified, the alpha has been found to be negative. Furthermore, when additional regressions using the Carhart four-factor model were conducted on these portfolios, it was found that the alpha could not be attributed to the market factors of the model. These results could potentially be explained as a causal effect of the two financial crashes present in our time frame. In combination with relatively high idiosyncratic risk, this could have caused the portfolios to be more sensitive to market contractions relative to the market. The increase in idiosyncratic risk when using CAPM is expected as it does not include the size effect nor the value effect. However, said risk is still present when using the Carhart four-factor model due to the market factors being statistically insignificant. The tests have been repeated with a additional portfolio (Appendix table 8.3) and with additional market factors (Appendix table 8.4 and table 8.5) with the same results.

The lowering of interest rates following the financial distress during this period may also have caused the investors to reallocate their assets from riskier investments to less volatile assets. (Appendix figure 8.2) The argument to this claim is based on the assumption of decreasing marginal utility on behalf of investors. As investors find themselves with a lower risk-free rate, their expected return in a potential market contraction decreases as their risky investments are expected to generate negative returns in such a state. Therefore their marginal utility of returns in a potential market contraction increases, offsetting their optimal investment allocation (Sharpe, 2008).

When conducting tests for difference in risk-adjusted returns, our results where not consistent. When only comparing our small cap portfolio with its large cap counterpart we found that the large cap portfolio achieved higher risk-adjusted returns. Additionally, when testing portfolios with different P/B ratios the results where ambiguous. For the small cap portfolios, the portfolio with a high P/B ratio outperformed the portfolio with a low P/B ratio. When testing the large cap portfolios the opposite results where found. Adding to the discrepancies, a low P/B ratio was not consistently found to increase the volatility of the portfolios.

Our thesis was based on an alternative approach to testing the small firm effect and the value effect. Instead of dividing the market into multiple portfolios based on percentiles (Fama and French, 1992), we have made use of the market's own segmentation. This decreases our thesis ability to directly evaluate the factor models, however it can be seen as a robustness test of the Fama and French Three-factor model and Carhart's four-factor model. As van Dijk (2011) stated, many of the papers finding additional risk factors have made use of similar data from the same time period. Additionally, various alternative factors have been tested before finding the ones relevant. This brings up the question of what is considered data mining and what is not.

Lastly, we think that despite its limitations, our thesis has successfully answered the primary question. There is no statistically significant consistent positive alpha for a portfolio solely based on holding small cap stocks. Nor was there any alpha for investing in a portfolio consisting of small cap stocks with a below median P/B ratio.

## 7.1 Further Research

The findings in this thesis prompt several questions to be investigated by future researchers. Are pricing anomalies such as the small firm effect just temporary pricing discrepancies that reflect the contemporary macroeconomic situation? Are there other risk factors today and what effect do they have on asset prices? And lastly but most importantly, where does one draw the line for data mining when conducting research? When Fama and French conducted their research on additional market factors, the examined the effect of multiple possible factors before reaching their final model. One could therefore argue that too many tests were conducted on the same data set and that their results can be questioned.

# 8. Appendix

**Table 8.1: Results of Statistical Tests (Size-based Portfolios)**

| **Variables** | **Small Cap** | **Large Cap** |
|---|---|---|
| Time Trend | 0.364 | 0.521 |
| Seasonality | 0.531 | 0.028 |
| | | |
| **CAPM** | | |
| White Test | 0.516 | 0.0000 |
| Breusch-Godfrey | 0.1442 | 0.5041 |
| | | |
| **Carhart** | | |
| White Tets | 0.9996 | 0.0000 |
| Breusch Godfrey | 0.1637 | 0.0706 |

*Table 8.1: P-values at a 5% level or lower necessitate detrending and/or Newey-West standard errors. Time trend refers to a linear time trend. Seasonality is tested for through monthly dummy variables. The tests are further specified in section 5.3.*

**Table 8.2: Results of Statistical Test (Value-based Portfolios)**

| **Variables** | **Small Cap (Low P/B)** | **Small Cap (High P/B)** | **Large Cap (Low P/B)** | **Large Cap (High P/B)** |
|---|---|---|---|---|
| Time Trend | 0.814 | 0.0482 | 0.8726 | 0.8533 |
| Seasonality | 0.0063 | 0.0985 | 0.1319 | 0.0121 |
| | | | | |
| **CAPM** | | | | |
| White Test | 0.0617 | 0.8768 | 0.0000 | 0.8287 |
| Breusch-Godfrey | 0.2071 | 0.0582 | 0.0025 | 0.0002 |
| | | | | |
| **Carhart** | | | | |
| White Test | 0.0000 | 0.7140 | 0.0000 | 0.0013 |
| Breusch-Godfrey | 0.1928 | 0.2056 | 0.0066 | 0.0001 |

*Table 8.2: P-values at a 5% level or lower necessitate detrending and/or Newey-West standard errors. Time trend refers to a linear time trend. Seasonality is tested for through monthly dummy variables. The tests are further specified in section 5.3.*

**Figure 8.1: Industry and Service Production Indices**

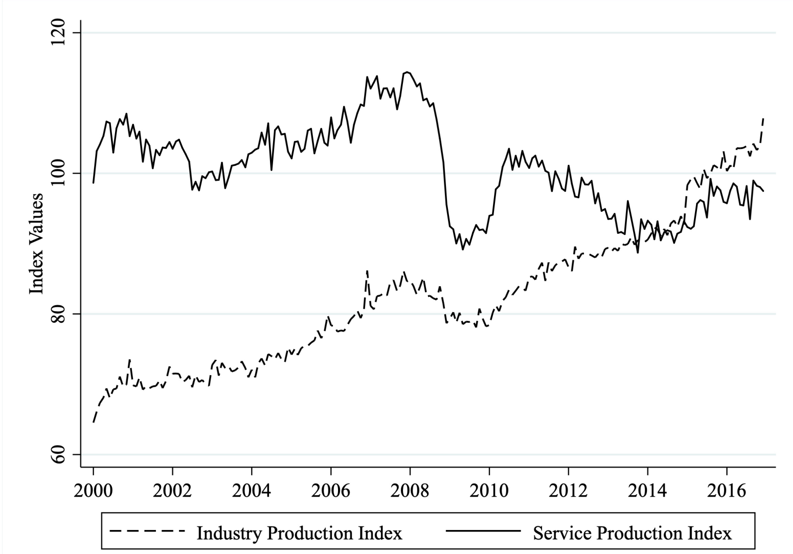



*Figure 8.1: The data for the indices was collected from Statistics Sweden (SCB). 2015 = 100. Monthly data is represented from Jan 2000 - Dec 2016.*

**Figure 8.2: Historic Risk-free Rate and OMXS30 Index**

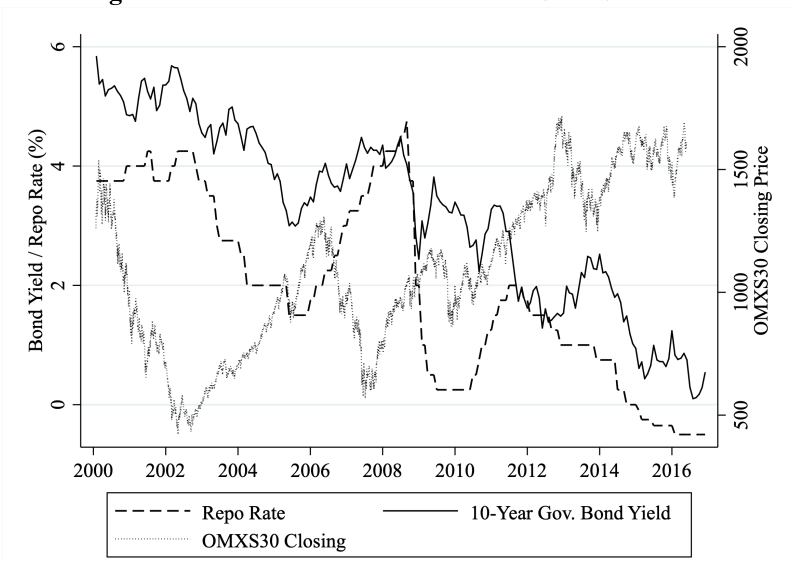
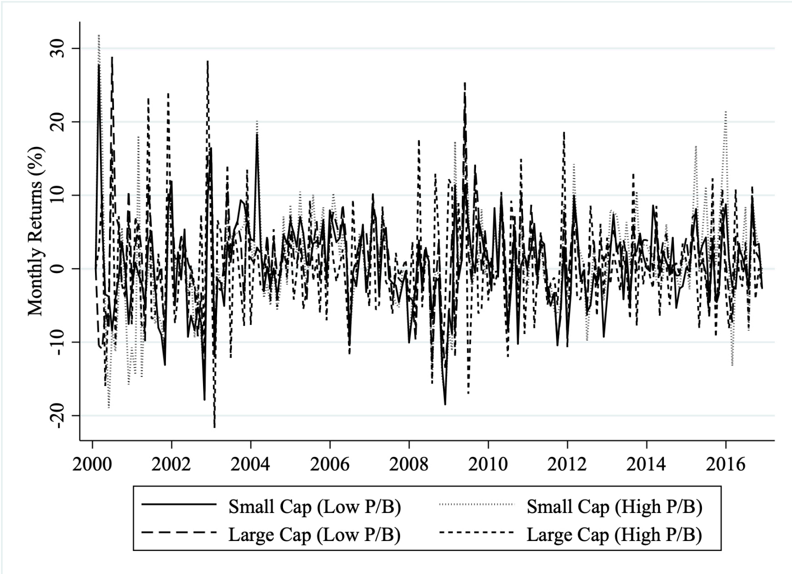



*Figure 8.2: The repo rate represents the Swedish Riksbank's policy rate. The data was collected from Bloomberg. Monthly observations are represented from Jan 2000 - Dec 2016. (Currency: SEK)*

**Figure 8.3: Monthly Returns**




*Monthly returns for equal investments in four different portfolios. Small cap represents all stocks with a market capitalization below 150 million euros. Similarly, the Large Cap portfolio is equally weighted between all firm stocks with a above 1 billion euro market capitalization. High P/B represents all stocks with an above median P/B ratio and Low P/B represents all stocks with a below median P/B ratio.*

**Table 8.3: Regressions for Smallest 25% Firms**

| **Variables** | **CAPM** | **Carhart** |
|---|---|---|
| Alpha | 0.0080 | 0.0080 |
| | (0.0063) | (0.0062) |
| Market | 0.3337** | 0.4608** |
| | (0.1064) | (0.1164) |
| SMB | | 0.0869 |
| | | (0.1205) |
| HML | | -0.2571 |
| | | (0.1493) |
| MOM | | 0.3620** |
| | | (0.1042) |
| $R^2$ | 0.0467 | 0.1313 |
| Number of Observations | 203 | 203 |

*Table 8.3: This portfolio was constructed using the 25% smallest firms at each re-balancing date (last trading day of June each year). Left column represents results from regression with CAPM and the right column represent results from regressions with the Carhart four-factor model.*

**Table 8.4: CAPM with Alternative Market Return and Risk-free Rate**

| Variables | Small Cap | Large Cap |
|---|---|---|
| Four-Factor Alpha | 0.0010 | 0.0097* |
| | (0.0070) | (0.0040) |
| Market | 0.3385* | 0.0896 |
| | (0.1373) | (0.0790) |
| SMB | 0.0748 | 0.0836 |
| | (0.1365) | (0.0786) |
| HML | -0.1523 | 0.0394 |
| | (0.1694) | (0.0975) |
| MOM | 0.2105 | 0.0622 |
| | (0.1178) | (0.0678) |
| $R^2$ | 0.0480 | 0.0104 |
| Number of Observations | 203 | 203 |

*Four-factor alpha is specified in section 3.6. The data used in the regressions are specified in chapter 3. Small cap represents the returns from a portfolio with equal holdings in all firm stocks with a market capitalization below 150 million euros. Similarly, the Large Cap portfolio is equally weighted between all firm stocks with a above 1 billion euro market capitalization.*
*** = Significant at a 1% significance level*
** = Significant at a 5% significance level*
*n = Newey-West standard errors reported*

**Table 8.5: Carhart with Alternative Market Return and Risk-free Rate**

| Variables | Small Cap (Low P/B) | Small Cap (High P/B) | Large Cap (Low P/B) | Large Cap (High P/B) |
|---|---|---|---|---|
| Four-Factor Alpha | 0.0040 | 0.0091 | 0.0084 | 0.0027 |
| | (0.0042) | (0.0051) | (0.0074) | (0.0055) |
| Market | 0.2829** | 0.3196** | 0.0432 | 0.0462 |
| | (0.0824) | (0.1011) | (0.0846) | (0.1086) |
| SMB | 0.0274 | 0.1220 | 0.0984 | -0.0552 |
| | (0.0819) | (0.1005) | (0.0841) | (0.1080) |
| HML | -0.1310 | -0.2063 | 0.1644 | 0.0010 |
| | (0.1016) | (0.1247) | (0.1043) | (0.1339) |
| MOM | 0.1593* | 0.2291** | 0.0541 | -0.0854 |
| | (0.0707) | (0.0867) | (0.0725) | (0.0931) |
| $R^2$ | 0.0862 | 0.0970 | 0.0147 | 0.0091 |
| Number of Observations | 203 | 203 | 203 | 203 |

*Four-factor alpha is specified in section 3.6. The data used in the regressions are specified in chapter 3. Small cap represents all stocks with a market capitalization below 150 million euros. Similarly, the Large Cap portfolio is equally weighted between all firm stocks with a above 1 billion euro market capitalization. High P/B represents all stocks with an above median P/B ratio and Low P/B represents all stocks with a below median P/B ratio.*
*** = Significant at a 1% significance level*
** = Significant at a 5% significance level*
*n = Newey-West standard errors reported*

# 9. References


Arbel, A., Carvell, S. and Strebel, P. (1983). Giraffes, Institutions and Neglected Firms. *Financial Analysts Journal*, 39(3), pp. 57-63.

Banz, R. (1981). The Relationship Between Return and Market Value of Common Stocks. *Journal of Financial Economics*, 9, pp. 3–18.

Berk, J. (1996). An Empirical Re-examination of the Relation Between Firm Size and Return. Semanticscholar.org [online]. Available at: https://www.semanticscholar.org/paper/An-Empirical-Re-examination-of-the-Relation-Between-Berk/db4880711384ae017ed28780e1305f051a6ffb0c.

Bodie, Z., Kane, A. and Marcus, A. (2013). *Essentials of investments*. 9th ed.

Brennan, M. and Subrahmanyam, A. (1996). Market microstructure and asset pricing: On the compensation for illiquidity in stock returns. *Journal of Financial Economics*, 41(3), pp. 441-464.

Carhart, M. (1997). On Persistence in Mutual Fund Performance. *The Journal of Finance*, 52(1), pp. 57–82.

Chan, K., Chen, N. and Hsieh, D. (1985). An exploratory investigation of the firm size effect. *Journal of Financial Economics*, 14(3), pp. 451-471.

Chen, N. (1983). Some Empirical Tests of The Theory of Arbitrage Pricing. *The Journal of Business*, 59(3) (1986), pp. 383–403.

Christie, S. (2005). Is the Sharpe Ratio Useful in Asset Allocation? *SSRN Electronic Journal*.

Fama, E. (1970). A Review of Theory and Empirical Work. *The Journal of Finance*, 25(2), pp. 383–417.

Fama, E. and French, K. (1998). Value versus Growth: The International Evidence. *The Journal of Finance*, 53(6), pp. 1975-1999.

Fama, E. and French, K. (1996). Multifactor Explanations of Asset Pricing Anomalies. *The Journal of Finance*, 51(1), pp. 55-84.

Fama, E. and French, K. (1995). Size and Book-to-Market Factors in Earnings and Returns. *The Journal of Finance*, 50(1), pp. 131–155.

Fama, E. and French, K. (1992). The Cross-Section of Expected Stock Returns. *The Journal of Finance*, 47(2), pp. 427–465.

Jegadeesh, N. and Titman, S. (1993). Returns to Buying Winners and Selling Losers: Implications for Stock Market Efficiency. *The Journal of Finance*, 48(2), pp. 65–91.

Keim, D. (1983). Size-related anomalies and stock return seasonality. *Journal of Financial Economics*, 12(1), pp. 13-32.

Klein, R. and Bawa, V. (1977). The effect of limited information and estimation risk on optimal portfolio diversification. *Journal of Financial Economics*, 5(1), pp. 89-111.

Lintner, J. (1965). The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets. *The Review of Economics and Statistics*, 47(1), pp. 13-37.

Low, R. and Tan, E. (2016). The role of analyst forecasts in the momentum effect. *International Review of Financial Analysis*, 48, pp. 67-84.

Markowitz, H. (1952). Portfolio Selection. *The Journal Of Finance*, 7(1) (1952), pp. 77–91.

Mossin, J. (1966). Equilibrium in a Capital Asset Market. *Econometrica*, 34(4), pp. 768-783.

Opdyke, J. (2007). Comparing Sharpe ratios: So where are the p-values? *Journal of Asset Management*, 8(5), pp. 308-336.

Otten, R. (2012). The Performance of Small Cap Mutual Funds: Evidence for the UK. *SSRN Electronic Journal*.

Rosenberg, B., Reid, K. and Lanstein, R. (1985). The Persuasive evidence of Market Inefficiency. *The Journal of Portfolio Management*, 11(3), pp. 9–16.

Sharpe, W. (2008). *Investors and Markets*. 3rd ed. Princeton: Princeton Univ. Press, pp. 39-40.

Sharpe, W. (1994). The Sharpe Ratio. *The Journal of Portfolio Management*, 21(1), pp. 49-58.

Sharpe, W. (1964). Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk. *The Journal of Finance*, 19(3), pp. 425-442.

Treynor, J. (1965). How to rate management of investment funds. *Harvard Business Review*, 43(1), pp. 63-75

van Dijk, M. (2011). Is size dead? A review of the size effect in equity returns. *Journal of Banking Finance*, 35(12), pp. 3263-3274.

van Holle, F., Annaert, J., Crombez, J. and Spinel, B. (2002). Value and Size Effect: Now you see It, Now you don't. *SSRN Electronic Journal*.

Wooldridge, J. (2012). *Introductory econometrics*. 5th ed.

**Databases:**

Bloomberg - The Bloomberg Terminal (last accessed May 20, 2019)

Swedish House of Finance - Data Center, available at webpage www.data.houseoffinance.se (Last accessed Mars 29, 2019)

Statistics Sweden – Statistics Database, available at www.statistikdatabasen.scb.se (Last accessed 20 May, 2019)