
Stock Return Reversal on the Stockholm Stock Exchange

Michael Blomqvist

20183@student.hhs.se

Sofie Trägårdh

20233@student.hhs.se

Abstract

The purpose of this paper has been to investigate whether a long term reversal investment strategy can be used to identify mispriced stocks and thereby earn abnormal returns on the Stockholm Stock Exchange during the period of 1982 to 2009. We assign the stocks to decile portfolios according to their five year historical period returns. We study the decile portfolios' market adjusted returns, propensity to deletion, standard deviations, Sharpe ratios, and their performance in different economic states. Finally, we control for risk using the CAPM and Fama-French three factor model. These tests are carried out for both equally and value weighted decile portfolio returns. Our main findings are that although a tendency for a stock return reversal effect can be observed, no strong support for the phenomenon is found.

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1. Introduction and Purpose

Studies in the US and the UK for example have found the existence of a long term return reversal effect (e.g. De Bondt and Thaler 1985, 1987; Arnold and Baker 2007). The return reversal effect suggests that a portfolio consisting of the previously worst stocks, in terms of a specified criterion¹, over a given historical time period will on average outperform a portfolio consisting of the previously best stocks over the long term horizon. What makes the reversal effect interesting is that previous empirical studies have not been able to entirely explain this type of outperformance after controlling for portfolio risk. De Bondt and Thaler found that the portfolio consisting of the worst stocks of the past outperformed the portfolio consisting of the best stocks of the past by five to ten percent per year on average over a five year holding period in US stock markets. In a more recent study on the UK market, Arnold and Baker found similar results to De Bondt and Thaler. They found that the portfolio of the worst stocks outperformed the market by 8.9 percent on average during the five year holding period while the portfolio of the best stocks underperformed the market by 47 percent over the entire five year period. Several additional studies have been conducted internationally, many of which found support for a return reversal effect. Baytas and Cakici (1999) found evidence of the return reversal effect in Canada, the UK, Japan, Germany, France and Italy while Schiereck, De Bondt and Weber (1999) found support for the success of reversal strategies on the Frankfurt Stock exchange.

On the other hand, Conrad et al. (2003) attempt to quantify the potential data-snooping bias from empirical tests of reversal strategies on the US equity market due to researchers' familiarity with the data. They found that when forming portfolios using a single sorting criterion, the potential data-snooping bias could account for up to 50 percent of the discovered patterns. In order to draw conclusions about whether the return reversal effect actually exists or is a product of data-snooping, it is important to extend the research to different markets, preferably with different characteristics.

This topic has not been extensively studied on the Swedish equity market (Hamberg and Novak, 2007). Hence it is interesting to investigate whether a stock return reversal effect can be found on the Stockholm Stock Exchange during the period of 1982 to 2009.

1.1 Research Question

Can a reversal investment strategy be used to consistently identify mispriced stocks and earn abnormal returns on the Stockholm Stock Exchange, using stock performance over a five year historical period as the sorting criterion?

¹ Examples of criteria used for ranking stocks may be past performance in terms of stock returns or various multiples such as market-to-book.

1.2 Contribution

The stock return reversal effect was discovered by De Bondt and Thaler who produced a paper on it in 1985, but only a limited amount of research has been conducted on the subject in Sweden (Hamberg and Novak, 2007). Our main contribution with this paper is to further extend the research on the return reversal effect to the Swedish equity market and complement existing literature on Swedish data with a different approach and method of studying the phenomenon. Listed below are the key points that differentiate our study from the one on Swedish data by Hamberg and Novak (2007).

First, in this paper we use a long run historical period of five years to evaluate the stocks' performance and to sort them into portfolios. The stocks' buy and hold return over the five year historical period is used as our portfolio sorting criteria. Hamberg and Novak (2007) used historical periods of three years and used market-to-book and earnings-to-price multiples as their sorting criterion. The reasoning for choosing a five year historical period is that previous international studies have found that the portfolio returns are more extreme after five years compared to shorter lengths (for example in Arnold and Baker, 2007).

Second, we use a different approach to avoid survivorship biased results than Hamberg and Novak (2007). They allowed for deletions during the portfolio holding period and invested the proceeds of deleted stocks in a size sorted proxy portfolio with similar risk characteristics as the decile portfolio. We allow for deletions during the holding period as well, but instead reinvest the proceeds of deleted stocks within the remaining stocks of the decile portfolio. This approach seems more rational for an investor to implement than creating additional portfolios that proxy for the reversal portfolios risk characteristics and investing in them instead. It is also likely that the total performance of the portfolio, over a five year period, will be affected due to the choice of method to treat deletions.

Third, we will attempt to quantify the portfolios' risk in six different ways, extending the risk measures used in Hamberg and Novak (2007) by studying the portfolios' Sharpe ratios, the frequency of stock delisting across portfolios, and using the Fama-French Three Factor Model to explain the portfolios' returns.

In addition, our paper will extend the investigated time period to February 2009 compared to Hamberg and Novak (2007) where data until 2004 was used, making the research up to date. By using an extended time period we will capture a substantial part of the financial crisis' effect on the Swedish equity market.

1.3 Outline

This thesis is composed of nine sections as well as a reference list, tables and figures and appendices at the end. Section 2 is a presentation of the theoretical framework that forms the foundation for the stock return reversal effect. The phenomenon itself will be discussed in brief, the conflicting theories

of the EMH and the overreaction hypothesis will be explained and alternative theories as to why the phenomenon may exist are given. In Section 3, previous research that has been made on the stock return reversal effect is discussed. Thereafter, Section 4 presents our hypothesis which is based on the theories and research from the two previous sections. In Section 5 we account for the data used in this study and in Section 6 the methodology is explained in detail along with encountered problems and their solutions. In Section 7 the analyses of the obtained results are found followed by Section 8 in which our conclusions are drawn. Finally, Section 9 is devoted to our suggestions for further research.

2. Theoretical Framework

The overreaction hypothesis and the Efficient Market Hypothesis (EMH) are key theories when discussing the reversal phenomenon. The overreaction hypothesis states that investors react irrationally to unexpected news on a given stock. Such behavior affects stock prices so that the firm's intrinsic value is not correctly reflected in the stock price. On the other hand, the EMH suggests that stock prices do reflect the firms' intrinsic values. Furthermore, the overreaction hypothesis is based on the belief that investors use historical prices to value their investments, whereas the EMH suggests that stock prices follow a random walk, implying that historical prices are useless predictors of future prices. In order to better understand the stock reversal phenomenon, this section will provide further explanations of the stock reversal phenomenon, the EMH and the overreaction hypothesis.

2.1 The Reversal Phenomenon in Brief

The theory behind a reversal strategy starts with the identification of mispriced stocks, both under- and overvalued stocks. The investor then takes a long position in the undervalued stocks and a short position in the overvalued stocks and holds them for a sufficiently long period of time. The reasoning is that during the holding period, other investors will realize that the stocks are mispriced when, for example, earnings reports in the future do not meet the investors' expectations. A progressive price correction will then occur, and the reversal investment will earn substantial returns. This price correction is referred to as the stock return reversal effect, when previously well performing stocks perform poorly in the future, and previously poorly performing stocks perform well in the future.

2.2 The Efficient Market Hypothesis

The EMH, first proposed by Fama (1970), is the notion that asset markets are, at least approximately, informationally efficient. This means that current stock prices reflect all relevant available information. If stock prices are determined rationally, then only new information will cause changes in them. This implies that prices should follow a random walk and hence future returns cannot be predicted using historical price information (Bodie et al., 2005). Furthermore, it should not be possible to construct a strategy that consistently beats the market portfolio over time when adjusting for risk. In other words, the only way for an investor to increase earned returns is by taking on more risk. The

rationale behind these assumptions is that it is a competitive business to find information about traded asset values, rendering easy profits unachievable.

Fama (1970) proposes three forms of the EMH. Each form offers a definition of what “all available information” actually refers to. In the weak form of the hypothesis, it refers to information that can be obtained by examining the market. The semi-strong form of the hypothesis states that it refers to all publically available information regarding the prospects of a firm. Finally, in the strong form of the hypothesis, “all available information” refers to all information that is relevant to the firm, both public and private, including insider information (Bodie et al., 2005).

According to Shleifer (2000), the EMH has three theoretical foundations which rest on progressively weaker assumptions. First, investors are assumed to be rational and to value securities rationally. Second, even if irrational investors do exist, their investments will be random and thereby cancel each other out. Third, if investors are irrational in similar ways (i.e. nonrandom investments), rational arbitrageurs will take positions in the stock market such that the impact of the irrational investors’ trades on the stocks’ prices are reversed. Hence, the long run EMH holds even when irrational investors’ trading strategies are correlated. Consequently, the EMH should always hold in the long run. In the sense that stock prices revert from mispriced levels to their intrinsic values, it is possible for stock return reversal to exist even if the long run EMH holds true. However, in reality a serious violation of the EMH occurs since stock return reversal strategies rely on past market information being useful in identifying future good and bad performing stocks. For a reversal strategy to be successful, stock prices cannot strictly follow a random walk.

Substantial research has been made on the EMH, where in general, past research (Fama, 1965 and Scholes, 1972) has found support for the theory whereas more recent empirical research has found results suggesting that the hypothesis may be outdated (Banz, 1981; Keim, 1983; De Bondt and Thaler, 1985; Jagadeesh and Titman, 1993 and Cochrane, 1999), however, Cochrane (2005) found support for markets still being fairly efficient.

2.3 The Overreaction Hypothesis

The overreaction hypothesis has its roots within the field of psychology. According to Bayesian theory, probability is a measure of belief that depends on the individual’s knowledge. Examples of such knowledge can be historical events or other types of information that the individual deems relevant for making predictions about the future. When the individual is asked to predict a future outcome, the probability of the outcome actually taking place is highly conditional on the knowledge and information that the individual has at hand. As new information that is relevant for the future prediction is unveiled, the individual’s probability of the future outcome taking place will be revised and is subject to change. This implies a high degree of individual rationality.

Kahneman et al. (1982) found that this rationality is not a rightful characterization of how individuals respond to new data. Instead it was found that an individual's conditional probabilities are connected to what previously has been learned, but when the conditional probabilities are revised, the individual tends to overweight recent information and underweight prior fundamental data. Consider the stock of a firm that currently experiences high earnings growth. In light of the results of Kahneman et al. (1982) an investor would overweight the high earnings growth of today, and underweight the fundamental data which is the tendency for firms experiencing high earnings growth to experience weaker earnings growth in the future (Koller et al., 2005). Hence, investors would regard the stock as an attractive investment which increases the demand for the stock and thereby increasing the stock price. This process continues as long as the underlying firm's quarterly or annual earnings reports are positive, making the stock overvalued. When the firm's earnings growth is weakened and starts to decline in the future, the investors will overweight this new information and start to sell the stock. The stock price will then start to fall.

As another example, a stock that has performed well in the past may become more publically exposed and gain a reputation of being a high performer. It gets labeled as a good investment for future periods as well, so the demand for the stock increases for irrational reasons driving the stock price upwards. In effect, the stock becomes overpriced and is therefore a poor investment since it is expensive in relation to its fundamental value. This theory is analogous to poor performing stocks becoming underpriced with time (Arnold and Baker, 2007).

Kahneman and Tversky found that individuals rely on "a limited number of heuristic principals which reduce the complex tasks of assessing probabilities and predicting values" when making decisions about uncertainty. This may lead to systematic errors and overreaction to unexpected events (Kahneman and Tversky, 1972).

In 1985, De Bondt and Thaler applied Kahneman and Trevsky's findings to the stock market. De Bondt and Thaler investigated the equilibrium conditions for markets with irrational agents that fail to revise their expectations according to Bayes' rule. They found that large abnormal returns could be earned in the stock market and suggest that the overreaction hypothesis may be the explanation. Other researchers have found evidence of investor behavior in line with the overreaction hypothesis in the options market as well as among professional investors and fund managers (Dreman and Berry 1995, Dreman 1998, Bauman et al. 1999 and Stein 1989).

Arnold and Baker (2007) found evidence of a return reversal effect on the UK equity market, and do not rule out that that the pattern may be caused by overreaction. The plausibility of the overreaction hypothesis was not explicitly tested. In this paper, we adopt a similar approach. We set out to test whether the return reversal effect can be observed on the Stockholm Stock Exchange, and leave the

overreaction hypothesis as a possible explanation, should we find evidence supporting the reversal effect. The overreaction hypothesis itself is not investigated in this paper.

2.3.1 Alternative Explanations for the Reversal Effect

Strategies that rely on historical prices violate the weak form of the EMH. Hence, the strategy has had many critics. Some critics found that the overreaction theory is not enough to explain the stock return reversal effect. Zarowin (1990), for example, showed that there is a “tendency for losers to be smaller-sized firms than winners”, or in other words a size effect, and that when losers and winners of equal sizes are compared, the stock return reversal effect disappears.

A further explanation for the stock return reversal effect, is simply that it is the result of compensation for additional risk bearing. The outperformance of loser portfolio over the winner portfolio may simply be due to compensation for the loser portfolio being the riskier of the two.

3. Previous Research

De Bondt and Thaler (1985) wrote a paper on market efficiency and whether overreaction behavior can affect stock prices in the US. They constructed winner and loser portfolios from 1926 to 1982 based on historical data and followed their performance over set holding periods. Consistent with the overreaction hypothesis, they found that the loser portfolios outperformed the winner portfolios. Three years subsequent to the time of portfolio formation, the loser portfolio had earned an average return that was approximately 25 percentage units higher than the winner portfolio. The winner portfolio was more risky and underperformed the market portfolio by five percentage units on average. These results indicate a violation the weak form of the EMH. Furthermore, De Bondt and Thaler (1985) found that the overreaction effect was asymmetric in the sense that it impacted loser portfolios more than winner portfolios. The stock return reversal effect was observed as late as five years after portfolio formation, which is the time period used in this paper. In 1987, De Bondt and Thaler produced a follow-up paper to the original paper written in 1985. They found further evidence to support the overreaction hypothesis and found that abnormal returns could be earned in both the short run and the long run.

Researchers such as Bremer and Sweeney (1991), continued to investigate and found proof of a stock return reversal effect in the short run. For the purpose of this paper, however, we will focus on the long run. Other researchers, such as Jagadeesh and Titman (1993) have investigated the opposite strategy commonly referred to as the momentum effect. They formed a zero-investment strategy where past winners of US listed company stocks were bought whilst losers were sold short. They found that this strategy was successful in the medium term (3 to 12 months), which partly contradicts the results from De Bondt and Thaler (1987).

Clare and Thomas (1995) produced a similar study to De Bondt and Thaler (1987) on all the firms traded on the London Stock Exchange from 1955 to 1990. They found evidence in favor of the overreaction effect on the UK market, however, when controlling for firm size the reversal returns decreased considerably. Consequently, they claimed that the overreaction effect is actually just another version of the size effect. The size effect is the tendency of small firms to generate, on average, higher returns than large firms. In other words, the loser portfolio consisted of small firms that generated returns superior to the winners. Additionally, Clare and Thomas (1995) argued that the losers had considerably higher CAPM betas, which means that they take on a higher market risk than the winner stocks. Hence the loser stocks' expected returns are higher, which explains why their average future performance in the long term is better. De Bondt and Thaler (1987) did not find that the size effect was a sufficient explanation, whereas other researchers (including Zarowin, 1990) showed that when controlling for firm size, the abnormal returns of the loser portfolio were reduced. Ball and Kothari's (1989) results suggested that the CAPM betas are much higher for the loser stocks than for the winners.

In the more recent literature on international markets Baytas and Cakici (1999) found evidence of the return reversal effect in Canada, the UK, Japan, Germany, France and Italy while Schiereck, De Bondt and Weber (1999) found support for the success of reversal strategies on the Frankfurt Stock exchange. Xing-qiang and Zhi-ping (2007) found support for the success of long term reversal strategies on the Chinese stock market.

Arnold and Baker produced the paper "Return Reversal in UK Shares" in 2007. The paper is recent and uses a larger data set than previous studies on the UK market. They study buy-and-hold returns for the decile portfolios which they argue are advantageous to alternative methods. Studying decile portfolios compared to the widely used approach of using quintile portfolios allows, according to Arnold and Baker, for a more sensitive analysis of the reversal effect. Adding to the uniqueness of the working paper is that the survivorship bias problem is dealt with by allowing for deletions during the holding period. Arnold and Baker also control for the existence of a size effect within the decile portfolios in two different ways and they also study the reversal effect within large firms and small firms. When assessing the risks associated with the decile portfolios, Arnold and Baker perform seven different risk tests; propensity to liquidation, performance in different market states, reliability, performance in different economic states, CAPM betas, standard deviations, and the Fama-French three factors. The methodology used by Arnold and Baker (2007) is more extensive than previous research, making the findings from their working paper especially relevant and interesting.

Arnold and Baker (2007) draw five main conclusions from their study. First, they found that the loser portfolio outperformed the winner portfolio as well as the UK market consistently over long term periods. Second, the more extreme the return is during the historical period, the greater is the

subsequent adjustment in the holding period. Third, when measuring risk using the CAPM beta, they found that losers tend to have lower risk than winners. The loser portfolios' returns had higher standard deviations than the winner portfolios, but the difference is not large enough to offset the difference in average returns. Fourth, they found that when controlling for the size effect the outperformance of the loser portfolio still cannot be fully explained. Fifth, the return reversal effect was found to be present in the largest 20 percent of companies as well as in mid-caps, small-caps and micro-caps. In this thesis we will employ a similar methodology to Arnold and Baker (2007) and apply it to the Swedish stock market.

In terms of Swedish studies, Hamberg and Novak (2007) test a reversal strategy by using earnings-to-price and book-to-market multiples as sorting criteria. They found that non-financial Swedish stocks generate average abnormal returns of 11 to 14 percent annually. To the best of our knowledge, there has not been any other recent investigation made on the long term reversal effect on the Stockholm Stock Exchange.

4. Hypotheses

Our hypotheses are based on discussions and conclusions from previous empirical studies on the stock reversal effect (see section 3), as well as some of the ideas presented in the theoretical framework (see section 2). In this paper, we test the following hypotheses:

1. On average, portfolios formed on the worst performing stocks during the past five years will, in the subsequent five years, outperform portfolios of stocks that have been the best performers during the past five years.
2. The more extreme the return during the past five years, the larger the subsequent adjustment will be.
3. The stock return reversal effect will be most noticeable five years after portfolio formation.

5. Data

Monthly return data for all stocks listed on the Stockholm Stock Exchange (SSE) from the period of 1977-2009 has been gathered from Thompson Datastream. More specifically, the total return index (RI) is the primary data type used which allows for capital changes, such as stock splits, and reinvests dividends as shown in the following formula²:

² Pre-1988, detailed dividend payment data is not available on Thompson Datastream and so the return index is constructed using an annualised dividend yield. Gross dividends are used where available and the calculation ignores tax and re-investment charges. Adjusted closing prices are used throughout to determine the price index and the return index (Thompson Datastream).

$$RI_t = RI_{t-1} \cdot \frac{P_t + D_t}{P_{t-1}} \quad (1)$$

where: RI_t is the price of the return index of the stock in month t ,
 P_t is the stock price and
 D_t is the dividend paid.

During the period of 1977 to 1981 information could only be found for five stocks listed on the SSE, effectively leaving us with a dataset that is useful for our empirical analysis spanning from the dates of 1982-02-01 to 2009-02-01. For each year, our starting point is the first of February. All references to years, including spans of years, throughout this paper refer to the first of February of the mentioned years.

We only included stocks in our sample that have been listed for at least five consecutive years. In order to determine which stocks that were actively traded, Thompson Datastream's equity status data was used. The number of stocks in the sample grows from 84 in 1982 to 246 in 2004. This is illustrated graphically in Figure 1.

Thompson Datastream has also been used to obtain market capitalization values (MV)³ for the above specified time period and for all the stocks that were used over this period. This data is necessary for value weighting the returns as well as for constructing the Fama French factors. Market-to-book data (MTBV) was downloaded for the time period 2008-01-01 to 2009-02-01. The market-to-book value is calculated as follows:

$$MTBV = \frac{MV}{NTA} \quad (2)$$

Where NTA are the net tangible assets and
MV is the market value⁴.

The MTBV data is required for the formation of Fama French factors. The reason as to why we only needed this for our final observation year is that the Fama French factors were already available from previous research that has been carried out at the Stockholm School of Economics (SSE) by Lundén and Hagwall (2008) for the rest of the observation period. Due to restrictions in the availability of MTBV data, the factor returns were only available from 1989-02-01 and onwards.

In the CAPM and the Fama French models, the proxy used for the Swedish market index, Affärvärlden's generalindex, was downloaded from Thompson Datastream.

³ Market capitalization = share price * number of ordinary shares in issue.

⁴ For companies which have more than one class of equity capital, both MV and NTA are expressed according to the individual issue (Thompson Datastream).

Furthermore, as a proxy for the risk-free rate, the Swedish 30-day T-bill rate has been obtained from the Riksbank on a monthly basis. Finally, the GDP of Sweden has been taken from Statistics Sweden (SCB) for the time period of 1991 to 2009.

6. Method

6.1 Portfolio Formation

Our reversal strategy is based on sorting the stocks into ten equally large portfolios according to their past performance in terms of returns. When ranking the stocks, five year buy and hold returns are calculated for each stock before sorting them into decile portfolios. The stocks in the top decile, i.e. the ten percent best performing stocks, will be labeled as the winner portfolio, whereas the stocks in the bottom decile, i.e. the ten percent worst performing stocks, will be labeled as the loser portfolio.

6.2 Survivorship Bias

Survivorship bias is a positive bias on time series returns due to only including firms or stocks that has been successful enough to survive throughout the entire studied period. Hence, to avoid the issue we have included the stocks that are delisted during the holding period in our study. There are several reasons for a delisting and those encountered are listed below together with the resulting remedies.

- Take-over
 - The latest traded share price, pre take-over, is used to calculate the amount to be reinvested equally among the remaining stocks in the portfolio.
- Conversion into a new security
 - The latest traded share price, pre conversion, is used to calculate the amount to be reinvested equally among the remaining stocks in the portfolio.
- Liquidation
 - Datastream does not always specify the reason for a stock delisting, other than take-overs and conversions. Therefore, in the case of liquidation, it is assumed that the continuation value of the firm's equity approaches zero, thereby driving down the share price to zero as well. This type of stock price behavior is observed in our data sample. Hence, the reinvested proceeds will be close to zero resulting in a negligible effect on the total portfolio performance. Therefore no special action is taken.

The rationale behind the treatment of take-overs and stock conversions is that the reversal strategy is a one-off investment decision on the basis of expected stock return reversal from previous mispriced levels. If a firm is taken over by another, it cannot be assumed that the security for the new, combined entity will show the same patterns of return reversal that was expected from the original security (pre take-over). Therefore, it would not be reasonable to reinvest the proceeds in the security for the

combined entity. The best solution is instead to reinvest the proceeds among the remaining stocks within the portfolio. The same reasoning can be applied to the conversion of one security into another. It seems unreasonable to assume that the new security is mispriced the same way that the original security was assumed to be according to its previous ranking, hence, the latest traded share price will be used to calculate the amount reinvested in the remaining shares of the portfolio.

6.3 Calculation of Portfolio Returns

Post portfolio formation returns are calculated on a monthly basis. Our choice of reinvesting the proceeds of delisted stocks within the decile portfolios poses some practical problems when calculating the portfolios' holding period returns. Since we use partially overlapping portfolios, a total of 18 portfolio formations are used, with each formation consisting of 10 portfolios. This means that monthly returns for 180 portfolios must be calculated.

Consider a portfolio formed at $t=0$, consisting of 20 stocks. If stock A is delisted at $t=x$, the proceeds from stock A at that time must be divided between and reinvested in the remaining 19 stocks in the portfolio. If stock B is delisted afterwards (at $t=y$) the proceeds from the weight allocated to stock B at $t=0$ plus the part of the proceeds from stock A allocated to stock B at $t=x$, must be reinvested among the remaining 18 stocks in the portfolio at $t=y$. Naturally, the weight allocated to stock B at $t=0$ will follow the performance of stock B between $t=0$ and $t=y$ while the weight that stock B received from stock A at $t=x$ will follow the performance of stock B between $t=x$ and $t=y$. Depending on the variation of stock B's monthly returns from $t=0$ to $t=y$, the two weights can perform very differently and must be calculated separately. As more stocks within the portfolio delist, this process builds up and the calculations of the portfolio's monthly returns becomes increasingly complex.

Value weighted decile portfolios are created in a similar manner where the stocks in each decile portfolio are weighted according to their market capitalization at $t=0$. Accordingly, the proceeds from delisted stocks are reinvested in the remaining stocks of the portfolios on a value weighted basis.

6.4 Overlapping Portfolios

The first historical period ends in 1987 and thereafter the stocks are ranked on a yearly basis, i.e. the portfolio formations will be partially overlapping. The advantage of using overlapping portfolios is that it enables a large number of portfolio formations to be used. This is the same approach that was used by Arnold and Baker (2007).

An alternative approach would be to use non-overlapping portfolios. However, there are two major drawbacks to using this approach. The first is that the number of portfolio formations will be drastically reduced, from 18 when using overlapping portfolios to a mere four. The second drawback is that the results from a non-overlapping approach can be largely dependent on the starting year that is chosen. To clarify, a certain starting year may result in business cycles being conveniently matched

with the observation and evaluation periods, resulting in biased results. There are also difficulties associated with the use of overlapping portfolios but it is the most suitable approach for our chosen length of the historical period.

6.4.1 Dealing with Overlapping Portfolios

To control for the decile portfolios' risk, the CAPM and the Fama-French three factor model will be used. Overlapping portfolios, however, create some difficulties for statistical inference, partly as there will be several values for each date for each portfolio, i.e. in our case there will be five values for each overlapping window as shown in Figure 2.

Within each overlapping window, the portfolios will include a different set of stocks depending on when the holding period began (i.e. when the investment was made) as the stocks will be re-ranked each year and assigned to a decile portfolio. For instance, it is therefore possible for a stock to be in portfolio 2 in one holding period and in portfolio 4 in another. In order to perform a regression on such data, the overlapping portfolios must be transformed into one vector of returns for each decile portfolio.

Previously, some studies (including Nagel, 2001 and Bildik and Gulay, 2002) have approached this issue by using an average of the portfolio returns for each overlapping window. As evident in Figure 2, when using this approach there will be a starting period where there will be less than five portfolio returns at time t . Likewise, there will be an ending period where there will be less than five portfolio returns at time t . In order to avoid biased results, it would be necessary to shorten the test period from 1987-2009 to 1991-2005. Using overlapping portfolios in the way described above, will likely induce a high degree of autocorrelation between time events. As a remedial measure, the Newey-West method can be used to obtain standard errors that are corrected for autocorrelation (Gujarati, 2003). However, the approach remains problematic due to the shortened test period length.

Therefore, we have decided to adopt the approach of Arnold and Baker (2007) instead. For portfolio 1, the monthly returns of the first holding period year for all 18 portfolio formations are used to compose a vector of first year returns. This is illustrated in Figure 3. This procedure is repeated for each of the holding period years and for each decile portfolio. In total, the returns of each decile portfolio will consist of five return vectors, one for each of the holding period years. Each return vector will contain 216 monthly returns observations. This procedure is used for both the equally weighted and value weighted portfolios.⁵

Creating separate vectors for each year of the holding period implies that the portfolios are re-balanced each year. This will in practice result in additional transaction costs that will affect the portfolios

⁵ A total of 10800 observations are used for the equally weighted portfolios (18 portfolio formations * 10 decile portfolios * 12 months per year * 5 holding period years). The same goes for the value weighted portfolios.

performance negatively. The magnitude of the transaction costs will depend on how the allocations of stocks within the decile portfolios change over time.

6.5 Market Adjusted Returns

The raw equally weighted returns are adjusted by an equally weighted market index consisting of the entire sample of stocks, i.e. all stocks from the decile portfolios. This results in portfolio excess returns over the sample market index, which enables a first comparison of the decile portfolios' performance relative to the market index and also a comparison of the portfolios' performance relative to each other. The raw value weighted returns will be adjusted by a value weighted market index consisting of the entire sample of stocks, where the weights are determined in accordance with the stocks' market capitalizations.

6.6 Risk Adjusted Returns

The decile portfolio returns will be analyzed further by comparing the equally weighted returns to the value weighted returns. If there is a significant small firm effect driving the performance of a decile portfolio, then the value weighted return for the portfolio should be substantially smaller than the equally weighted return since the portfolio weights are shifted from the small firms to the larger ones. Additionally, the portfolios' standard deviations will be compared and Sharpe ratios will be computed for all decile portfolios, allowing for a comparison of risk adjusted returns. Furthermore, the portfolios' propensity to deletion will be studied and the reliability of the reversal strategy in different economic states will be analyzed. As final measures of the decile portfolios' risk, regression analysis using the CAPM and the Fama-French three factor model will be performed in order to test for alphas significantly different from zero.

6.7 The CAPM

A CAPM regression will be performed using the return vectors described in section 6.1 where the explanatory variable is the excess return of a proxy for the broad market index.

$$r_{p,t} - r_{f,t} = \alpha_p + \beta_p(r_{m,t} - r_{f,t}) + \varepsilon_{p,t} \quad (3)$$

where: $r_{p,t}$ is the t month return for portfolio p ,
 $r_{f,t}$ is the risk-free rate at time t and
 $r_{m,t}$ is the market return at time t .

The regression in Equation (3) is performed on each of the holding period vectors resulting in five alpha and beta values being obtained for each decile portfolio. Apart from comparing the estimated coefficients across portfolios, the difference between the estimated coefficients within portfolios, over the five holding period years will be analyzed as well.

We test that the necessary OLS assumptions are fulfilled in order to determine if corrections need to be made. We test for an error term with zero mean, stationary variables, autocorrelation in the error term, heteroskedasticity and for a normally distributed error term. Robustness tests for the equally and value weighted returns using the CAPM are performed in Appendices A and B.

6.8 The Three Factor Model

The same methodology will be used for the regressions using the Fama-French three factor model. The difference from the CAPM regression, however, is the addition of two explanatory variables, namely the small-minus-big (SMB) and high-minus-low (HML) factors. The regression in full is shown as follows:

$$r_{p,t} - r_{f,t} = \alpha_p + \beta_p(r_{m,t} - r_{f,t}) + s_p(SMB_t) + h_p(HML_t) + \varepsilon_{p,t} \quad (4)$$

where: SMB is the Fama-French small-minus-big factor and
 HML is the Fama-French high-minus-low factor.

The Fama-French factor returns from 1989-02-01 to 2008-02-01 have been obtained from a previous master thesis at the Stockholm School of Economics by Lundén and Hagwall (2008). We have calculated the factor returns from 2008-02-01 to 2009-02-01 in order to complete the data set. The factors have been composed using the same method as that of Fama and French (1993), which is also the method used by Lundén and Hagwall (2008).

The market factor is the same as the one used for the CAPM. In order to calculate the HML and SMB factor returns, we first constructed six portfolios formed on size and book-to-market using all stocks listed on the Stockholm Stock Exchange. The six portfolios were created by first splitting the stocks into two groups, small and big, with the breaking point being the median market capitalization at the start of each year. Secondly, each of these two groups are split into three portfolios, with the 30 percent highest book-to-market ratio stocks in a first portfolio (high); the 30 percent lowest book-to-market ratio stocks in a second portfolio (low); and the 40 percent remaining stocks in a third portfolio (neutral)⁶. The outcome is six portfolios: small/high (S/H), small/neutral (S/M), small/low (S/L), big/high (B/H), big/neutral (B/M) and big/low (B/L), Fama and French (1993).

The SMB factor is the average value weighted return of the three small portfolios minus the average value weighted return of the three big portfolios. The HML factor is the average value weighted return of the two high book-to-market portfolios minus the average value weighted return of the two low book-to-market portfolios (Fama and French, 1993). Hence, the SMB and HML factors are obtained as follows:

⁶ Negative book common equity firms are disregarded when finding the breaking points.

$$SMB = \frac{(S/H+S/M+S/L)-(B/H+B/M+B/L)}{3} \quad (5)$$

$$HML = \frac{(S/H+B/H)-(S/L+B/L)}{2} \quad (6)$$

We test that the necessary OLS assumptions are fulfilled in order to determine if corrections need to be made. We test for an error term with a zero mean, stationary variables, autocorrelation in the error term, heteroskedasticity and for a normally distributed error term. Robustness tests for the equally and value weighted returns using the three factor model are performed in Appendices C and D.

7. Results

7.1 Equally Weighted Portfolio Returns

From Table 1 and Figure 4 it is evident that portfolio 8 (i.e. the 70 to 80 percent historically worst performing stocks) on average outperforms all other portfolios at any given time of the holding period. The p-value from the Student's t-test indicates that the average return after five years is significantly different from zero at the five percent level.

In general, the longer a portfolio is held, the more extreme the holding period return is. Portfolios 1, 8, 9 and 10 follow an upward return trend and portfolios 2, 3, 4 and 5 follow a downward trend. In other words, the 30 percent worst performing stocks during the historical five year period, on average, outperform the market portfolio during the directly following five year holding period. Similarly, the 10 to 50 percent best performing stocks during the five year historical period, on average, underperform the market portfolio during the directly following five year holding period. These results to some extent indicate that there may be a stock return reversal effect.

We did not find support for our hypothesis that the more extreme the returns were during the historical period, the larger the subsequent holding period returns would be, even when excluding the top and bottom decile portfolios. If this were the case, then the decile portfolios' returns would be increasing in strict order when moving from the winner portfolio to the loser portfolio.

On average, the loser portfolio does not generate the largest market adjusted returns compared to the other portfolios. The winner portfolio, on average, performs well during the entire holding period with the exception of the first year. Three years after portfolio formation the winner portfolio outperforms the loser portfolio and continues to perform similarly to the loser portfolio after five years. These findings do not support the existence of a stock return reversal effect. Worth noting, however, is that neither the average returns for portfolio 1 or portfolio 10 are statistically significantly different from zero.

In Table 3 one can see that for equally weighted returns, the 30 percent historically best performing stocks generate negative returns 70 percent of the time, after a five year holding period. The 30 percent historically worst performing stocks generate positive returns 56 percent of the time, after a five year holding period.

Figure 6 shows the average equally weighted loser-winner portfolio⁷ returns after the five year holding periods. From 1991 to 1994 as well as from 2001 to 2006 the loser-winner portfolio generates positive returns. From 1995 to 2000 as well as from 2007 to the end of our observation period, the loser-winner portfolio generates negative returns. There seems to be a cyclical behavior for the returns of the zero-investment strategy. There is, however, no apparent relation between the 60th month portfolio returns and the real GDP growth (red bars) or the equity bear markets (black dots).

From the perspective of an investor, the results of the loser-winner portfolio seem very unreliable with extremely large losses during several occasions. In 1999 the loser-winner portfolio return is approximately -600 percent, due to the winner portfolio substantially outperforming the loser portfolio. This is due to the strategy involving short selling, resulting in an unlimited downside risk resulting in the possibility of negative returns beyond -100 percent.

When studying the data it is evident that the performance of portfolio 1 is largely driven by a select few stocks. Measurements of the persistence of the allocation of stocks within portfolio 1 throughout all portfolio formations show that 77 percent of the stocks in portfolio 1 are allocated to portfolio 1 in more than one holding period while 17 percent are allocated to portfolio 1 in more than six holding periods. This indicates that there is some persistence of the stock allocation in portfolio 1 over time. When studying the winner portfolios' data in even more detail, HENNES & MAURITZ 'B' is found in no less than 13 holding periods, ERICSSON 'B' is found in nine holding periods and ERICSSON 'A' is found in eight holding periods. Due to their allocation to the winner portfolio, these stocks are by definition historically extremely well performing stocks. Due to the evident persistence in their allocation to portfolio 1 over time, these stocks continue to exhibit extremely good performance over future periods. The conclusion that can be drawn is that the performance of the winner portfolio is to a large extent driven by a few stocks that have not only done well historically, but have continued to do well during long periods of time.

It is evident that in the case of equally weighted portfolios, the top and bottom decile portfolios do not seem to exhibit tendencies to reversal. Instead it is interesting to see if a reversal strategy excluding the loser and winner portfolio, i.e. consisting of portfolios 9 and 2, can provide better performance. The results from the reliability test of a zero-investment portfolio with a long position in portfolio 9 and a short position in portfolio 2 (9-2 portfolio) are found in Figure 7. In comparison to the loser-winner

⁷ i.e. the zero-investment portfolio which is constructed by taking a long position in the loser portfolio and a short position in the winner portfolio.

portfolio, the most striking difference is that the 9-2 strategy generates negative returns during five occasions, compared to 9 negative five year returns for the loser-winner portfolio. The most negative return for the 9-2 portfolio is -180 percent in 1999 compared to the loser-winner portfolio's return of -642 percent that same year. The positive returns generated from the 9-2 portfolio seem to be significantly smaller than those of the loser-winner portfolio. The standard deviation of the returns for portfolio 9-2 is 123 percent compared to 308 percent for the loser-winner portfolio. This indicates that the 9-2 strategy is more reliable, or less risky, than the loser-winner strategy. However, the five out of 18 negative returns along with one return of -180 percent suggest that the strategy may not be reliable enough for an investor to be willing to implement the strategy.

The rationale behind implementing such a strategy where the top and bottom deciles are avoided could be that strong return persistence seems to be evident in portfolio 1, where stocks that have performed well continue to do so whereas the opposite is true for portfolio 10 on average. Many of the stocks in the bottom decile are also very small in terms of market capitalization which may be an indicator of the stocks having low turnover volumes and being illiquid. This could be a valid reason for an investor to avoid such stocks where trades are difficult to settle and the performance may be affected by a bid-ask-bounce. We realize that a zero-investment strategy with portfolio 8 and 2 would likely provide even better returns than the 9-2 strategy. However, it is even more difficult to motivate the specific choice of portfolio 8 from a reversal point of view.

In both Figure 6 and Figure 7 it is possible to observe years with extreme performance. This will affect the average performance of the portfolios which makes it interesting to study whether the extreme performance is due to a small firm effect. This will be done by value weighting the portfolios and thereby shifting the portfolio weights from the small cap stocks to the large cap stocks. Differences between the equally weighted portfolios' performance and the value weighted portfolios' performance will be discussed in the following section.

7.2 Value Weighted Portfolio Returns

The most notable differences between the value weighted returns and the equally weighted ones, as seen in Figure 10, is that the returns of portfolio 8 and 10 are greatly reduced after value weighting. This suggests that these two portfolios in particular experience a strong small firm effect. Another key difference after value weighting the portfolios is that the returns of portfolios 4, 6 and 9 are greatly increased as shown in Table 2 and Figure 5. This suggests that these two portfolios experience the opposite of a small firm effect where the larger firms included in the portfolios exhibit better performance than the smaller stocks.

It is evident that when looking at the value weighted returns, portfolio 9 is the best performing portfolio at any given time of the holding period. Most portfolio returns, on average, have either a

positive or negative trend throughout the entire holding period. Portfolios 1, 6, 8, and 9 produce positive returns whereas portfolios 2, 3, 4, 5, and 10 produce negative returns. As in the case of equally weighted returns, one can to some extent distinguish a pattern of return reversal when disregarding the top and bottom decile portfolios. For there to be strong support for a reversal effect not only portfolios 1 and 10 should produce the most extreme returns, but portfolios 5 and 6 should produce returns closer to the market index, i.e. market adjusted returns close to zero. Before dismissing the existence of long term return reversal, on average, one should note that in the case of value weighted portfolios only one out of ten portfolio returns was statistically different from zero at the five percent level. There are several possible reasons for these results. For example, the high p-values could likely be the result of a sample that is too small. Only 18 portfolio formations could be created with the data available and therefore only 18 observations exist for each year of the holding period. The high p-values may also be the result of high variance within the sample, widening the confidence interval so that it encompasses both positive and negative values. Therefore, it is difficult to draw any definitive conclusions from the results presented so far.

Figure 8 shows the value weighted loser-winner portfolio five year returns. During the majority of the time, from the years of 1995 to 2002 as well as from 2006 to the end of our observation period, the loser-winner portfolio generates negative returns. From 1991 to 1994 as well as from 2003 to 2005 the loser-winner portfolio generates positive returns. The returns overall are lower than the ones when using equally weighted portfolios but the pattern is fairly similar. Again, there is no apparent relation between the 60th month portfolio returns and the negative real GDP growth (red bars) or the negative return on equities (black dots). The strategy produces negative returns during bear markets more frequently than it produces positive returns.

According to our hypothesis, the loser portfolio was expected to generate large positive returns relative to the other decile portfolios, which clearly is not the case as the loser portfolio fails, on average, to beat the market portfolio at any point of time of the holding period. In addition, the winner portfolio, on average, generates slightly lower but still positive returns after value weighting. The winner portfolio is not the best performing portfolio, but it manages to outperform the loser portfolio during each year of the holding period on average. These findings are not in line with the stock return reversal effect. It can be concluded that the loser-winner strategy is highly unreliable and unattractive from an investor's perspective.

The results from the 9-2 strategy are shown in Figure 9. With the exception of years 1997 and 1999, where extreme performance is observed, the 9-2 strategy seems to be fairly stable. From an investor's perspective, the negative return of -511 percent in 1999 may make it an unattractive strategy as it indicates that the strategy is susceptible to extremely large losses.

The conclusions that can be drawn from these first analyses are that, in general, no obvious signs of a persistent reversal effect can be seen on the Stockholm Stock Exchange. Both the winner and loser portfolios exhibit returns that are the direct opposite of what would be expected from our hypothesis of the stock return reversal existence. Implementing a zero-investment strategy consisting of a short position in the winner portfolio and a long position in the loser portfolio would result in highly unpredictable returns, with extremely large negative returns during certain years. When disregarding the top and bottom deciles, it is to a certain extent possible to distinguish a return reversal pattern. Our 9-2 strategies exhibit more stable and positive returns than the loser-winner strategy, however, years of extreme negative performance are still observed.

7.3 Propensity to Deletion

As seen in Table 5, there are on average 14.1 to 15.1 stocks in each portfolio at the time of portfolio formation. After portfolio formation, stocks successively become deleted leaving each portfolio with an average of 6.1 to 10.1 stocks at the end of the five year holding period. An interesting point that can be seen in Table 6 is that the loser portfolio, on average, has the highest number of deleted stocks during any given year of the holding period. This is somewhat expected considering the fact that the stocks allocated to the loser portfolio are the historically worst performing stocks which increases the probability of them becoming take-over targets or financially distressed and eventually liquidated (Arnold and Baker, 2007). As the number of stocks in each portfolio is rather small to begin with, this leaves the loser portfolio with quite few stocks to account for the continued performance. If the remaining stocks happen to be poor or mediocre performers relative to the market index, then this could be an explanation to why the loser portfolio does not perform as well as expected.

Similarly, the winner portfolio has relatively few deletions during the holding period in comparison to the other decile portfolios. Considering the fact that the performance of portfolio 1 is largely driven by a few stocks that continue to do well during extensive periods of time, deletions within portfolio 1 will result in the remaining proceeds being allocated to these well performing stocks, which may explain the unexpectedly good performance.

7.4 Standard Deviations

After analyzing and comparing the decile portfolios' market adjusted returns with each other, it is relevant to compare the portfolios risk levels in terms of standard deviation. For example, after having found indications that implementing a long short investment strategy involving portfolio 9 and portfolio 2 will on average generate positive returns, it is interesting to see if the difference in returns between these portfolios can be explained by differences in the volatility associated with them.

Table 7 and Table 8 show the respective standard deviations of the decile portfolios excess returns over the risk free rate for both the equally weighted and value weighted portfolios. The two tables are

fairly similar, both indicating that the loser portfolio is more volatile than the winner portfolio by two percentage units in the case of equally weighted portfolios. The difference is one percentage unit for the value weighted portfolios. In the case of equally weighted portfolios, this indicates that despite the loser portfolio on average performing very closely to the winner portfolio (Table 1) after a five year holding period it is the notably more volatile portfolio. Value weighting the portfolios makes matters even worse since the winner portfolio on average substantially outperforms the loser portfolio after a five year holding period (Table 2), whilst being less volatile than the loser portfolio (although the volatility gap has decreased). These results do not support our hypothesis of there being a reversal effect on the Stockholm stock exchange and show that it is a better strategy for an investor to merely invest in the winner portfolio.

The standard deviations for all decile portfolios increase when value weighting, except for portfolio 10 which remains unchanged. When studying the standard deviations for portfolios 2 through 8, one can see that for the equally weighted portfolios the volatility gap between the best performing portfolio (portfolio 8) and portfolio 2 is two percentage units. When studying the standard deviations from the value weighted portfolios the volatility gap between the best performer (portfolio 9) and portfolio 2 is only one percentage unit. Excluding the winner and loser portfolios, portfolios 6 to 9 seem to have slightly higher standard deviations than portfolios 2 to 5. Considering the fact that most portfolios generate returns different from one another, it is difficult to make more extensive comparisons of the decile portfolios without taking their respective returns into consideration. This will be done in the next section where the portfolios' Sharpe ratios will be analyzed.

7.5 Sharpe Ratios

The Sharpe ratio is a reward-to-volatility measure that can be used to gauge how well the excess return of an asset compensates for the risk that the investor has taken. A higher Sharpe ratio means that the asset generates a higher return for a certain amount of risk. Hence, a portfolio with a high Sharpe ratio is generally a better investment than a portfolio with a low Sharpe ratio. The Sharpe ratio is defined as (Sharpe, 1998):

$$S_p = \frac{R_p - R_f}{\sigma_p} = \frac{E(R_p - R_f)}{\sqrt{\text{var}(R_p - R_f)}} \quad (7)$$

where R_p is the monthly excess portfolio return,
 R_f is the risk-free return and
 σ_p is the portfolio standard deviation.

Table 9 presents the Sharpe ratios for the equally weighted portfolios. The highest average Sharpe ratios are found in portfolios 6 through 9 together with the winner portfolio while the lowest Sharpe ratios are found in portfolios 2 through 5 together with the loser portfolio. This supports the previous

results indicating that there is a tendency of stock return reversal when excluding the top and bottom decile portfolios. The loser portfolio has a lower Sharpe ratio than the winner portfolio by 2 percentage units. Surprisingly, portfolio 7 exhibits the highest Sharpe ratio of 0.20, despite the portfolio earning market adjusted returns that are on average substantially lower than the best performing portfolio (portfolio 8). This is because it has the lowest standard deviation of the equally weighted portfolios, which has a positive effect on the Sharpe ratio. Portfolio 8, also generates one of the highest Sharpe ratios of 0.18.

Table 10 presents the Sharpe ratios for the value weighted portfolios. When studying the value weighted portfolios, the largest average Sharpe ratios are found in portfolios 6, 8 and 9 whilst the lowest average Sharpe ratios are found in portfolios 2, 3 and 10. This, as well, provides some support for the existence of the reversal effect when disregarding the extreme portfolios. Similar to the equally weighted portfolios, the value weighted Sharpe ratio for the winner portfolio is higher than the loser portfolio's, by a margin of five percentage units. The proposed strategy of using portfolios 9 and 2 to create a zero-investment strategy seems to be a good idea after analyzing the portfolios respective Sharpe ratios. The average Sharpe ratio differential of portfolio 9 versus portfolio 2 is seven percentage units.

7.6 Returns in Different Market Conditions

As a further step in analyzing the decile portfolios' performance, their respective average monthly returns are calculated in four different categories based on when the market index had its worst performing 30 months, the remaining months with negative returns, the best performing 30 months, and the remaining months of positive returns. The results are reported in Table 4. During the worst 30 months of the market index as well as during the remaining months with negative returns, the loser portfolio on average outperforms the winner portfolio. During the best performing 30 months of the market index, the winner portfolio outperforms the loser portfolio by an average of four percentage units monthly. During the remaining months of positive market index returns, the loser and winner portfolios on average perform equally. The loser portfolio does not show any signs of being prone to exhibiting large negative returns during months when the market as a whole performs poorly. Instead, using only the results presented in Table 4 it seems as if the loser portfolio has a lower correlation coefficient to the market than the winner portfolio. The 9-2 strategy shows negative average monthly returns of -1 percent only during the market's best 30 months, and in the remaining categories it earns monthly returns equal to zero or above.

7.7 CAPM Regression

The results from the performed OLS regressions using the CAPM are analyzed in this section. The results are reported in Table 11 and Table 12. For the equally weighted portfolios, the beta coefficients are relatively high for the winner portfolio. In fact, the winner portfolio has the highest beta values in

all years but the first of the holding period. The loser portfolio on the other hand exhibits relatively low beta values. These results are consistent with the hypothesis of the winner and loser portfolios' correlation with the market. The spread between the winner and loser beta coefficients range between 0.0 and 0.6, which is rather large when comparing to the results of Arnold and Baker (2007) whose beta coefficients for the winner and loser portfolios were fairly equal over the holding period.

The alphas presented in Table 11 and Table 12 can be interpreted as the part of the monthly portfolio returns that cannot be explained by the CAPM, i.e. returns that cannot be explained by market risk. We will interpret statistically significant alphas as an indication of a portfolio earning abnormal returns.

For the equally weighted portfolios, the loser portfolio produces only one significant alpha at the five percent level, during the fourth year of the holding period while the winner portfolio fails to produce any positive and significant alphas at all. Portfolio 8, which on average is the best performing equally weighted portfolio, produces positive and significant alphas in four out of five years of the holding period. The alphas are also highly economically significant ranging from 0.7 percent to 1.6 percent monthly, or if annually compounded 8.7 percent to 21.0 percent. Portfolio 9 manages to produce significant positive alphas at the five percent level in the second, third and fourth year of the holding period. These alphas are economically significant as well, ranging from 0.8 percent to 1.1 percent per month. In total, 19 out of 50 alphas from the equally weighted portfolio CAPM regressions are statistically significant at the five percent level. The results are consistent with the findings of Arnold and Baker (2007). However, they found that the winner portfolio produced negative alphas in four of the five holding period years.

The loser-winner portfolio does not generate any abnormal returns and seems to have a beta that is negative or close to zero throughout the holding period. The 9-2 strategy on the other hand generates one positive alpha at the five percent level or two at the ten percent level while having a beta that is close to zero during the holding period. This suggests that in the second and third holding period year, the portfolio earns positive abnormal returns of 8.7 and 12.7 percent annually that are close to being independent of market risk. This result gives some support for a reversal strategy based on portfolios 9 and 2 being successful on average.

The resulting beta coefficients from the value weighted portfolios are quite similar to the ones obtained from the equally weighted portfolio regressions. The winner portfolio still has the highest beta coefficient in all but the first year of the holding period. Similarly, the loser portfolio still exhibits a beta coefficient substantially lower than one throughout all years of the holding period. The main difference between the beta coefficients of the value weighted portfolios compared to the equally weighted ones is firstly that the value weighted portfolio betas are lower than the equally weighted

ones during the first year of the holding period. Secondly, they are generally higher than the equally weighted portfolio beta coefficients during the remaining four years of the holding period.

When studying the alphas from the value weighted portfolio CAPM regressions, it is clear that the number of significant alphas at the five percent level has been greatly reduced, from 19 to only 6. Neither the winner or loser portfolios produce any significant alphas at the five percent level during any of the holding period years. Portfolio 8 exhibits statistically significant alphas during the first two years of the holding period, and portfolio 9 during the second year, in the range of 0.9 to 1.7 percent per month. Other than that, portfolio 6 yields positive and significant alphas in the first and fifth year of the holding period while portfolio 7 yields a positive and significant alpha during the fifth year. None of the top decile portfolios generate negative alphas during the holding period which suggests that they are not significantly overvalued. Neither the loser-winner strategy nor the 9-2 strategy earns abnormal returns during any of the holding period years at the five percent significance level. These results do not give support to the reversal effect and consequently they also differ from the Arnold and Baker (2007) results.

Our main conclusion from the CAPM regressions is that the portfolios that earned abnormal returns most frequently were portfolios 6, 7, 8 and 9. The pattern is similar for both the equally weighted and value weighted CAPM results, with the bottom five decile portfolios earning abnormal returns more frequently than the top five decile portfolios. To some extent these results give support to the existence of a reversal effect. However, despite the winner portfolio not earning any significant abnormal returns during the holding period, the loser portfolio does not perform in accordance with the existence of a return reversal effect. In addition, portfolios 6 and 7 earn abnormal returns more frequently than expected from a reversal point of view. They were expected to perform close to the market portfolio and not earn any abnormal returns. None of the zero-investment portfolios exhibit any greater success in terms of abnormal returns, regardless of using equally weighted or value weighted portfolios. The 9-2 strategy, however, seems preferable to the loser-winner strategy. In conclusion, the results are consistent with those from previous tests. A tendency to a reversal effect can be observed, however, no strong support for the phenomenon can be found.

7.8 The Fama-French Three Factor Model

The results from the performed OLS regressions using the Fama-French Three Factor model are analyzed in this section. The results are reported in Table 13 and Table 14. Firstly, the estimated coefficients of the three factors will be analyzed and secondly, the alphas will be analyzed.

Starting out with the results for the equally weighted decile portfolios, the beta coefficients for the winner portfolio are high relative to the other portfolios, similar to the results from the CAPM. For the last four years of the holding period, the winner portfolio has a substantially higher beta coefficient

than all the other portfolios suggesting that it has a substantially larger loading on market risk. The loser portfolio, on the other hand exhibits the highest beta coefficient of all portfolios in the first year of the holding period while it has amongst the lowest beta coefficients for the remainder of the holding period. On average, the loser portfolio has a relatively low loading on market risk compared to the winner portfolio in particular. The general pattern seems to be that portfolios 6 through 10 have lower loadings on the market factor than portfolios 1 through 5. All estimated beta coefficients are significant at the five percent level. These results are consistent with the results from the CAPM regressions and also consistent with the results of Arnold and Baker (2007).

A total of 12 SMB coefficients are significant at the five percent level and they all have positive signs. The general pattern is that portfolios 5 through 10 exhibit significant SMB coefficients more frequently than portfolios 1 through 5. The signs of the coefficients are different from those reported in Arnold and Baker (2007) where roughly half of the coefficients are negative. One should note, however, that the p-values or t-statistics of their estimated coefficients are not reported. Our results suggest that there is a significant small firm effect in portfolios 5 through 10, but not in portfolios 1 through 4. In other words, the loser portfolio can be interpreted as more risky than the winner portfolio in this sense.

36 of the estimated coefficients of the HML factor are significant at the five percent level and they have overwhelmingly negative signs. The main exception is the winner portfolio which has positive HML coefficients throughout all years of the holding period. These results differ quite substantially from those of Arnold and Baker (2007) where they report HML coefficients that are positive for the loser portfolio and mostly negative for the winner portfolio. If the HML factor is to be interpreted as a proxy for financial distress, then our results suggest that the winner portfolio generally consists of stocks in more financial distress than the loser portfolio. Differently put, the results suggest that the loser portfolio may be less risky than the winner portfolio in this sense.

In total, 23 alphas are significant at the five percent level and they all have positive signs. This indicates that the Fama-French Three Factor model fails to explain the decile portfolios' returns in roughly half of the cases. Portfolio 6 earns significant abnormal returns at the five percent level in all five holding period years, in the range of 7.4 to 10.0 percent annually. Portfolio 8 exhibits the largest alphas of all portfolios in four out of the five holding period years in the range of 12.7 to 23.9 percent per year, which is consistent with our previous results showing that portfolio 8 on average is the best performing equally weighted decile portfolio. The loser portfolio generates a positive and significant alpha during only one of the holding period years. However, it is rather large at 1.8 percent per month. These results are different from those of Arnold and Baker (2007) where they found significant and positive alphas for the loser portfolio in four of the five years. Consistent with our results from the CAPM regressions, the winner portfolio does not earn any statistically significant abnormal returns.

Arnold and Baker (2007) also found that the winner portfolios' alphas were statistically insignificant for all years of the holding period. It is notable that all significant alphas are positive, even those of portfolios 2 and 3, which on average are poor performing portfolios relative to the sample market index. This leads us to believe that the sample market index outperforms the broad market index consisting of all listed stocks on the Stockholm Stock Exchange. Arnold and Baker (2007) reported similar results where their correspondent to our portfolio 2 showed a significant and positive alpha during one of the holding period years.

The loser-winner portfolio does not produce any positive and significant alphas at the five percent level. However, the 9-2 strategy earns positive alphas in two out of the five years at the five percent level. The results are similar to the ones obtained when using the CAPM, suggesting no signs of abnormal success for the loser-winner strategy while the 9-2 strategy seems to be fairly successful. In the second year of the holding period, the 9-2 strategy earns an average abnormal return of 1.2 percent per month. On an annually compounded basis this corresponds to 15.4 percent, which is quite substantial. In the third year of the holding period the 9-2 strategy earns an average abnormal return of 8.7 percent per year. These results give some support to the existence of a reversal effect. However, the portfolios that earn abnormal returns do not strictly follow a reversal pattern. The most apparent deviations from a reversal pattern is the loser portfolio as well as portfolios 6 and 7 which earn abnormal returns just as frequently as portfolio 8 and more frequently than portfolio 9. In addition, portfolios 2 and 3 earn abnormal returns in two of the holding period years which also deviates from a reversal pattern.

When studying the results from the value weighted decile portfolios, the estimated beta coefficients show a similar pattern to the ones when using equally weighted portfolios with the winner portfolio having the highest beta while the loser portfolio has one of the lowest betas. The exception from this pattern is the first year where the winner portfolio's beta is substantially lower than the loser portfolio's. All beta coefficients are significant at the five percent level. Again, these results are consistent with those of Arnold and Baker (2007).

Only eight SMB coefficients are significant at the five percent level with both positive and negative signs. At the ten percent significance level the loser portfolio exhibits quite large positive SMB coefficients suggesting that there is a substantial small firm effect in this portfolio. The winner portfolio exhibits a small firm effect at the ten percent significance level as well, however, when comparing to the loser portfolio it is evident that the small firm effect in the winner portfolio is substantially smaller in magnitude. This suggests that the loser portfolio is riskier than the winner portfolio.

27 of the HML coefficients are significant and they all exhibit negative signs. The winner portfolio shows four positive HML coefficients, however, all of them are insignificant at the five percent level.

On the other hand, the loser portfolio shows negative HML coefficients in all five years. However, only one is significant at the five percent level. The loser portfolio seems to be only marginally less risky in terms of financial distress than the winner portfolio after value weighting.

Both the winner and loser portfolios fail to produce any significant abnormal returns. Instead, portfolio 6 earns abnormal returns most frequently. In the first and fifth year of the holding period, portfolio 6 earns abnormal returns of 12.7 percent annually while in the second year it earns an annual abnormal return of 8.7 percent on average. Portfolio 8 earns abnormal returns of 26.8 percent and 11.4 percent annually in the first and second holding period year respectively. In addition, portfolios 7 and 9 earn abnormal returns in one of the five years. After value weighting, the portfolios that earn abnormal returns seem to be quite random and do not follow a clear cut reversal pattern. Neither the loser-winner nor the 9-2 strategies earn any abnormal returns significant at the five percent level after value weighting the portfolios.

In conclusion, the results from the regressions using the Fama-French three factor model were similar to those from the CAPM regressions. The bottom five decile portfolios exhibit significant and positive alphas more frequently than the top five decile portfolios. Once again, the results support the existence of a reversal effect to some extent. However, the behavior of the loser portfolio along with portfolios 6 and 7 do not follow a reversal pattern. Of the zero-investment strategies the 9-2 portfolio generated more abnormal returns than the loser-winner portfolio which fail to earn any at all. These results do not give strong support to the existence of a reversal effect on the Stockholm Stock Exchange.

8. Conclusion

The purpose of this paper has been to investigate whether a reversal investment strategy can be used to identify potentially mispriced stocks and thereby earn abnormal returns on the Stockholm Stock Exchange. Our main findings are that a tendency for a stock return reversal effect can be found when disregarding the winner and loser portfolios. However, the results do not exhibit the type of strict pattern one should expect from a return reversal effect. Hence, results do not show strong support for a return reversal effect on the Stockholm Stock Exchange. Instead, the long run EMH and rational investors arbitraging prices back to their fundamental values seems more plausible than a systematic overreaction effect.

These results differ from those of Hamberg and Novak (2007) who showed that a reversal strategy on the Swedish market generated an annual value premium of 10.8 percent and 13.8 percent after a three year holding period using strategies based on the earnings-to-price and book-to-market ratios, respectively. When adjusting for size and risk, the value premiums were only marginally reduced. Furthermore, the strategy was improved by adjusting for transitory earnings and for a bias caused by

accounting conservatism. We believe that the difference in results is mainly due to us using a different methodology than Hamberg and Novak (2007), as described in section 1.2.

Our results also differ from those of several international studies including De Bondt and Thaler (1987) who found that loser portfolios outperformed the winner portfolios by five to ten percent per year on average over a five year holding period on US stock markets; Arnold and Baker (2007) who found similar results for the UK; Baytas and Cakici (1999) who found evidence for the return reversal effect in Canada, the UK, Japan, Germany, France and Italy; as well as Schiereck, De Bondt and Weber (1999) who found support for the effect on the Frankfurt Stock exchange. However, Conrad et al. (2003) found that when forming portfolios using a single sorting criterion, the potential data-snooping bias could account for up to 50 percent of the discovered patterns. Although one cannot completely dismiss the possibility of previous findings being the result of data-snooping, it seems unlikely considering that evidence of the reversal effect has been found on a large number of different equity markets.

Similar to our results, several researchers fail to find strong support for a stock return reversal effect. Fama and French (1986) and Zarowin (1989), (1990) suggest that the reversal effect on the US market can be explained by the size effect. Clare and Thomas (1995) found that after controlling for size the return reversal in UK stocks disappeared. Kryzanowski and Zhang (1992) found that stock return reversal strategies do not work on the Canadian equity markets and suggest that the variation of results depend on the chosen methodology. Kryzanowski and Zhang (1992) looked at cumulative abnormal returns, Sharpe ratios and Jensens' alpha and found that all three performance measures failed to show significant reversal patterns over the long term. When controlling for risk using the CAPM, Chan (1988) found that a stock return reversal strategy earned only small and likely economically insignificant returns. Ball et. al (1995) found evidence suggesting that calculations of reversal profits are highly sensitive to the choice of portfolio formation date and liquidity effects. Our research on the Swedish stock market suggests that the return reversal effect may be confined to certain markets, perhaps with similar characteristics, and that it may not be a general phenomenon.

9. Further Research

The aim with this paper has been to investigate whether the stock return reversal effect exists on the Swedish stock market. In order to do this we have chosen a certain method and limited our research to answering the research question at hand. There are, however, alternative methods that can be used and there is further research that can be done on the subject.

Firstly, a different sorting criterion could be used to form portfolios. It is evident that the choice of methodology can to a large extent affect the outcome of a study. We chose to rank stocks according to their historical returns. Perhaps historical stock returns are inadequate when it comes to identifying

mispriced stocks. Examples of other sorting criteria that could be used to rank stocks are the multiples used in Hamberg and Novak (2007). Perhaps a reversal strategy would be more successful if several sorting criteria are used. One could for example impose a liquidity constraint on the stocks to be included in the sample. However, the risk of data-snooping bias accounting for a large part of the results increases as the number of sorting criteria increases Conrad et al. (2003).

Secondly, the chosen length of the historical period is likely to have a substantial effect on the outcome of a return reversal study. Perhaps five year historical periods are not optimal for the Swedish equity market. Instead, one could compare the results from using different historical period lengths with each other to determine the optimal one.

Finally, transaction costs could be accounted for in the research. Transaction costs are highly relevant for an investor who wishes to implement an investment strategy based on the stock return reversal effect. If support is found for a return reversal effect, does the strategy still generate abnormal returns after controlling for transaction costs?

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Figures and Tables

Figures

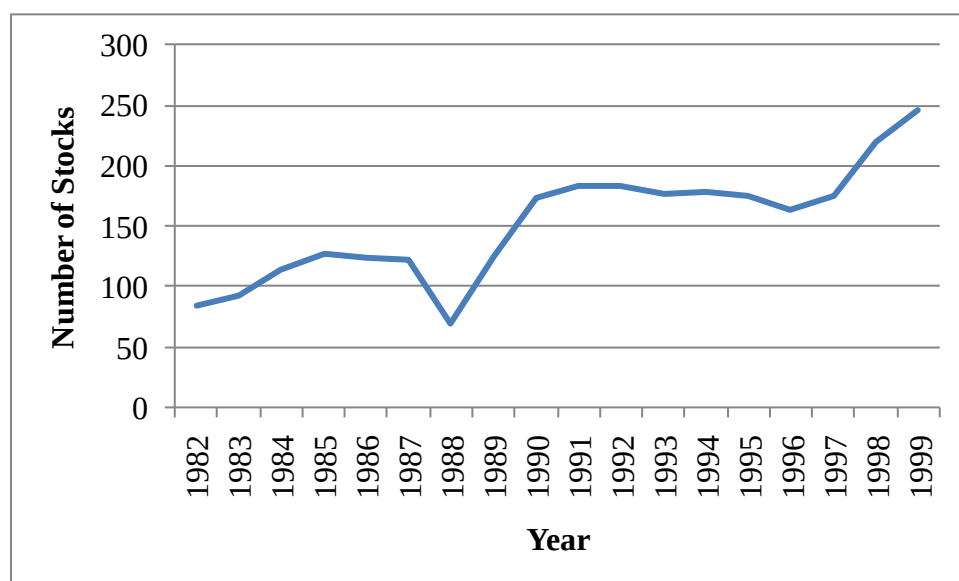


Figure 1: Number of stocks in the sample. The graph shows the number of stocks in all decile portfolios at the time of portfolio formation.

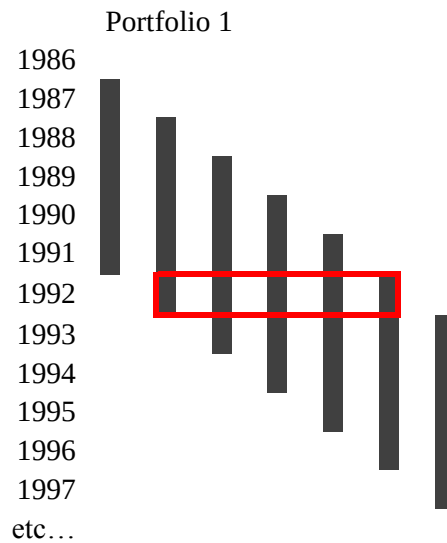


Figure 2: Overlapping portfolios. Each dark grey bar represents the five year holding period for decile portfolio one. As the portfolios are partially overlapping, decile portfolio 1 will have five portfolio returns for each year from 1991 to 2005. This is illustrated by the rectangle in the figure. This is analogous for all ten decile portfolios.

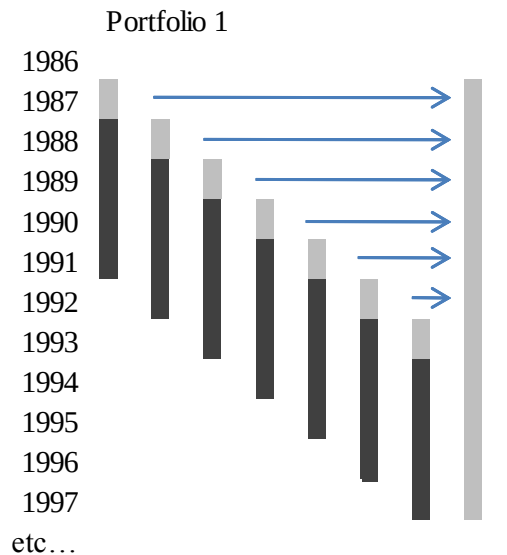


Figure 3: Dealing with overlapping portfolios. Each dark and light grey bar represents the five year holding period for decile portfolio 1. In order to form a single vector of first year returns for portfolio 1, the first year holding period returns are taken from each overlapping portfolio. Similar vectors are constructed the same way for the second, third, fourth and fifth holding period year returns for portfolio 1. In total we end up with five return vectors for decile portfolio 1. This is analogous for all ten decile portfolios.

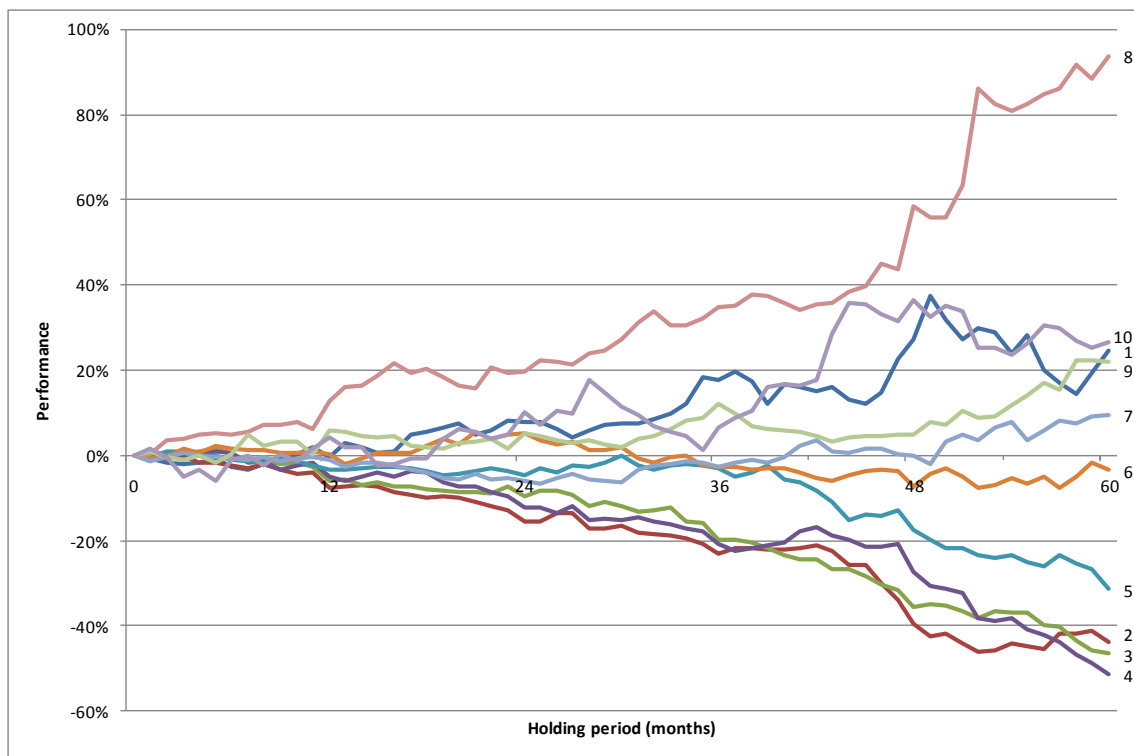


Figure 4: Equally weighted market adjusted returns for each decile portfolio over the holding period. Each line in the graph represents the average, equally weighted performance of a decile portfolio. In other words, each line is the average return of eighteen portfolio formations over the period 1987 to 2004. The stock returns have been market adjusted using our equally weighted sample market index.

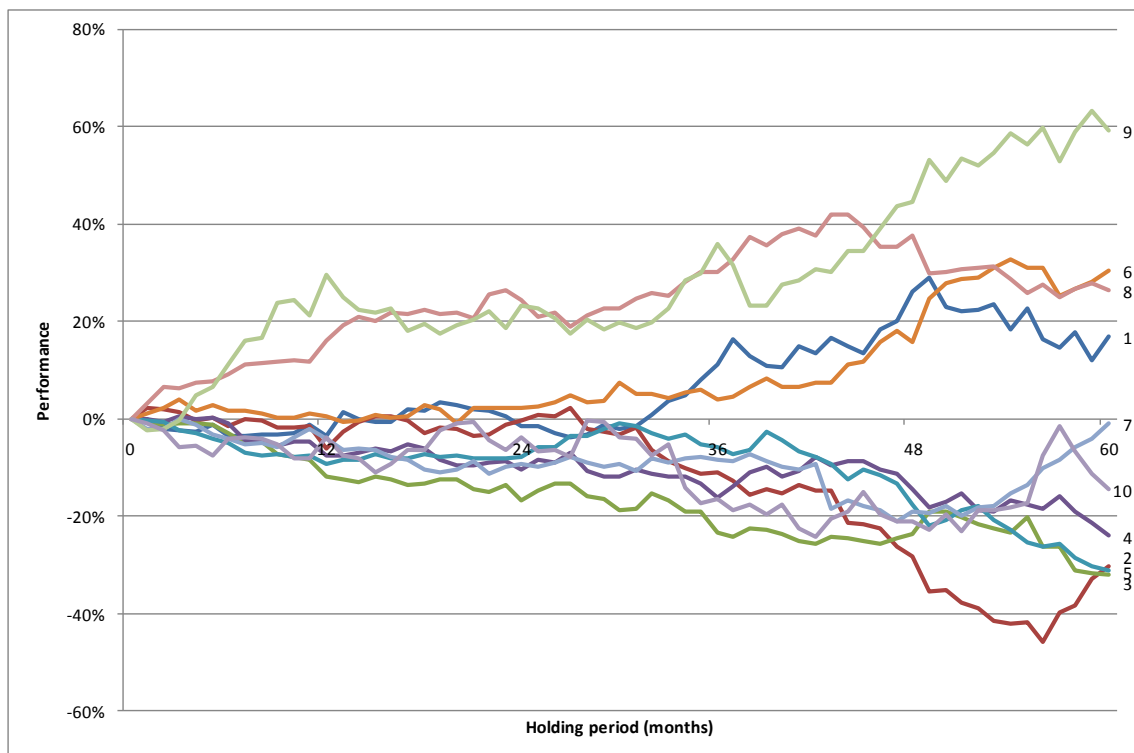


Figure 5: Value weighted market adjusted returns for each decile portfolio over the holding period. Each line in the graph represents the average, equally weighted performance of a decile portfolio. In other words, each line is the average return of eighteen portfolio formations over the period 1987 to 2004. The stock returns have been market adjusted using our equally weighted sample market index.

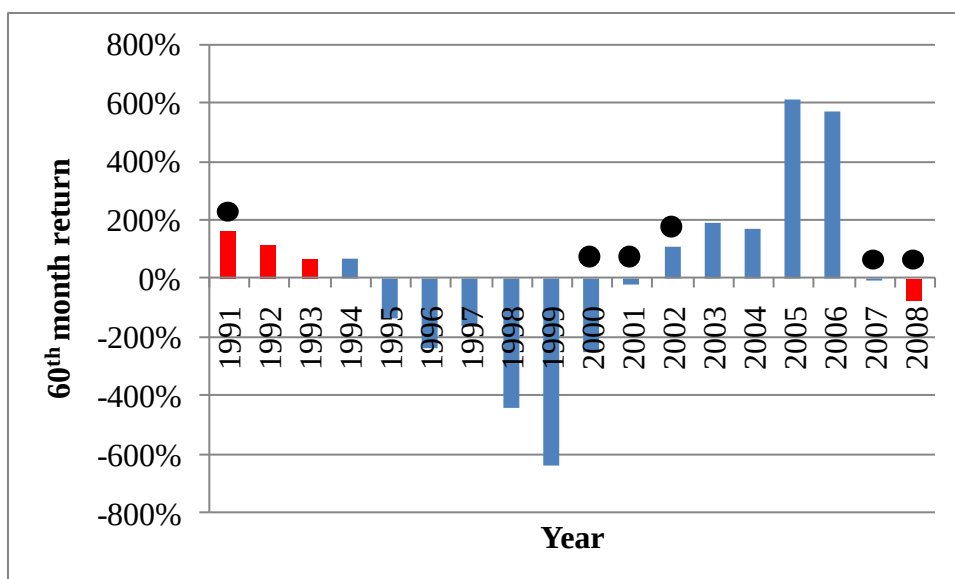


Figure 6: Equally weighted loser-winner portfolio 60th month returns. The stocks are ranked each year according to their past performance and the top ten percent form the winner portfolio and the bottom ten percent form the loser portfolio. The loser-winner portfolio is constructed by taking a long position in the loser portfolio and a short position in the winner portfolio. The bars in the chart show the average equally weighted 60th month returns of eighteen portfolio rankings that were formed over the period 1987 to 2004. The red bars show years of negative real GDP growth (SCB). The black dots show years of negative return on equities (Affärsvärldens generalindex).

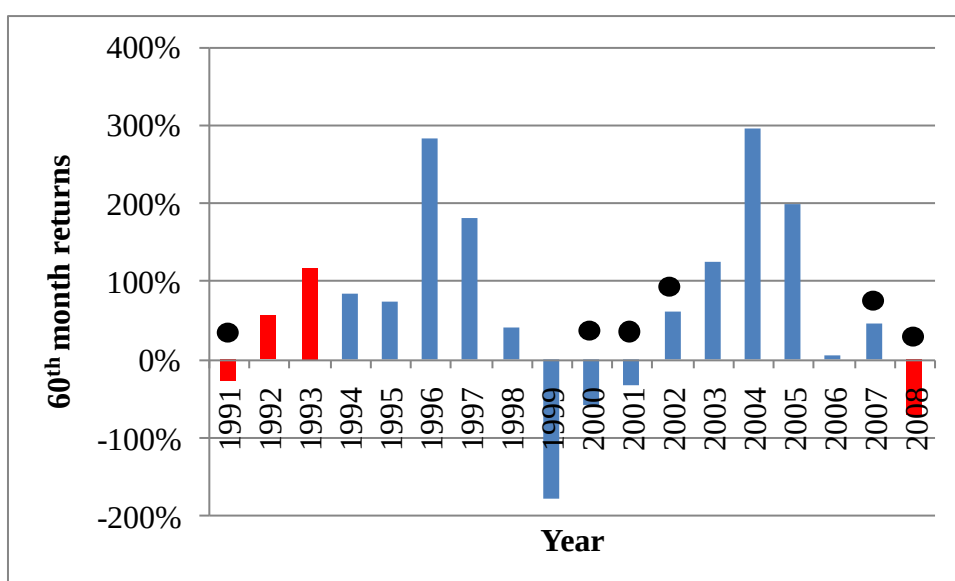


Figure 7: Equally weighted 9-2 portfolio 60th month returns. The stocks are ranked each year according to their past performance and the top 10 to 20 percent form portfolio 2 and the bottom 10 to 20 percent form portfolio 9. The 9-2 portfolio is constructed by taking a long position in portfolio 9 and a short position in portfolio 2. The bars in the chart show the average equally weighted 60th month returns of eighteen portfolio rankings that were formed over the period 1987 to 2004. The red bars show years of negative real GDP growth (SCB). The black dots show years of negative return on equities (Affärsvärldens generalindex).

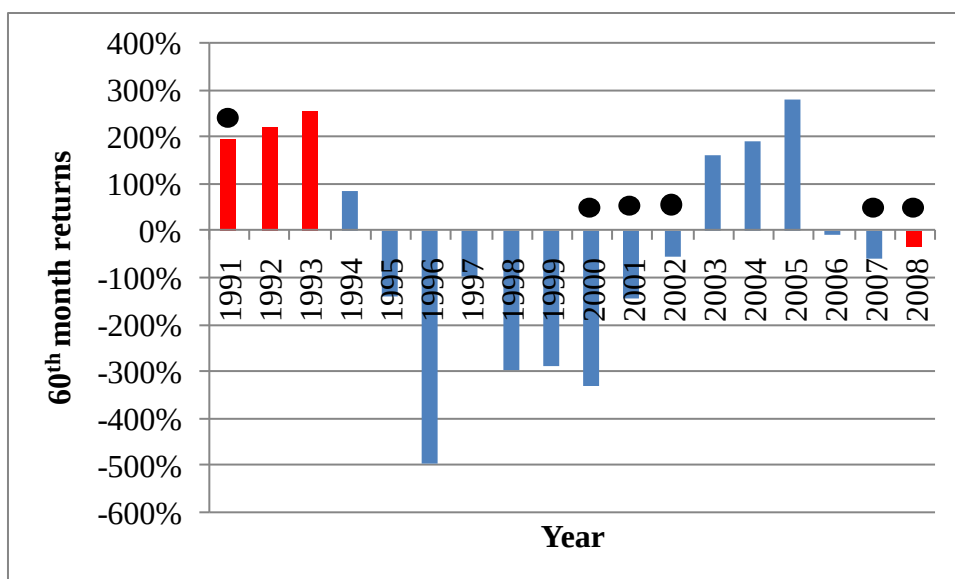


Figure 8: Value weighted loser-winner portfolio 60th month returns. The stocks are ranked each year according to their past performance and the top ten percent form the winner portfolio and the bottom ten percent form the loser portfolio. The loser-winner portfolio is constructed by taking a long position in the loser portfolio and a short position in the winner portfolio. The bars in the chart show the average equally weighted 60th month returns of eighteen portfolio rankings that were formed over the period 1987 to 2004. The red bars show years of negative real GDP growth (SCB). The black dots show years of negative return on equities (Affärsvärldens generalindex).

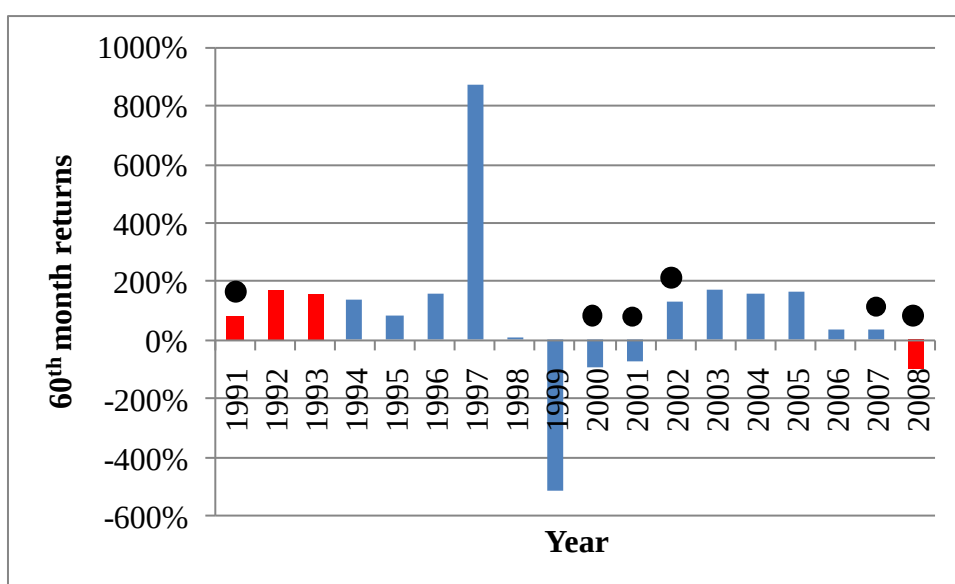


Figure 9: Value weighted 9-2 portfolio 60th month returns. The stocks are ranked each year according to their past performance and the top 10 to 20 percent form portfolio 2 and the bottom 10 to 20 percent form portfolio 9. The 9-2 portfolio is constructed by taking a long position in portfolio 9 and a short position in portfolio 2. The bars in the chart show the average equally weighted 60th month returns of eighteen portfolio rankings that were formed over the period 1987 to 2004. The red bars show years of negative real GDP growth (SCB). The black dots show years of negative return on equities (Affärsvärldens generalindex).

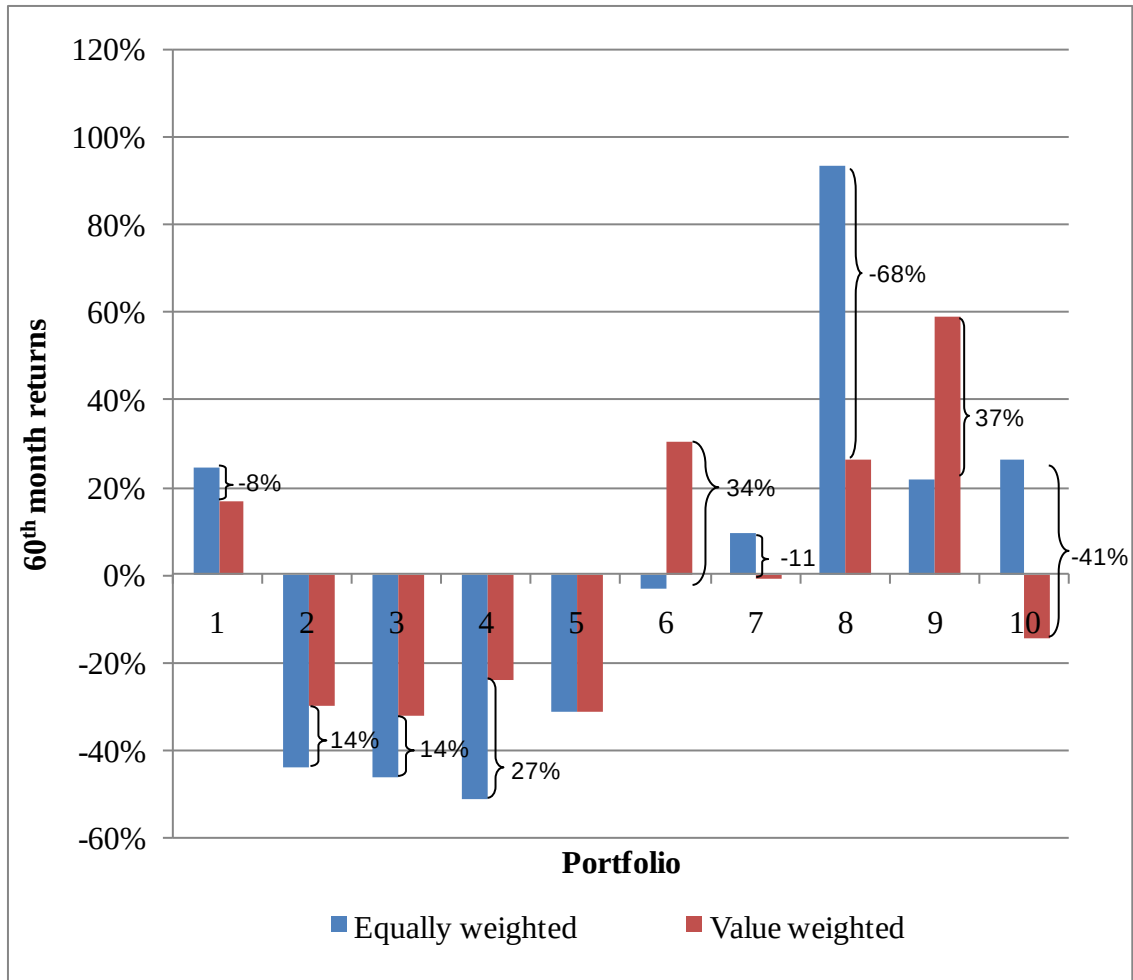


Figure 10: Comparing 60th month buy and hold returns of equally and value weighted portfolios. The stocks are ranked each year according to their past performance and divided into decile portfolios. Each decile portfolio bar in the chart is an average of eighteen portfolio formations over the period 1987 to 2004. The percentages in the brackets are the equally weighted portfolios' 60th month buy and hold returns minus the value weighted portfolios' 60th month buy and hold returns.

Tables

Table 1: Average equally weighted portfolio returns adjusted by the equally weighted market index. The stocks are ranked each year according to their past performance and are assigned to a decile portfolio. The portfolios are held for five years and are partially overlapping. The table below displays the average returns of the eighteen equally weighted portfolio formations over the period 1987 to 2004 for each decile portfolio. The stock returns have been adjusted by an equally weighted market index using all the stocks in our sample. P-values from Student's t-tests are presented in parentheses where the null hypotheses are that the returns are equal to zero.

Decile portfolio	Holding period (months)				
	12	24	36	48	60
1(W)	-0.26% (0.97)	7.97% (0.51)	17.81% (0.42)	27.21% (0.47)	24.54% (0.57)
2	-7.67% (0.11)	-15.52% (0.01)	-23.05% (0.02)	-39.37% (0.00)	-43.87% (0.01)
3	-5.91% (0.21)	-9.70% (0.06)	-19.63% (0.00)	-35.60% (0.00)	-46.53% (0.00)
4	-4.94% (0.25)	-12.09% (0.00)	-20.62% (0.01)	-27.50% (0.01)	-51.19% (0.00)
5	-3.29% (0.13)	-4.56% (0.28)	-2.84% (0.62)	-17.39% (0.08)	-31.44% (0.02)
6	0.25% (0.91)	5.25% (0.39)	-2.53% (0.72)	-7.21% (0.40)	-3.36% (0.79)
7	-0.88% (0.75)	-6.11% (0.32)	-2.65% (0.80)	-0.16% (0.99)	9.62% (0.59)
8	12.64% (0.10)	19.61% (0.12)	34.88% (0.23)	58.64% (0.10)	93.84% (0.05)
9	5.86% (0.39)	5.12% (0.33)	11.97% (0.28)	4.99% (0.76)	21.96% (0.37)
10(L)	4.20% (0.65)	10.02% (0.28)	6.66% (0.64)	36.38% (0.27)	26.44% (0.50)

Table 2: Average value weighted portfolio returns adjusted by the value weighted market index. The stocks are ranked each year according to their past performance and are assigned to a decile portfolio. The portfolios are held for five years and are partially overlapping. The table below displays the average returns of the eighteen value weighted portfolio formations over the period 1987 to 2004 for each decile portfolio. The stock returns have been adjusted by an equally weighted market index using all the stocks in our sample. P-values from Student's t-tests are presented in parentheses where the null hypotheses are that the returns are equal to zero.

Decile portfolio	Holding period (months)				
	12	24	36	48	60
1(W)	-3.52% (0.75)	-1.63% (0.89)	11.09% (0.65)	26.14% (0.41)	16.96% (0.58)
2	-6.02% (0.38)	-0.29% (0.98)	-11.00% (0.35)	-28.24% (0.01)	-30.14% (0.28)
3	-11.97% (0.04)	-16.61% (0.00)	-23.27% (0.00)	-23.79% (0.03)	-32.05% (0.00)
4	-7.46% (0.24)	-10.40% (0.06)	-16.18% (0.04)	-14.52% (0.22)	-24.06% (0.12)
5	-9.13% (0.09)	-7.90% (0.09)	-5.80% (0.48)	-17.54% (0.18)	-31.18% (0.07)
6	0.59% (0.77)	2.13% (0.71)	4.07% (0.66)	15.77% (0.27)	30.35% (0.16)
7	-4.09% (0.35)	-9.30% (0.23)	-8.43% (0.42)	-19.10% (0.23)	-0.88% (0.96)
8	15.95% (0.01)	24.29% (0.02)	30.02% (0.02)	37.73% (0.07)	26.30% (0.20)
9	29.57% (0.22)	23.40% (0.08)	35.83% (0.10)	44.52% (0.17)	59.18% (0.20)
10(L)	-3.92% (0.63)	-3.68% (0.81)	-16.34% (0.38)	-20.97% (0.22)	-14.47% (0.62)

Table 3: Frequency of positive and negative five year market-adjusted portfolio returns. The stocks are ranked each year according to their past performance and are assigned to a decile portfolio. The portfolios are held for five years. The table below displays the number of occasions when the equally and value weighted portfolios produce either positive or negative average buy and hold returns at the end of the five year period. The percentages below the brackets display how many percent of the time the top and bottom three equally weighted decile portfolios generate positive or negative returns.

Portfolio	1	2	3	4	5	6	7	8	9	10
Positive Returns										
Value Weighted	8	4	2	6	2	13	8	10	10	7
Equally Weighted	9	5	2	1	4	8	8	11	11	8
	30%							56%		
Negative Returns										
Value Weighted	9	13	15	11	15	4	9	7	7	10
Equally Weighted	9	13	16	17	14	10	10	7	7	10
	70%							44%		

Table 4: Average monthly portfolio returns for the worst and best months of the stock market. The average monthly returns of the decile portfolios are compared to the performance of the market index (Affärsvärlden generalindex) in four different categories: the market index's worst performing 30 months (Worst₃₀), the remaining 81 months when the market index earned negative returns (Negative₈₁), the market index's best performing 30 months (Best₃₀) and the remaining 123 months when the market index generated positive returns (Positive₁₂₃). The p-values from the Student's t-test with the null hypothesis of the returns being equal to zero are shown in brackets.

Portfolio	1(W)	2	3	4	5	6	7	8	9	10(L)	Market	L-W
Category												
Worst₃₀	-0.10 (0.00)	-0.09 (0.00)	-0.09 (0.00)	-0.10 (0.00)	-0.10 (0.00)	-0.09 (0.00)	-0.07 (0.00)	-0.08 (0.00)	-0.07 (0.00)	-0.07 (0.00)	-0.11 (0.00)	0.03 (0.03)
Negative₈₁	-0.03 (0.00)	-0.02 (0.00)	-0.02 (0.00)	-0.02 (0.00)	-0.02 (0.00)	-0.02 (0.00)	-0.01 (0.00)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.06)	-0.03 (0.00)	0.01 (0.04)
Positive₁₂₃	0.04 (0.00)	0.04 (0.00)	0.03 (0.00)	0.04 (0.00)	0.04 (0.00)	0.04 (0.00)	0.04 (0.00)	0.04 (0.00)	0.04 (0.00)	0.04 (0.00)	0.04 (0.00)	0.00 (0.66)
Best₃₀	0.12 (0.00)	0.09 (0.00)	0.09 (0.00)	0.09 (0.00)	0.10 (0.00)	0.09 (0.00)	0.08 (0.00)	0.09 (0.00)	0.08 (0.00)	0.07 (0.00)	0.11 (0.00)	-0.04 (0.00)

Table 5: The decile portfolios' average number of stocks during the holding period. The table below shows the average number of shares that remain in each decile portfolio after each year of the holding period.

Months after formation	0	12	24	36	48	60
Decile Portfolio						
1(W)	14.1	13.1	12.0	11.0	10.1	9.5
2	14.3	12.7	12.1	11.0	10.0	9.6
3	14.4	12.6	11.3	10.0	9.5	8.6
4	15.1	13.3	12.6	11.7	10.7	10.1
5	15.1	12.8	11.8	10.8	10.2	9.6
6	15.1	12.2	10.7	9.7	8.9	8.2
7	14.9	12.1	10.3	9.2	7.8	7.0
8	14.6	12.3	10.7	9.3	8.2	7.2
9	14.4	12.3	11.0	9.7	8.8	8.2
10(L)	14.2	11.7	9.9	8.4	7.1	6.1

Table 6: The decile portfolios' average number of deleted stocks during the holding period. The table below shows the average number of stocks that have been deleted in each decile portfolio after each holding period year.

Months after formation	12	24	36	48	60
Decile Portfolio					
1 (W)	1.1	2.1	3.1	4.0	4.6
2	1.4	2.1	3.1	4.1	4.5
3	1.5	2.8	4.2	4.6	5.5
4	0.8	1.5	2.4	3.4	4.0
5	1.3	2.3	3.3	3.9	4.6
6	1.9	3.4	4.4	5.2	5.9
7	2.1	3.8	4.9	6.3	7.1
8	1.8	3.4	4.8	5.9	6.9
9	1.8	3.2	4.4	5.3	5.9
10 (L)	2.4	4.2	5.7	7.0	8.1

Table 7: Average standard deviations of monthly excess returns for the equally weighted decile portfolios.

Holding Period	1987 -1992	1988 -1993	1989 -1994	1990 -1995	1991 -1996	1992 -1997	1993 -1998	1994 -1999	1995 -2000	1996 -2001	1997 -2002	1998 -2003	1999 -2004	2000 -2005	2001 -2006	2002 -2007	2003 -2008	2004 -2009	Average
Portfolio																			
1 (W)	0.07	0.05	0.08	0.11	0.09	0.07	0.06	0.06	0.09	0.11	0.11	0.12	0.12	0.09	0.08	0.05	0.04	0.08	0.08
2	0.07	0.07	0.09	0.09	0.07	0.06	0.06	0.05	0.06	0.05	0.06	0.07	0.07	0.07	0.05	0.05	0.04	0.05	0.06
3	0.08	0.06	0.07	0.09	0.08	0.07	0.06	0.06	0.05	0.07	0.06	0.06	0.05	0.05	0.06	0.05	0.04	0.05	0.06
4	0.08	0.08	0.10	0.09	0.08	0.07	0.06	0.06	0.06	0.06	0.05	0.06	0.07	0.04	0.05	0.05	0.05	0.06	0.06
5	0.07	0.09	0.09	0.07	0.08	0.07	0.06	0.05	0.05	0.06	0.07	0.08	0.06	0.06	0.04	0.06	0.05	0.07	0.07
6	0.07	0.07	0.08	0.09	0.07	0.08	0.07	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.05	0.06	0.06
7	0.08	0.08	0.06	0.07	0.06	0.07	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06
8	0.07	0.08	0.08	0.06	0.08	0.12	0.07	0.06	0.07	0.05	0.06	0.06	0.15	0.21	0.05	0.06	0.10	0.06	0.08
9	0.12	0.06	0.07	0.06	0.08	0.11	0.10	0.06	0.05	0.07	0.07	0.05	0.04	0.05	0.06	0.07	0.08	0.07	0.07
10 (L)	0.07	0.10	0.06	0.08	0.09	0.17	0.14	0.07	0.07	0.10	0.05	0.06	0.06	0.05	0.14	0.29	0.10	0.11	0.10

Table 8: Average standard deviations of monthly excess returns for the value weighted decile portfolios.

Holding Period	1987 -1992	1988 -1993	1989 -1994	1990 -1995	1991 -1996	1992 -1997	1993 -1998	1994 -1999	1995 -2000	1996 -2001	1997 -2002	1998 -2003	1999 -2004	2000 -2005	2001 -2006	2002 -2007	2003 -2008	2004 -2009	Average
Portfolio																			
1 (W)	0.09	0.07	0.09	0.12	0.11	0.08	0.06	0.07	0.06	0.10	0.13	0.09	0.14	0.12	0.11	0.05	0.04	0.05	0.09
2	0.08	0.07	0.09	0.08	0.07	0.07	0.05	0.07	0.09	0.06	0.09	0.15	0.14	0.07	0.06	0.05	0.04	0.06	0.08
3	0.09	0.06	0.14	0.09	0.07	0.07	0.07	0.06	0.07	0.08	0.07	0.07	0.06	0.06	0.06	0.05	0.04	0.07	0.07
4	0.08	0.08	0.10	0.11	0.08	0.09	0.06	0.08	0.06	0.06	0.06	0.07	0.08	0.07	0.07	0.06	0.04	0.06	0.07
5	0.08	0.11	0.09	0.08	0.09	0.08	0.07	0.05	0.06	0.06	0.07	0.10	0.07	0.06	0.05	0.11	0.05	0.08	0.08
6	0.08	0.09	0.10	0.09	0.06	0.10	0.08	0.07	0.07	0.08	0.08	0.08	0.06	0.07	0.08	0.06	0.05	0.06	0.07
7	0.08	0.09	0.08	0.09	0.08	0.11	0.08	0.06	0.06	0.05	0.05	0.14	0.06	0.06	0.05	0.07	0.10	0.08	0.08
8	0.08	0.09	0.08	0.09	0.09	0.12	0.09	0.07	0.06	0.05	0.10	0.07	0.06	0.06	0.06	0.08	0.11	0.10	0.08
9	0.08	0.08	0.10	0.09	0.10	0.13	0.17	0.05	0.05	0.08	0.07	0.07	0.07	0.06	0.07	0.09	0.09	0.08	0.09
10 (L)	0.09	0.12	0.12	0.10	0.09	0.23	0.13	0.06	0.06	0.06	0.08	0.06	0.05	0.07	0.09	0.16	0.12	0.07	0.10

Table 9: Average Sharpe ratios for the equally weighted decile portfolios. The red filling indicates the portfolios with the highest and second highest Sharpe ratios. The blue filling indicates the portfolios with the lowest and second lowest Sharpe ratios. The decile portfolios average Sharpe ratio is found on the far right of the table.

Holding Period	1987 -1992	1988 -1993	1989 -1994	1990 -1995	1991 -1996	1992 -1997	1993 -1998	1994 -1999	1995 -2000	1996 -2001	1997 -2002	1998 -2003	1999 -2004	2000 -2005	2001 -2006	2002 -2007	2003 -2008	2004 -2009	Average
Portfolio																			
1 (W)	0.01	-0.02	0.03	-0.02	0.12	0.29	0.38	0.44	0.39	0.28	0.10	-0.04	-0.02	-0.15	0.01	0.24	0.47	0.15	0.15
2	0.08	-0.07	0.02	-0.03	0.09	0.17	0.36	0.13	0.35	0.24	0.12	0.00	0.10	0.02	0.12	0.33	0.31	0.18	0.14
3	-0.07	-0.09	0.02	0.03	0.03	0.16	0.31	0.14	0.29	0.25	0.10	0.02	0.10	0.12	0.16	0.37	0.44	0.10	0.14
4	0.01	-0.18	-0.03	-0.01	0.02	0.17	0.20	0.14	0.30	0.27	0.15	-0.05	0.07	0.18	0.22	0.42	0.41	0.01	0.13
5	0.03	-0.07	0.03	-0.15	0.10	0.20	0.36	0.04	0.29	0.27	0.07	-0.02	0.19	0.06	0.32	0.25	0.48	0.02	0.14
6	-0.02	0.01	0.03	0.01	0.04	0.25	0.36	0.22	0.22	0.42	0.15	0.04	0.20	0.25	0.29	0.32	0.43	0.07	0.18
7	0.08	-0.09	0.12	0.11	0.03	0.17	0.32	0.25	0.27	0.22	0.14	0.23	0.28	0.23	0.55	0.40	0.34	0.03	0.20
8	0.11	0.12	0.00	-0.06	0.12	0.12	0.41	-0.03	0.35	0.31	0.17	0.06	0.18	0.21	0.28	0.52	0.42	-0.02	0.18
9	0.05	0.02	0.14	0.07	0.15	0.24	0.29	0.17	0.21	0.11	0.06	0.13	0.34	0.47	0.33	0.23	0.21	0.03	0.18
10 (L)	0.19	0.11	0.11	0.04	-0.04	0.11	0.16	-0.04	0.11	0.19	0.09	0.11	0.24	0.22	0.27	0.19	0.23	0.05	0.13

Table 10: Average Sharpe ratios for the value weighted decile portfolios. The red filling indicates the portfolios with the highest and second highest Sharpe ratios. The blue filling indicates the portfolios with the lowest and second lowest Sharpe ratios. The decile portfolios average Sharpe ratio is found on the far right of the table.

Holding Period	1987 -1992	1988 -1993	1989 -1994	1990 -1995	1991 -1996	1992 -1997	1993 -1998	1994 -1999	1995 -2000	1996 -2001	1997 -2002	1998 -2003	1999 -2004	2000 -2005	2001 -2006	2002 -2007	2003 -2008	2004 -2009	Average
Portfolio																			
1 (W)	-0.04	-0.02	0.01	-0.09	0.14	0.31	0.35	0.31	0.38	0.27	0.12	0.06	-0.01	-0.12	-0.05	0.15	0.36	0.12	0.13
2	0.05	-0.05	-0.19	-0.11	0.10	0.01	0.31	0.08	0.37	0.18	0.11	-0.03	0.01	0.00	0.06	0.17	0.24	0.09	0.08
3	-0.02	-0.13	0.05	-0.02	0.00	0.14	0.28	0.15	0.21	0.18	0.02	-0.07	0.02	0.06	0.12	0.26	0.33	0.04	0.09
4	-0.06	-0.21	0.01	0.03	0.02	0.16	0.22	0.09	0.26	0.28	0.09	-0.06	0.08	0.12	0.13	0.28	0.46	-0.06	0.11
5	0.03	-0.01	-0.01	-0.15	0.07	0.17	0.18	0.05	0.22	0.23	0.07	-0.04	0.10	0.07	0.22	0.08	0.44	-0.01	0.10
6	0.01	-0.01	0.01	-0.04	0.09	0.14	0.34	0.21	0.11	0.35	0.09	-0.01	0.14	0.14	0.23	0.35	0.39	0.07	0.15
7	0.07	0.01	0.09	0.08	-0.08	0.06	0.28	-0.03	0.36	0.19	0.16	-0.12	0.18	0.19	0.37	0.27	0.15	-0.05	0.13
8	0.16	0.17	0.07	0.00	0.11	0.09	0.27	-0.01	0.24	0.18	0.13	0.02	0.16	0.17	0.29	0.38	0.17	0.00	0.15
9	0.13	0.14	0.08	0.10	0.15	0.16	0.29	0.11	0.17	0.03	-0.01	0.12	0.21	0.25	0.28	0.16	0.17	-0.16	0.15
10 (L)	0.15	0.16	0.17	0.03	0.02	0.02	0.17	-0.08	0.09	0.03	-0.19	-0.08	0.22	0.18	0.24	0.10	0.13	0.05	0.08

Table 11: CAPM regression results for the equally weighted decile portfolios. The use of partially overlapping portfolios results in 18 portfolio formations for each decile portfolio. One vector of returns for each year of the holding period is formed for each decile portfolio (see section 6.1). The equally weighted decile portfolio returns in excess of the risk-free rate returns are regressed against the market return in excess of the risk-free rate ($r_{p,t} - r_{f,t} = \alpha_p + \beta_p(r_{m,t} - r_{f,t}) + \varepsilon_{p,t}$). Zero-investment portfolios (L-W and 9-2) are formed by taking a long position in the loser portfolio and a short position in the winner portfolio ($r_{L,t} - r_{W,t} = \alpha + \beta(r_{m,t} - r_{f,t}) + \varepsilon_t$). This is analogous for the 9-2 portfolio. The regression coefficients and their p-values are show in the table below.

Holding period year	Decile Portfolio	Alpha	p-value	Beta	p-value
1	1(W)	0.004	0.209	0.881	0.000
1	2	0.000	0.835	0.769	0.000
1	3	0.002	0.397	0.791	0.000
1	4	0.003	0.205	0.769	0.000
1	5	0.002	0.517	0.834	0.000
1	6	0.005	0.087	0.743	0.000
1	7	0.005	0.235	0.696	0.000
1	8	0.011	0.010	0.830	0.000
1	9	0.008	0.103	0.773	0.000
1	10(L)	0.005	0.502	0.928	0.000
1	L-W	0.001	0.916	0.047	0.822
1	9-2	0.008	0.106	0.004	0.970
2	1(W)	0.005	0.206	1.067	0.000
2	2	0.001	0.818	0.773	0.000
2	3	0.004	0.177	0.797	0.000
2	4	0.002	0.497	0.828	0.000
2	5	0.005	0.167	0.799	0.000
2	6	0.009	0.033	0.740	0.000
2	7	0.006	0.063	0.672	0.000
2	8	0.009	0.013	0.834	0.000
2	9	0.011	0.008	0.716	0.000
2	10(L)	0.017	0.088	0.644	0.000
2	L-W	0.013	0.219	-0.424	0.008
2	9-2	0.010	0.036	-0.057	0.617
3	1(W)	0.004	0.193	1.105	0.000
3	2	0.003	0.261	0.877	0.000
3	3	0.004	0.118	0.739	0.000
3	4	0.003	0.325	0.858	0.000
3	5	0.007	0.033	0.880	0.000
3	6	0.005	0.129	0.821	0.000
3	7	0.009	0.027	0.623	0.000
3	8	0.007	0.103	0.686	0.000
3	9	0.010	0.015	0.637	0.000
3	10(L)	0.012	0.079	0.687	0.000
3	L-W	0.008	0.287	-0.418	0.003
3	9-2	0.007	0.058	-0.240	0.004
4	1(W)	0.006	0.194	1.165	0.000
4	2	0.006	0.022	0.839	0.000
4	3	0.002	0.556	0.790	0.000
4	4	0.005	0.128	0.908	0.000
4	5	0.003	0.175	0.947	0.000
4	6	0.006	0.014	0.797	0.000
4	7	0.011	0.001	0.640	0.000
4	8	0.016	0.025	0.765	0.000
4	9	0.008	0.032	0.645	0.000
4	10(L)	0.017	0.007	0.536	0.000
4	L-W	0.011	0.155	-0.629	0.000
4	9-2	0.002	0.540	-0.195	0.024
5	1(W)	0.006	0.115	1.121	0.000
5	2	0.008	0.005	0.845	0.000
5	3	0.007	0.017	0.882	0.000
5	4	0.000	0.958	0.955	0.000
5	5	0.000	0.881	0.912	0.000
5	6	0.007	0.007	0.779	0.000
5	7	0.010	0.009	0.760	0.000
5	8	0.014	0.050	0.799	0.000
5	9	0.009	0.054	0.667	0.000
5	10(L)	0.003	0.606	0.797	0.000
5	L-W	-0.004	0.585	-0.325	0.141
5	9-2	0.001	0.861	-0.178	0.066

Table 12: CAPM regression results for the value weighted decile portfolios. The use of partially overlapping portfolios results in 18 portfolio formations for each decile portfolio. One vector of returns for each year of the holding period is formed for each decile portfolio (see section 6.1). The value weighted decile portfolio returns in excess of the risk-free rate returns are regressed against the market return in excess of the risk-free rate ($r_{p,t} - r_{f,t} = \alpha_p + \beta_p(r_{m,t} - r_{f,t}) + \varepsilon_{p,t}$). Zero-investment portfolios (L-W and 9-2) are formed by taking a long position in the loser portfolio and a short position in the winner portfolio ($r_{L,t} - r_{W,t} = \alpha + \beta(r_{m,t} - r_{f,t}) + \varepsilon_t$). This is analogous for the 9-2 portfolio. The regression coefficients and their p-values are show in the table below.

Holding period year	Decile Portfolio	Alpha	p-value	Beta	p-value
1	1(W)	0.003	0.563	0.573	0.000
1	2	0.005	0.143	0.402	0.001
1	3	0.000	0.925	0.630	0.000
1	4	0.004	0.179	0.547	0.001
1	5	0.001	0.905	0.631	0.000
1	6	0.008	0.037	0.560	0.002
1	7	0.004	0.432	0.575	0.000
1	8	0.017	0.001	0.582	0.000
1	9	0.016	0.057	0.608	0.000
1	10(L)	-0.003	0.757	0.821	0.000
1	L-W	-0.006	0.570	0.248	0.052
1	9-2	0.011	0.210	0.206	0.050
2	1(W)	-0.001	0.705	1.255	0.000
2	2	0.003	0.502	0.879	0.000
2	3	0.002	0.561	0.859	0.000
2	4	0.001	0.767	0.942	0.000
2	5	0.004	0.406	0.912	0.000
2	6	0.006	0.127	0.889	0.000
2	7	0.003	0.644	0.857	0.000
2	8	0.009	0.049	0.820	0.000
2	9	0.010	0.037	0.873	0.000
2	10(L)	0.014	0.103	0.671	0.000
2	L-W	0.015	0.127	-0.583	0.000
2	9-2	0.006	0.401	-0.007	0.978
3	1(W)	0.000	0.919	1.286	0.000
3	2	-0.003	0.304	1.047	0.000
3	3	0.000	0.875	0.782	0.000
3	4	0.001	0.799	1.016	0.000
3	5	0.006	0.090	0.933	0.000
3	6	0.003	0.369	0.912	0.000
3	7	0.005	0.238	0.789	0.000
3	8	0.004	0.352	0.819	0.000
3	9	0.006	0.186	0.727	0.000
3	10(L)	-0.001	0.918	0.750	0.000
3	L-W	0.000	0.974	-0.536	0.001
3	9-2	0.009	0.136	-0.320	0.106
4	1(W)	0.007	0.057	1.221	0.000
4	2	-0.004	0.279	1.105	0.000
4	3	0.000	0.977	0.930	0.000
4	4	0.005	0.142	0.943	0.000
4	5	-0.001	0.735	0.968	0.000
4	6	0.005	0.172	0.938	0.000
4	7	-0.001	0.887	0.564	0.000
4	8	0.004	0.382	0.779	0.000
4	9	0.003	0.578	0.791	0.000
4	10(L)	0.008	0.117	0.678	0.000
4	L-W	0.001	0.885	-0.544	0.009
4	9-2	0.007	0.298	-0.314	0.114
5	1(W)	0.005	0.127	1.180	0.000
5	2	0.000	0.986	1.067	0.000
5	3	0.008	0.104	0.999	0.000
5	4	-0.001	0.882	1.012	0.000
5	5	-0.001	0.815	1.008	0.000
5	6	0.009	0.000	0.933	0.000
5	7	0.010	0.022	0.742	0.000
5	8	0.002	0.561	0.851	0.000
5	9	0.005	0.316	0.803	0.000
5	10(L)	0.005	0.381	0.771	0.000
5	L-W	-0.001	0.895	-0.409	0.078
5	9-2	0.005	0.540	-0.264	0.147

Table 13: Fama French Three Factor Model regression results for the equally weighted decile portfolios. The use of partially overlapping portfolios results in 18 portfolio formations for each decile portfolio. One vector of returns for each year of the holding period is formed for each decile portfolio (see section 6.1). The equally weighted decile portfolio returns in excess of the risk-free rate returns are regressed against the market return in excess of the risk-free rate, the SMB factor and the HML factor ($r_{p,t} - r_{f,t} = \alpha_p + \beta_p(r_{m,t} - r_{f,t}) + s_p(SMB) + h_p(HML) + \varepsilon_{p,t}$). Zero-investment portfolios (L-W and 9-2) are formed by taking a long position in the loser portfolio and a short position in the winner portfolio ($r_{L,t} - r_{W,t} = \alpha + \beta(r_{m,t} - r_{f,t}) + s(SMB) + h(HML) + \varepsilon_t$). This is analogous for the 9-2 portfolio. The regression coefficients and their p-values are shown in the table below.

Holding period year	Decile Portfolio	Alpha	p-value	Beta	p-value	SMB	p-value	HML	p-value
1	1(W)	0.004	0.179	0.921	0.000	0.075	0.177	0.253	0.005
1	2	0.000	0.874	0.746	0.000	0.011	0.895	-0.035	0.560
1	3	0.003	0.370	0.768	0.000	0.101	0.174	-0.130	0.001
1	4	0.004	0.074	0.739	0.000	0.066	0.340	-0.142	0.001
1	5	0.003	0.244	0.825	0.000	0.135	0.005	-0.236	0.000
1	6	0.006	0.047	0.710	0.000	0.148	0.003	-0.198	0.001
1	7	0.006	0.147	0.660	0.000	0.133	0.142	-0.159	0.002
1	8	0.013	0.004	0.832	0.000	0.381	0.024	-0.280	0.000
1	9	0.010	0.067	0.790	0.000	0.636	0.000	-0.244	0.001
1	10(L)	0.008	0.270	0.983	0.000	0.982	0.000	-0.393	0.000
1	L-W	0.004	0.522	0.062	0.693	0.906	0.000	-0.646	0.000
1	9-2	0.009	0.059	0.044	0.614	0.624	0.000	-0.210	0.029
2	1(W)	0.004	0.193	1.070	0.000	0.188	0.047	0.214	0.061
2	2	0.000	0.900	0.773	0.000	0.060	0.423	-0.107	0.113
2	3	0.004	0.153	0.796	0.000	0.081	0.202	-0.047	0.446
2	4	0.003	0.291	0.833	0.000	0.036	0.614	-0.177	0.000
2	5	0.006	0.129	0.792	0.000	0.107	0.086	-0.077	0.144
2	6	0.010	0.005	0.741	0.000	0.068	0.415	-0.249	0.000
2	7	0.007	0.013	0.671	0.000	0.174	0.073	-0.225	0.001
2	8	0.010	0.006	0.826	0.000	0.228	0.133	-0.132	0.032
2	9	0.012	0.001	0.718	0.000	0.283	0.003	-0.249	0.000
2	10(L)	0.022	0.076	0.627	0.000	1.024	0.178	-0.197	0.100
2	L-W	0.017	0.148	-0.443	0.006	0.836	0.273	-0.412	0.024
2	9-2	0.012	0.005	-0.055	0.609	0.223	0.076	-0.141	0.209
3	1(W)	0.004	0.135	1.094	0.000	0.158	0.108	0.252	0.066
3	2	0.004	0.102	0.878	0.000	0.162	0.035	-0.129	0.043
3	3	0.004	0.044	0.741	0.000	0.095	0.145	-0.106	0.046
3	4	0.004	0.122	0.864	0.000	0.050	0.408	-0.191	0.000
3	5	0.008	0.012	0.884	0.000	0.031	0.635	-0.137	0.049
3	6	0.006	0.034	0.828	0.000	0.102	0.107	-0.256	0.000
3	7	0.009	0.010	0.626	0.000	0.025	0.767	-0.166	0.018
3	8	0.008	0.055	0.686	0.000	0.187	0.026	-0.170	0.002
3	9	0.011	0.004	0.635	0.000	0.186	0.060	-0.111	0.076
3	10(L)	0.014	0.062	0.670	0.000	0.610	0.043	-0.131	0.017
3	L-W	0.010	0.171	-0.424	0.002	0.452	0.140	-0.384	0.016
3	9-2	0.007	0.050	-0.244	0.003	0.024	0.869	0.018	0.760
4	1(W)	0.004	0.229	1.154	0.000	0.071	0.435	0.327	0.042
4	2	0.007	0.003	0.841	0.000	0.113	0.273	-0.146	0.006
4	3	0.002	0.461	0.788	0.000	0.131	0.218	-0.017	0.746
4	4	0.006	0.044	0.911	0.000	0.113	0.159	-0.203	0.010
4	5	0.004	0.063	0.951	0.000	-0.012	0.785	-0.121	0.014
4	6	0.008	0.002	0.799	0.000	0.116	0.153	-0.185	0.003
4	7	0.013	0.000	0.643	0.000	0.123	0.126	-0.202	0.000
4	8	0.018	0.037	0.756	0.000	0.656	0.229	-0.159	0.116
4	9	0.008	0.028	0.645	0.000	-0.006	0.950	-0.029	0.672
4	10(L)	0.018	0.005	0.528	0.000	0.276	0.003	0.053	0.657
4	L-W	0.013	0.081	-0.626	0.000	0.206	0.146	-0.274	0.004
4	9-2	0.001	0.739	-0.195	0.010	-0.119	0.460	0.118	0.037
5	1(W)	0.005	0.132	1.110	0.000	0.124	0.345	0.362	0.020
5	2	0.010	0.002	0.851	0.000	0.190	0.160	-0.124	0.034
5	3	0.008	0.002	0.888	0.000	0.064	0.391	-0.166	0.003
5	4	0.001	0.606	0.963	0.000	0.140	0.154	-0.180	0.014
5	5	0.001	0.522	0.918	0.000	0.036	0.461	-0.171	0.005
5	6	0.008	0.001	0.785	0.000	0.063	0.359	-0.145	0.000
5	7	0.011	0.003	0.766	0.000	0.089	0.528	-0.151	0.004
5	8	0.016	0.049	0.805	0.000	0.544	0.099	-0.071	0.305
5	9	0.010	0.060	0.667	0.000	0.161	0.259	0.051	0.459
5	10(L)	0.005	0.382	0.805	0.000	0.282	0.003	-0.196	0.032
5	L-W	0.000	0.989	-0.304	0.095	0.158	0.396	-0.558	0.000
5	9-2	0.000	0.976	-0.184	0.019	-0.030	0.886	0.174	0.009

Table 14: The Fama French Three Factor Model regression results for the value weighted decile portfolios. The use of partially overlapping portfolios results in 18 portfolio formations for each decile portfolio. One vector of returns for each year of the holding period is formed for each decile portfolio (see section 6.1). The value weighted decile portfolio returns in excess of the risk-free rate returns are regressed against the market return in excess of the risk-free rate, the SMB factor and the HML factor ($r_{p,t} - r_{f,t} = \alpha_p + \beta_p(r_{m,t} - r_{f,t}) + s_p(SMB) + h_p(HML) + \varepsilon_{p,t}$). Zero-investment portfolios (L-W and 9-2) are formed by taking a long position in the loser portfolio and a short position in the winner portfolio ($r_{L,t} - r_{W,t} = \alpha + \beta(r_{m,t} - r_{f,t}) + s(SMB) + h(HML) + \varepsilon_t$). This is analogous for the 9-2 portfolio. The regression coefficients and their p-values are shown in the table below.

Holding period year	Decile Portfolio	Alpha	p-value	Beta	p-value	SMB	p-value	HML	p-value
1	1(W)	0.005	0.437	0.496	0.001	0.223	0.103	0.102	0.562
1	2	0.006	0.164	0.314	0.005	0.183	0.181	-0.070	0.391
1	3	0.000	0.893	0.565	0.000	-0.074	0.284	-0.180	0.010
1	4	0.005	0.103	0.506	0.003	0.031	0.812	-0.241	0.025
1	5	0.002	0.753	0.560	0.000	0.283	0.008	-0.265	0.002
1	6	0.010	0.010	0.503	0.004	0.171	0.264	-0.357	0.002
1	7	0.005	0.337	0.501	0.001	0.092	0.552	-0.278	0.017
1	8	0.020	0.001	0.543	0.001	0.411	0.015	-0.348	0.001
1	9	0.019	0.048	0.581	0.000	0.221	0.270	-0.409	0.023
1	10(L)	-0.003	0.743	0.775	0.000	0.549	0.064	-0.322	0.063
1	L-W	-0.007	0.438	0.279	0.015	0.327	0.315	-0.424	0.004
1	9-2	0.012	0.201	0.267	0.016	0.038	0.860	-0.339	0.022
2	1(W)	-0.001	0.843	1.252	0.000	0.155	0.057	-0.017	0.753
2	2	0.002	0.662	0.881	0.000	-0.227	0.207	0.174	0.279
2	3	0.003	0.352	0.862	0.000	-0.002	0.974	-0.167	0.019
2	4	0.002	0.547	0.949	0.000	-0.018	0.867	-0.264	0.000
2	5	0.005	0.287	0.908	0.000	0.040	0.647	-0.129	0.049
2	6	0.007	0.035	0.894	0.000	-0.102	0.415	-0.262	0.002
2	7	0.003	0.495	0.856	0.000	0.101	0.437	-0.262	0.005
2	8	0.009	0.040	0.827	0.000	-0.105	0.377	-0.120	0.102
2	9	0.011	0.007	0.866	0.000	0.360	0.000	-0.390	0.000
2	10(L)	0.016	0.056	0.649	0.000	0.680	0.053	-0.177	0.021
2	L-W	0.017	0.099	-0.603	0.000	0.525	0.163	-0.160	0.124
2	9-2	0.010	0.116	-0.016	0.930	0.587	0.006	-0.564	0.011
3	1(W)	0.001	0.816	1.277	0.000	0.355	0.002	0.022	0.693
3	2	-0.004	0.228	1.043	0.000	0.006	0.924	0.076	0.281
3	3	0.000	0.836	0.786	0.000	-0.083	0.308	-0.098	0.192
3	4	0.002	0.499	1.027	0.000	-0.074	0.309	-0.240	0.000
3	5	0.006	0.069	0.942	0.000	-0.182	0.003	-0.129	0.046
3	6	0.005	0.130	0.924	0.000	0.000	0.998	-0.320	0.000
3	7	0.006	0.155	0.793	0.000	0.006	0.965	-0.157	0.037
3	8	0.004	0.253	0.822	0.000	0.014	0.887	-0.178	0.016
3	9	0.008	0.087	0.726	0.000	0.275	0.075	-0.210	0.006
3	10(L)	0.001	0.814	0.746	0.000	0.364	0.006	-0.073	0.365
3	L-W	0.001	0.931	-0.530	0.001	0.009	0.946	-0.095	0.409
3	9-2	0.011	0.058	-0.318	0.069	0.269	0.123	-0.285	0.027
4	1(W)	0.008	0.032	1.218	0.000	0.146	0.098	0.013	0.903
4	2	-0.004	0.275	1.110	0.000	-0.236	0.095	0.007	0.952
4	3	0.001	0.740	0.933	0.000	0.103	0.307	-0.186	0.035
4	4	0.007	0.031	0.950	0.000	0.052	0.700	-0.305	0.000
4	5	-0.001	0.680	0.975	0.000	-0.176	0.006	-0.107	0.070
4	6	0.006	0.084	0.942	0.000	0.052	0.618	-0.156	0.081
4	7	0.001	0.729	0.569	0.000	0.131	0.251	-0.303	0.001
4	8	0.004	0.308	0.781	0.000	0.006	0.957	-0.061	0.478
4	9	0.003	0.570	0.793	0.000	-0.025	0.797	-0.030	0.664
4	10(L)	0.010	0.062	0.678	0.000	0.215	0.109	-0.177	0.129
4	L-W	0.002	0.761	-0.540	0.005	0.069	0.704	-0.190	0.271
4	9-2	0.008	0.272	-0.317	0.117	0.211	0.085	-0.038	0.817
5	1(W)	0.005	0.176	1.175	0.000	0.033	0.675	0.150	0.082
5	2	0.000	0.954	1.066	0.000	-0.201	0.521	-0.025	0.835
5	3	0.009	0.060	1.006	0.000	0.021	0.811	-0.214	0.015
5	4	0.001	0.761	1.021	0.000	0.001	0.996	-0.269	0.000
5	5	0.001	0.788	1.018	0.000	-0.070	0.457	-0.286	0.000
5	6	0.010	0.000	0.935	0.000	-0.162	0.015	-0.106	0.177
5	7	0.010	0.007	0.747	0.000	-0.039	0.702	-0.168	0.011
5	8	0.003	0.387	0.856	0.000	0.115	0.296	-0.104	0.178
5	9	0.006	0.228	0.807	0.000	0.123	0.408	-0.084	0.197
5	10(L)	0.007	0.215	0.782	0.000	0.297	0.076	-0.254	0.059
5	L-W	0.002	0.664	-0.393	0.053	0.263	0.152	-0.404	0.036
5	9-2	0.006	0.476	-0.259	0.173	0.324	0.421	-0.059	0.722

Appendix A: Robustness Tests – Equally Weighted CAPM

Residuals with Zero Mean

The first underlying assumption of the OLS regression model is that the regression residuals have an expected value, or a mean, equal to zero. The residuals from the 50 equally weighted CAPM regressions were tested using a Student's t-test with the null hypothesis of the residuals being equal to zero. The resulting t-values are presented in the table below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.000	0.000	0.000	-0.000	0.000
2	-0.000	-0.000	-0.000	0.000	-0.000
3	-0.000	0.000	0.000	0.000	-0.000
4	0.000	0.000	0.000	-0.000	-0.000
5	-0.000	-0.000	0.000	0.000	0.000
6	-0.000	-0.000	-0.000	0.000	-0.000
7	0.000	0.000	0.000	0.000	-0.000
8	0.000	-0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	-0.000
10	0.000	0.000	0.000	-0.000	0.000

The critical values at the five percent level are 1.97 and -1.97 which means that the null hypothesis of an error term with a mean equal to zero cannot be rejected in any of the 50 cases. Therefore, we have no reason to assume that the error term has a mean different from zero.

Test for Series Stationarity

In order to test whether the return series are non stationary, we perform an augmented Dickey-Fuller test since it does not require the assumption of the error terms being independently and identically distributed to be fulfilled (Gujarati, 2003). The null hypothesis is that there is a presence of a unit root. The model estimated is the following.

$$\Delta y_{p,t} = \alpha + \delta y_{p,t-1} + \sum_{i=1}^n \beta_i \Delta y_{p,t-i} + \varepsilon_t$$

Where y_p is the excess return of portfolio p , ($p = 1, 2, \dots, 10$). As stated in Wooldridge (2009) there are no general rules to follow when determining the number of lags to include in the above equation. The number of lags to include involves a tradeoff between controlling for serial correlation in $\Delta y_{p,t}$ and the power of the test. Wooldridge (2009) suggests that the number of lags included can be determined by the frequency of the used data. Therefore, since monthly return data is used for all portfolios used, twelve lags will be included in the equation above. The resulting MacKinnon approximate p-values are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.003	0.006	0.001	0.001	0.001
2	0.018	0.015	0.002	0.002	0.002
3	0.007	0.013	0.030	0.002	0.014
4	0.016	0.015	0.014	0.012	0.087
5	0.002	0.035	0.006	0.006	0.015
6	0.013	0.003	0.011	0.009	0.157
7	0.002	0.001	0.014	0.013	0.072
8	0.001	0.001	0.037	0.003	0.001
9	0.001	0.002	0.003	0.005	0.024
10	0.004	0.000	0.001	0.001	0.004

The results suggest that there is evidence of non-stationarity in three of the fifty return series at the five percent significance level. At the 10 percent significance level, the results suggest that there is evidence of non-stationarity in one of the fifty return series.

As an alternative to the augmented Dickey-Fuller test, we use the Phillips-Perron Unit Root test. The Phillips-Perron test uses nonparametric statistical methods to take care of autocorrelation in the error term without adding lagged difference terms as opposed to the augmented Dickey-Fuller test (Gujarati, 2003). The null hypothesis is that there is a presence of a unit root. Using the same reasoning as in the augmented Dickey-Fuller test, 12 lags are included in the Phillips-Perron regressions as well. The resulting MacKinnon approximate p-values are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000

The results from the Phillips-Perron unit root test suggest that there is not strong evidence against the null hypothesis of there being a unit root. Therefore, no measures to adjust any of the series for non-stationarity will be taken.

Test for Autocorrelation in the Error Terms

To test for autocorrelation in the error terms or more specifically, AR(1) autocorrelation, Durbin's alternative test statistic is computed for each of the 50 regression residuals. An advantage with this test compared to calculating the Durbin-Watson d-statistic is that Durbin's alternative test does not require all regressors to be strictly exogenous. The resulting p-values from the test, under the null hypothesis of no autocorrelation in the error term, are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.001	0.033	0.048	0.000	0.255
2	0.860	0.287	0.369	0.052	0.064
3	0.931	0.099	0.058	0.449	0.887
4	0.443	0.974	0.390	0.260	0.240
5	0.762	0.002	0.819	0.961	0.673
6	0.001	0.001	0.413	0.145	0.718
7	0.000	0.092	0.017	0.078	0.817
8	0.070	0.656	0.052	0.346	0.985
9	0.010	0.891	0.305	0.917	0.813
10	0.632	0.488	0.403	0.160	0.045

There is evidence that there exists first order autocorrelation in 39 out of 50 error terms at the five percent level. Durbin's alternative test showed similar results using 12 lags, indicating autocorrelation of the twelfth order.

Test for Homoskedastic Error Terms

In order to test for the error terms being homoskedastic, White's test for heteroskedasticity is performed because it does not rely on the assumption of normally distributed error terms. The null hypothesis is that the error term is homoskedastic and the resulting p-values are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.000	0.005	0.001	0.000	0.000
2	0.083	0.002	0.380	0.001	0.010
3	0.031	0.000	0.000	0.001	0.475
4	0.000	0.000	0.000	0.000	0.007
5	0.139	0.015	0.001	0.000	0.018
6	0.000	0.024	0.001	0.001	0.007
7	0.021	0.002	0.170	0.183	0.001
8	0.657	0.055	0.029	0.742	0.714
9	0.446	0.086	0.458	0.533	0.594
10	0.129	0.695	0.538	0.205	0.000

The null hypothesis of a homoskedastic error term can be rejected in 19 of the 50 cases at the five percent level. These results suggest that there is evidence that 19 out of 50 error terms are heteroskedastic.

In addition to the White's test, we test for autoregressive conditional heteroskedasticity in the error terms by performing an ARCH(1) test. The null hypothesis is that there is no ARCH(1) effect in the error term. The obtained p-values are presented in the table below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.000	0.000	0.000	0.000	0.001
2	0.207	0.470	0.826	0.840	0.635
3	0.486	0.559	0.728	0.213	0.324
4	0.015	0.003	0.145	0.000	0.016
5	0.273	0.473	0.534	0.150	0.010
6	0.009	0.000	0.289	0.352	0.617
7	0.892	0.994	0.180	0.538	0.044
8	0.923	0.916	0.049	0.959	0.988
9	0.001	0.452	0.753	0.466	0.090
10	0.674	0.966	0.990	0.305	0.964

The null hypothesis of no ARCH(1) effect in the error term can be rejected in 13 out of 50 cases at the five percent level suggesting time varying volatility in these cases.

Test for Normally Distributed Error Terms

In this section the Jarque-Bera test of normality is used in order to test if the error terms are normally distributed. The test is based on the OLS residuals where the skewness and kurtosis measures are computed. The JB test statistic is then computed as below.

$$JB = n \left(\frac{S^2}{6} + \frac{(K - 3)^2}{24} \right)$$

Under the null hypothesis of the test that the error term is normally distributed the JB test statistic should be equal to zero. In large samples, the JB test statistic follows a Chi-square distribution with two degrees of freedom. The resulting p-values for the tests are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.000	0.000	0.000	0.000	0.000
2	0.002	0.000	0.000	0.000	0.000
3	0.482	0.634	0.000	0.000	0.000
4	0.040	0.016	0.115	0.000	0.000
5	0.000	0.260	0.000	0.000	0.000
6	0.003	0.000	0.001	0.000	0.000
7	0.054	0.000	0.298	0.001	0.000
8	0.000	0.000	0.001	0.000	0.000
9	0.000	0.000	0.119	0.825	0.000
10	0.000	0.000	0.000	0.000	0.001

The results suggest that there is evidence of 8 of the 50 error terms being non-normally distributed at the five percent level. The violation of the normality assumption in these cases will not affect the unbiasedness of OLS and the OLS estimators will still be asymptotically normally distributed (Wooldridge, 2009). Therefore, no action is taken to remedy the violation of the normality assumption.

Remedies

The results from the robustness tests suggest that there is evidence of both heteroskedasticity and autocorrelation in the error terms. This will result in the OLS estimators being inefficient in terms of minimum variance, although they will still be linearly unbiased as well as consistent and asymptotically normally distributed (Gujarati, 2003). In order to correct for this, we apply the general treatment of standard errors that are heteroskedasticity and autocorrelation consistent by using the approach of Newey-West as described by Gujarati (2003). This method is strictly valid for large samples and our sample of 216 observations per regression is considered to be large.⁸ Considering the use of monthly data, we correct for autocorrelation in the error term up to the twelfth lag.

⁸ In Gujarati (2003) a sample of 40 observations was considered to be reasonably large in the context of using Newey-West standard errors.

Appendix B: Robustness Tests – Value Weighted CAPM

Residuals with Zero Mean

The t-values from the Student's t-test with the null hypothesis of the residuals being equal to zero are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	-0.000	-0.000	-0.000	0.000	0.000
2	-0.000	-0.000	0.000	-0.000	0.000
3	-0.000	0.000	0.000	-0.000	-0.000
4	0.000	-0.000	0.000	0.000	-0.000
5	0.000	0.000	0.000	0.000	0.000
6	0.000	-0.000	-0.000	-0.000	-0.000
7	-0.000	0.000	0.000	0.000	-0.000
8	0.000	0.000	-0.000	-0.000	-0.000
9	0.000	0.000	-0.000	-0.000	0.000
10	0.000	0.000	0.000	0.000	-0.000

The critical values at the five percent level are 1.97 and -1.97 which means that the null hypothesis of an error term with a mean equal to zero cannot be rejected in any of the 50 cases. Therefore, we have no reason to assume that the error term has a mean different from zero.

Test for Series Stationarity

The MacKinnon approximate p-values from the augmented Dickey-Fuller test are found in the table below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.005	0.024	0.007	0.000	0.003
2	0.066	0.001	0.003	0.007	0.009
3	0.007	0.008	0.069	0.013	0.025
4	0.006	0.033	0.001	0.003	0.204
5	0.003	0.042	0.001	0.005	0.033
6	0.002	0.002	0.013	0.004	0.149
7	0.005	0.002	0.004	0.002	0.012
8	0.002	0.000	0.006	0.002	0.011
9	0.000	0.000	0.009	0.002	0.040
10	0.001	0.000	0.001	0.002	0.003

The results suggest that there is evidence of non-stationarity in four of the fifty return series at the five percent significance level. At the 10 percent significance level, the results suggest that there is evidence of non-stationarity in two of the fifty return series.

As an alternative, the Phillips-Perron unit root test is performed and the resulting p-values are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000

The results from the Phillips-Perron unit root test suggest that there is not strong evidence against the null hypothesis of there being a unit root. Therefore, no measures to adjust any of the series for non-stationarity will be taken.

Test for Autocorrelation in the Error Terms

To test for autocorrelation in the error terms or more specifically, AR(1) autocorrelation, Durbin's alternative test statistic is computed for each of the 50 regression residuals. The resulting p-values from the test, under the null hypothesis of no autocorrelation in the error term, are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.203	0.527	0.675	0.606	0.261
2	0.019	0.003	0.802	0.479	0.592
3	0.283	0.202	0.699	0.016	0.010
4	0.023	0.866	0.719	0.403	0.781
5	0.012	0.073	0.267	0.026	0.975
6	0.246	0.573	0.838	0.104	0.876
7	0.365	0.050	0.320	0.263	0.955
8	0.233	0.079	0.233	0.069	0.970
9	0.001	0.743	0.736	0.429	0.834
10	0.342	0.045	0.919	0.202	0.035

There is evidence of first order autocorrelation in 41 out of 50 error terms at the five percent level. Durbin's alternative test showed similar results using 12 lags, indicating autocorrelation of the twelfth order.

Test for Homoskedastic Error Terms

White's test for heteroskedasticity is performed under the null hypothesis that the error term is homoskedastic. The resulting p-values are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.000	0.000	0.726	0.002	0.000
2	0.014	0.000	0.000	0.000	0.014
3	0.000	0.014	0.388	0.057	0.017
4	0.000	0.001	0.000	0.000	0.059
5	0.005	0.199	0.002	0.011	0.621
6	0.000	0.000	0.000	0.004	0.000
7	0.001	0.526	0.455	0.239	0.014
8	0.004	0.214	0.004	0.015	0.892
9	0.180	0.000	0.045	0.960	0.821
10	0.714	0.728	0.535	0.000	0.000

The null hypothesis of a homoskedastic error term can be rejected in 17 of the 50 cases at the five percent level. These results suggest that there is evidence that 17 out of 50 error terms are heteroskedastic.

In addition to the White's test, we test for autoregressive conditional heteroskedasticity in the error terms by performing an ARCH(1) test. The null hypothesis is that there is no ARCH(1) effect in the error term. The obtained p-values are presented in the table below:

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.000	0.452	0.000	0.001	0.652
2	0.000	0.123	0.787	0.007	0.863
3	0.504	0.688	0.249	0.032	0.000
4	0.029	0.072	0.762	0.003	0.214
5	0.000	0.153	0.294	0.393	0.466
6	0.946	0.021	0.000	0.007	0.109
7	0.657	0.141	0.323	0.875	0.026
8	0.023	0.431	0.602	0.556	0.844
9	0.000	0.154	0.887	0.924	0.808
10	0.736	0.892	0.760	0.508	0.986

The null hypothesis of no ARCH(1) effect in the error term can be rejected in 34 out of 50 cases at the five percent level. This suggests that there is time varying volatility in a quite large number of cases.

Test for Normally Distributed Error Terms

In this section the Jarque-Bera test of normality is used in order to test if the error terms are normally distributed. The resulting p-values for the tests are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.000	0.646	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000
3	0.001	0.029	0.000	0.000	0.000
4	0.000	0.000	0.000	0.012	0.000
5	0.000	0.000	0.000	0.060	0.000
6	0.000	0.000	0.021	0.000	0.000
7	0.000	0.000	0.000	0.000	0.001
8	0.000	0.000	0.000	0.000	0.000
9	0.000	0.001	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000

The results suggest that there is evidence of 2 of the 50 error terms being non-normally distributed at the five percent level. No action is taken to remedy the violation of the normality assumption.

Remedies

In order to correct for heteroskedasticity and autocorrelation in the error terms, we apply the general treatment of standard errors that are heteroskedasticity and autocorrelation consistent by using the approach of Newey-West as described by Gujarati (2003).

Appendix C: Robustness Tests – Equally Weighted Fama-French

Residuals with Zero Mean

The t-values from the Student's t-test with the null hypothesis of the residuals being equal to zero are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	-0.000	-0.000	0.000	0.000	-0.000
2	-0.000	0.000	-0.000	0.000	-0.000
3	-0.000	-0.000	0.000	-0.000	0.000
4	-0.000	-0.000	-0.000	0.000	0.000
5	0.000	-0.000	-0.000	-0.000	0.000
6	0.000	0.000	-0.000	-0.000	-0.000
7	0.000	0.000	-0.000	0.000	0.000
8	-0.000	0.000	0.000	-0.000	-0.000
9	0.000	-0.000	0.000	0.000	-0.000
10	0.000	0.000	0.000	0.000	0.000

The critical values at the five percent level are 1.97 and -1.97 which means that the null hypothesis of an error term with a mean equal to zero cannot be rejected in any of the 50 cases. Therefore, we have no reason to assume that the error term has a mean different from zero.

Test for Series Stationarity

The MacKinnon approximate p-values from the augmented Dickey-Fuller test are found in the table below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.007	0.011	0.001	0.001	0.001
2	0.040	0.032	0.002	0.002	0.002
3	0.015	0.026	0.028	0.002	0.014
4	0.045	0.020	0.011	0.012	0.087
5	0.004	0.046	0.004	0.006	0.015
6	0.025	0.005	0.008	0.009	0.157
7	0.006	0.001	0.013	0.013	0.072
8	0.004	0.002	0.037	0.003	0.001
9	0.002	0.003	0.003	0.005	0.024
10	0.009	0.001	0.001	0.001	0.004

The results suggest that there is evidence of non-stationarity in three of the fifty return series at the five percent significance level. At the 10 percent significance level, the results suggest that there is evidence of non-stationarity in one of the fifty return series.

As an alternative, the Phillips-Perron unit root test is performed and the resulting p-values are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000

The results from the Phillips-Perron unit root test suggest that there is not strong evidence against the null hypothesis of there being a unit root in any of the cases. Therefore, no measures to adjust any of the series for non-stationarity will be taken.

Test for Autocorrelation in the Error Terms

To test for autocorrelation in the error terms or more specifically, AR(1) autocorrelation, Durbin's alternative test statistic is computed for each of the 50 regression residuals. The resulting p-values from the test, under the null hypothesis of no autocorrelation in the error term, are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.129	0.393	0.801	0.266	0.212
2	0.736	0.201	0.584	0.007	0.026
3	0.901	0.085	0.053	0.423	0.829
4	0.668	0.238	0.542	0.140	0.646
5	0.160	0.002	0.744	0.545	0.980
6	0.017	0.124	0.386	0.276	0.943
7	0.013	0.408	0.217	0.291	0.850
8	0.065	0.352	0.113	0.409	0.641
9	0.884	0.483	0.402	0.962	0.851
10	0.283	0.778	0.579	0.266	0.034

There is evidence of first order autocorrelation in 44 out of 50 error terms at the five percent level. Durbin's alternative test showed similar results using 12 lags, indicating autocorrelation of the twelfth order.

Test for Homoskedastic Error Terms

White's test for heteroskedasticity is performed under the null hypothesis that the error term is homoskedastic. The resulting p-values are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.031	0.170	0.000	0.141	0.001
2	0.000	0.000	0.003	0.000	0.000
3	0.292	0.006	0.000	0.000	0.007
4	0.001	0.000	0.357	0.167	0.095
5	0.149	0.001	0.000	0.000	0.045
6	0.000	0.002	0.009	0.000	0.357
7	0.005	0.003	0.276	0.318	0.000
8	0.017	0.156	0.149	0.005	0.047
9	0.838	0.804	0.184	0.832	0.844
10	0.319	0.005	0.022	0.754	0.005

The null hypothesis of a homoskedastic error term can be rejected in 19 of the 50 cases at the five percent level, suggesting that there is evidence that 17 out of 50 error terms are heteroskedastic.

In addition to the White's test, we test for autoregressive conditional heteroskedasticity in the error terms by performing an ARCH(1) test. The null hypothesis is that there is no ARCH(1) effect in the error term. The obtained p-values are presented in the table below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.238	0.347	0.000	0.000	0.374
2	0.100	0.933	0.270	0.820	0.501
3	0.227	0.402	0.934	0.486	0.511
4	0.347	0.002	0.446	0.000	0.438
5	0.797	0.700	0.326	0.096	0.036
6	0.124	0.114	0.744	0.989	0.421
7	0.634	0.543	0.619	0.909	0.140
8	0.946	0.917	0.136	0.942	0.934
9	0.891	0.242	0.406	0.453	0.186
10	0.621	0.941	0.888	0.263	0.675

The null hypothesis of no ARCH(1) effect in the error term can be rejected in 45 out of 50 cases at the five percent level. This suggests that there is time varying volatility in the majority of cases.

Test for Normally Distributed Error Terms

In this section the Jarque-Bera test of normality is used in order to test if the error terms are normally distributed. The resulting p-values for the tests are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.003	0.000	0.006	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000
3	0.550	0.837	0.000	0.000	0.000
4	0.554	0.077	0.200	0.000	0.000
5	0.005	0.622	0.000	0.028	0.000
6	0.001	0.000	0.011	0.005	0.000
7	0.458	0.001	0.236	0.001	0.000
8	0.000	0.000	0.003	0.000	0.000
9	0.000	0.000	0.045	0.845	0.000
10	0.000	0.000	0.000	0.000	0.003

The results suggest that there is evidence of 9 of the 50 error terms being non-normally distributed at the five percent level. The violation of the normality assumption in these cases will not affect the unbiasedness of OLS and the OLS estimators will still be asymptotically normally distributed (Wooldridge, 2009). Therefore, no action is taken to remedy the violation of the normality assumption.

Remedies

In order to correct for heteroskedasticity and autocorrelation in the error terms, we apply the general treatment of standard errors that are heteroskedasticity and autocorrelation consistent by using the approach of Newey-West as described by Gujarati (2003).

Appendix D: Robustness Tests – Value Weighted Fama-French

Residuals with Zero Mean

The t-values from the Student's t-test with the null hypothesis of the residuals being equal to zero are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	-0.000	0.000	0.000	0.000	0.000
2	-0.000	-0.000	-0.000	0.000	0.000
3	0.000	0.000	-0.000	-0.000	-0.000
4	0.000	0.000	0.000	0.000	-0.000
5	0.000	-0.000	-0.000	0.000	-0.000
6	-0.000	-0.000	0.000	-0.000	-0.000
7	0.000	0.000	-0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000
9	-0.000	-0.000	-0.000	-0.000	-0.000
10	-0.000	0.000	0.000	0.000	0.000

The critical values at the five percent level are 1.97 and -1.97 which means that the null hypothesis of an error term with a mean equal to zero cannot be rejected in any of the 50 cases. Therefore, we have no reason to assume that the error term has a mean different from zero.

Test for Series Stationarity

The MacKinnon approximate p-values from the augmented Dickey-Fuller test are found in the table below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.010	0.038	0.007	0.000	0.003
2	0.162	0.002	0.003	0.007	0.009
3	0.019	0.012	0.068	0.013	0.025
4	0.017	0.041	0.001	0.003	0.204
5	0.006	0.055	0.001	0.005	0.033
6	0.005	0.004	0.009	0.004	0.149
7	0.010	0.003	0.003	0.002	0.012
8	0.005	0.000	0.007	0.002	0.011
9	0.001	0.000	0.012	0.002	0.040
10	0.001	0.000	0.001	0.002	0.003

The results suggest that there is evidence of non-stationarity in five of the fifty return series at the five percent significance level. At the 10 percent significance level, the results suggest that there is evidence of non-stationarity in three of the fifty return series.

As an alternative, the Phillips-Perron unit root test is performed and the resulting p-values are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000

The results from the Phillips-Perron unit root test suggest that there is not strong evidence against the null hypothesis of there being a unit root. Therefore, no measures to adjust any of the series for non-stationarity will be taken.

Test for Autocorrelation in the Error Terms

To test for autocorrelation in the error terms or more specifically, AR(1) autocorrelation, Durbin's alternative test statistic is computed for each of the 50 regression residuals. The resulting p-values from the test, under the null hypothesis of no autocorrelation in the error term, are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.294	0.500	0.603	0.905	0.239
2	0.061	0.005	0.924	0.420	0.728
3	0.207	0.642	0.564	0.032	0.041
4	0.005	0.158	0.034	0.273	0.232
5	0.014	0.197	0.492	0.464	0.345
6	0.084	0.264	0.753	0.035	0.776
7	0.492	0.415	0.808	0.170	0.772
8	0.184	0.251	0.172	0.103	0.997
9	0.009	0.834	0.648	0.469	0.604
10	0.097	0.010	0.819	0.312	0.058

There is evidence of first order autocorrelation in 41 out of 50 error terms at the five percent level. Durbin's alternative test showed similar results using 12 lags, indicating autocorrelation of the twelfth order.

Test for Homoskedastic Error Terms

White's test for heteroskedasticity is performed under the null hypothesis that the error term is homoskedastic. The resulting p-values are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.001	0.003	0.725	0.103	0.000
2	0.218	0.000	0.000	0.000	0.000
3	0.017	0.093	0.752	0.625	0.000
4	0.000	0.001	0.000	0.000	0.001
5	0.064	0.253	0.011	0.153	0.996
6	0.002	0.000	0.005	0.000	0.000
7	0.145	0.998	0.485	0.749	0.561
8	0.075	0.764	0.043	0.000	0.996
9	0.031	0.739	0.278	1.000	0.501
10	0.336	0.339	0.926	0.009	0.000

The null hypothesis of a homoskedastic error term can be rejected in 25 of the 50 cases at the five percent level suggesting that there is evidence that 25 out of 50 error terms are heteroskedastic.

In addition to the White's test, we test for autoregressive conditional heteroskedasticity in the error terms by performing an ARCH(1) test. The null hypothesis is that there is no ARCH(1) effect in the error term. The obtained p-values are presented in the table below:

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.001	0.321	0.041	0.002	0.566
2	0.000	0.075	0.790	0.054	0.762
3	0.535	0.486	0.576	0.043	0.000
4	0.064	0.412	0.481	0.206	0.703
5	0.000	0.338	0.717	0.700	0.471
6	0.868	0.794	0.246	0.091	0.222
7	0.902	0.240	0.601	0.897	0.010
8	0.061	0.647	0.908	0.625	0.828
9	0.000	0.122	0.885	0.926	0.851
10	0.528	0.575	0.747	0.486	0.839

The null hypothesis of no ARCH(1) effect in the error term can be rejected in 41 out of 50 cases at the five percent level. This suggests that there is time varying volatility in a quite large number of cases.

Test for Normally Distributed Error Terms

In this section the Jarque-Bera test of normality is used in order to test if the error terms are normally distributed. The resulting p-values for the tests are tabulated below.

Decile portfolio	Holding period year				
	1	2	3	4	5
1	0.000	0.859	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000
3	0.000	0.253	0.000	0.000	0.000
4	0.003	0.000	0.030	0.001	0.000
5	0.000	0.000	0.000	0.039	0.000
6	0.000	0.000	0.573	0.000	0.000
7	0.000	0.000	0.000	0.000	0.002
8	0.000	0.000	0.000	0.000	0.000
9	0.000	0.013	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000

The results suggest that there is evidence of 3 of the 50 error terms being non-normally distributed at the five percent level. The violation of the normality assumption in these cases will not affect the unbiasedness of OLS and the OLS estimators will still be asymptotically normally distributed (Wooldridge, 2009). Therefore, no action is taken to remedy the violation of the normality assumption.

Remedies

In order to correct for heteroskedasticity and autocorrelation in the error terms, we apply the general treatment of standard errors that are heteroskedasticity and autocorrelation consistent by using the approach of Newey-West as described by Gujarati (2003).