Bachelor thesis economie en bedrijfseconomie

# Price momentum: a quantitative analysis of the returns from the price momentum strategy and its relationship with firm size

Name: Marieke de Schepper

Student number: 411826

Supervisor: dr. J. Zenhorst

Date: 13-7-2017

**Abstract**

This research investigates the returns of the price momentum strategy in the US stock market and the relationship between price momentum and firm size. The strategy ranks stocks based on their past returns and buys the winner decile and sells the loser decile. The results show that the strategy does not lead to positive returns since the returns of the loser portfolios are negative. However, some winner portfolios yield positive returns. Secondly, the returns of the winner portfolios decrease when firm size increases. The reason why the price momentum strategy leads to negative returns for the loser portfolios is interesting for further research.

Keywords: price momentum, anomaly, firm size, portfolios, past returns

Erasmus University Rotterdam

Erasmus School of Economics

Section Finance

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## Summary

### Price momentum: a quantitative analysis of the returns from the price momentum strategy and its relationship with firm size

This research examines if price momentum strategies yield positive returns in the US stock market during the years 1990 till 2016 and studies the relationship between price momentum and firm size. Price momentum is one of the anomalies of the CAPM and can be regarded as an argument against the model. Researchers differ in opinion about the source of the anomaly, which makes this thesis theoretical relevant. Besides, investigating investment strategies is relevant for investors and companies.

Former research shows that the CAPM has several anomalies. Jegadeesh and Titman (1993) first noticed the price momentum anomaly. The authors use a strategy that buys stocks that performed well in the past months and short sells stocks that performed badly. All the price momentum strategies yield positive returns in their tests. Hong, Lim and Stein (2000) notice that the returns of the price momentum strategies decrease when the market cap of firms increases.

This thesis uses the monthly stock prices from the database CRSP. The returns of the stocks are calculated as a percentage growth in the last J months. The strategy ranks the returns of the stocks and then buys the decile with the best performing stocks and sells the decile with the worst performing stocks. This portfolio is hold for K months. Both J and K differ from 3, 6, 9, to 12 months. A One-Sample t test has been performed to test if the monthly returns of the sixteen different strategies are significant different from zero. Subsequently, nine groups from small to large market caps have been made. The price momentum strategies have been tested in these nine size groups.

The results show that the price momentum strategy does not lead to positive returns. Both the loser and total portfolios result in negative returns that are significant different from zero. However, eleven of the sixteen winner portfolios earn positive returns that are significant different from zero. The second test shows that these positive returns decrease with firm size. Lastly, the spread between the returns of the winner and loser portfolios becomes smaller in higher deciles.

The results of this research are different from the literature summarized above since the returns of all total portfolios are negative. However, the decreasing size pattern of the winner portfolios is comparable to the research of Hong, Lim and Stein (2000). The different results might be caused by an unknown mistake in the methodology that is used to form the portfolios. The cause of the negative returns from the strategy could be relevant for further research.

In conclusion, price momentum strategies do not lead to positive returns in this paper. However, buying the winner portfolios in the smaller size deciles results in positive returns.

## I. Introduction

When studying Finance at a University, the Capital Asset Pricing Model (CAPM) from Sharpe (1964) and Lintner (1965) is one of the first models students have to understand. The CAPM states that assets that bear a higher risk will lead to higher expected returns. Although the model is still used widely at Universities and in practice, it has been criticized a lot by authors who found anomalies which cannot be explained by the CAPM.

This research investigates one of the anomalies of the CAPM model: price momentum. Jegadeesh and Titman (1993) first examined this anomaly in the United States (US) stock market. Since their paper price momentum has been researched by many authors. It has been tested in other markets than the US and during other periods than Jegadeesh and Titman (1993) studied. The possible sources of the returns from the price momentum strategies are still being debated. The relationship between price momentum and other anomalies, such as firm size, has been studied as well.

Price momentum is a vivid and relevant topic, because earning high yields on stocks is interesting for investors and companies for practical reasons. A reason why the topic is theoretical relevant, is that researchers do not agree on the cause of price momentum. Secondly, the CAPM is still popular and price momentum could be regarded as a justification against the CAPM. For all of these reasons it is relevant to further investigate if price momentum results in positive returns.

To contribute to the existing literature, this research will study the returns from the price momentum strategy in a different time span than Jegadeesh and Titman (1993) did, with the objective to test their research. Furthermore, it will examine if the returns from the momentum strategy differ between size groups of firms, to investigate the relationship between price momentum and firm size. This leads to the following research question:

*'Does using a price momentum strategy lead to positive returns on stocks in the United States during the years 1990 till 2016 and is there a relationship between the returns and the size of the firms?'*

The research question will be answered by testing two hypotheses:

Hypothesis 1: The price momentum strategy will lead to positive returns in the United States in the years 1990 till 2016.

Hypothesis 2: The returns from the price momentum strategy are higher for firms with a smaller market cap and the returns decrease when the market cap increases.

The rest of this research has the following structure: in section II the existing literature on price momentum will be discussed, in section III the data used for this research is described and in section IV the methodology is covered. Afterwards, section V will present, discuss and interpret the results of the hypotheses and in section VI the results and limitations of this study are discussed. Finally in section VII the conclusion for this research is presented and further recommendations are given.

## II. Literature research

In this section the existing literature about price momentum is discussed. The section starts with introducing the CAPM and its limitations. Afterwards, several anomalies are discussed, such as the reversal effect, size effect and earnings/price effect. Next, price momentum is introduced and the possible sources of the anomaly are discussed. Finally, the findings on the relationship between price momentum and firm size are covered.

### The CAPM and its anomalies

The CAPM states that investors will be rewarded with a higher expected return on assets if they hold assets that bear a higher risk. The model's formula equates the relationship between the risk of an asset and the expected returns. The formula consists of an estimation of beta, which measures the risk an asset adds to a well-diversified portfolio. Following the model there are two different kinds of risks: systematic risk and unsystematic risk. It is possible to reduce unsystematic risk by diversifying the portfolio with multiple types of assets. The systematic risk is the risk that cannot be reduced by diversifying the portfolio and has an effect on the expected returns. The CAPM assumes that the asset market is perfect competitive and efficient. This means that all investors can borrow and lend at the same rate and all investors have homogeneous expectations about assets, for example concerning expected return or risk (Berk & Demarzo, 2007). These are unrealistic assumptions, but as Sharpe (1964) describes, it is more important that the implication of the assumptions is realistic rather than the assumptions themselves. Since the assumptions imply an efficient market, Sharpe considers the model to be correct. However, contrarian perceptions will follow later in this section.

Fama and French (1992) state that the relationship between the beta of the CAPM and the average returns is weak and even disappears in the years 1963-1990. Besides, they conclude that book-to-market equity and size can explain the variation in stock returns if the prices of stocks are rationally priced. The authors regressed size and beta on the average returns and found that the slope of size is -0.15% and significant different from zero. The slope of beta in the regression is only 0.46 standard errors away from 0. Since the slope is not significant different from zero, they conclude that beta does not have an effect on average returns.

Even if there would have been a significant relationship between beta and average return, Fama and French (1992) do not consider a positive relationship to be enough proof for the CAPM since the equation should explain all the variation and not a part. In other words, there are factors that explain the expected returns just as good as beta does, or even better. These factors cannot be explained by the CAPM and are

called anomalies. There are more authors, who found anomalies, which they consider as a proof for the misspecification of the CAPM. Banz (1981) describes the size effect that shows that, when adjusted for risk, small New York Stock Exchange (NYSE) firms earn higher returns than large firms. The author states that there is an average excess return on stocks from small firms of 1.52% per month and 19.8% per year, compared to stocks of large firms. Secondly, Basu (1983) points at the earnings/price effect: companies with a high earnings yield earn higher risk adjusted returns than companies with a low earnings yield. For instance, the 20% stocks with the highest earnings yield earned on average 1.38% per month, whereas the lowest 20% earned on average 0.72% per month. This earnings/price effect is also significant after controlling for the size effect.

### The reversal effect and price momentum

De Bondt and Thaler (1985) describe an anomaly using past returns instead of economic variables such as size or earnings yield. They examine two hypotheses: movements in stock prices will lead to movements in the opposite direction on the long term and the bigger the movement is, the bigger the reversing movement is. They indeed notice that portfolios which performed bad in the past have higher returns on the long term than portfolios which performed well in the past. These loser portfolios outperform the winner portfolios after three years by having 25% more earnings on the stocks. Jegadeesh and Titman (1993) question a contrarian strategy which states that well performing portfolios have higher expected returns than bad performing portfolios on the short term. The strategy thus buys past winners and short sells past losers. Their results show that this strategy can lead to abnormal profits in the 12 months after the formation of the portfolio. They perform sixteen tests and except for one, all strategies lead to positive returns that are significant different from zero. For example, the highest return yields 1.49% per month and has a test statistic of 3.74.

The anomaly Jegadeesh and Titman (1993) examined, is called ‘price momentum’ and has been discussed by many researchers. Price momentum is inconsistent with the CAPM since past winners should have lower expected returns because they are less risky. Jegadeesh and Titman (1993) performed several tests on the returns of stocks to test the hypothesis if there is price momentum in the US stock market. In the tests the holding period differs from 3, 6, 9 to 12 months and the stocks are rated based on their past 3, 6, 9 to 12 month returns. Fifteen out of sixteen tests on the returns are significant, meaning that on average the momentum strategy leads to abnormal returns. Their findings on the long run are consistent with those of De Bondt and Thaler (1985): the price momentum reverses and the loser portfolios outperform the winner portfolios on the long run. For instance, Jegadeesh and Titman (1993) noted that 13 months after the formation date, the average return of the price momentum strategy was -0.56% and the returns stayed negative after the thirteenth month.

Both studies show that expected returns can be forecasted with past data and thereby they provide more evidence against the CAPM. The main difference between the price momentum strategy and the reversal strategy is the time span. The former strategy holds stock for 3 to 12 months and the latter holds it for 3 to 5 years. One interpretation of the anomaly is that price momentum may indicate an overreaction effect: information that shows that stocks yield high (low) returns can cause investors to push the prices to a higher (lower) amount than it should be. This overreaction could also explain the 'reversal effect' of de Bondt and Thaler (1985) since the prices need to adjust to their true values on the long term. If the prices need to adjust to their true values, they will reverse. However, this is just one of many possible explanations of price momentum.

### Behavioral models versus rational models

There are two different points of view about the sources that could explain the price momentum anomaly. One source is explained with behavioral models and the other argues that the profits can be seen as a compensation for extra risk and thus assumes the rational model to be correct. Conrad and Kaul (1998) reason that price momentum cannot be predicted with time-series but originates from the variation of expected stock returns over cross-sections of different stocks. This is in line with the rational model that has been of main interest in finance for a long time. However, in recent years some economists took over the idea that men are not rational and they used psychological biases to explain the misspecification of prices. Research shows that people value information incorrect and through this cause a under- or overreaction of prices (Hirshleifer, 2001). Daniel, Hirshleifer and Subrahmanyam (1998) use their overconfidence model to describe how these psychological biases in interpreting information can push prices further up or down and cause price momentum with an overreaction. Another behavioral explanation is that prices adjust too slowly to new events and thus underreact. Hong, Lim and Stein (2000) find results in favor of the hypothesis that if underreacting is the correct cause of momentum, then stocks for which new information reaches investors slowly should encounter a stronger momentum effect.

### Research on price momentum

While the source of price momentum is still being debated, there has been done more research to test the robustness of Jegadeesh and Titman (1993) results. In a subsequent paper Jegadeesh and Titman (2001) show that in the years 1990-1998 the price momentum strategy still results in abnormal profits in the first year after the portfolio has been composed. On average, the best performing decile gains 1.39% more returns than the worst performing decile in the following six months. As in their first paper, the strategy is not profitable on the long run, which is consistent with the predictions of the behavioral models and inconsistent with the rational price models. Nevertheless, the reversal effect only occurs under certain

circumstances, suggesting that it can only be explained by the behavioral models for a part. Besides the US stock market, Rouwenhorst (1998) tested the price momentum strategy in a different sample consisting of 12 European countries. He ascertains price momentum in all 12 countries, concluding that the market is not efficient. The author observed that the returns variate from 0.64% to 1.35% per month. All the returns are significant different from zero. Moreover, Lee and Swaminathan (2000) show that the returns of the price momentum strategies reverse after a certain period and that trading volume can estimate how big the returns will be and after how long they will reverse. For example, low volume loser portfolios reverse faster than high volume loser portfolios. In addition, the profits of the low volume loser portfolios are 1.02% higher than the profits of the high volume losers. These papers all show that the price momentum that Jegadeesh and Titman (1993) found also returns in other countries and different time periods, pointing out that it is probably not a result of data mining.

### The three factor model

While many researchers tested the results of Jegadeesh and Titman (1993), Fama and French (1996) thought that anomalies are related to each other and made a three factor model to estimate the difference between the expected return and the risk free rate of securities. The model explains much of the variation in returns over different cross-sections like size and book-to-market equity. In addition, it also captures the long run reversal effect. The three factor model is able to explain these anomalies better than the CAPM. However, the model cannot explain the price momentum effect and the authors give three possible explanations. Firstly, they think that price momentum can be a result of data snooping, although there is evidence of a momentum in the years after the first tests from Jegadeesh and Titman (1993). The second explanation is that stock prices are irrational and price momentum is a result from underreaction or overreaction. At last they consider that stock prices are rational but price momentum is a short-coming of their three factor model. Despite not being able to explain the price momentum anomaly, their research shows that anomalies are related to each other.

### The relationship between price momentum and size

Since anomalies might be related to each other, several authors studied if there is a relationship between price momentum and the size of a company. Hong, Lim and Stein (2000) conclude that the profits of momentum strategies decrease when company size increases. The returns from the price momentum strategy peak in the third size decile with a return of 1.43% per month. After the third decile, the returns keep decreasing until they reach zero in the tenth decile. The authors explain this ‘size pattern’ with the underreaction of prices. Information from smaller companies takes more time to reach investors and so the effect of the momentum strategy is higher on these stocks. Fama and French (2012) state that there are

positive momentum returns in all size groups and that the duration of the positive returns is longer for small stocks. Besides that, the difference between the returns on small and large stocks is 0.42% per month and is 2.76 standard errors from zero. Moreover, Jegadeesh and Titman (1993) describe how the returns on the momentum strategy are lower in the group with the largest firms, suggesting that there is a relation between the abnormal returns and the firm size. For example, the return of the winner portfolio is 1.82% per month (test statistic=3.99) in the small group and 1.57% per month (test statistic=4.11) in the large group. Finally, Rouwenhorst (1998) noted the relationship between size and price momentum when the author observed results that are corresponding with the size pattern in 12 European countries. Although the two anomalies seem to be related, it should be interpreted with caution, because they might be related through an omitted variable that is not found yet.

There is much research in favor of the momentum strategy. However to use it in practice it is relevant to investigate if the strategy is still rewarding after controlling for transaction cost. Since the strategy requires a lot of selling and buying it might nullify the abnormal returns. Korajczyk and Sadka (2004) estimate the profitability of momentum strategies after controlling for trade costs. Although the profits decline when trade costs are taken into consideration, the strategy is still profitable except for portfolios which are worth more than 4.5 billion dollars. The research shows that the price momentum strategy is interesting to use in practice.

To summarize the findings of the former papers; the CAPM has several anomalies such as the reversal effect and price momentum. Price momentum seems to occur on different stock markets at different time periods, which strengthens the idea that it is not a result of data mining. The different possible sources of price momentum are still widely discussed, as is the relationship with other anomalies such as size. Former research shows that the returns from price momentum decrease when the firm size increases.

## III. Data

This research uses the database CRSP (Wharton Research Data Services) for the monthly security prices in the US stock market from the years 1990 till 2016. Since Jegadeesh and Titman (1993) tested their hypothesis in the US, this research as well examines price momentum in the US to build forward on their research. It is relevant to use a different time span than Jegadeesh and Titman (1993) did, to examine if their results still continue to exist in later years. This is why the years 1990 till 2016 are chosen. Jegadeesh and Titman (1990) use a dataset till 1990 and 2016 is the most recent completed year. All stocks traded on the NYSE, American Stock Exchange and Nasdaq are gathered in the dataset, except the stocks from firms in the lowest 10% market capitalization and stock prices smaller than 5 dollar. This is in line with the study of Jegadeesh and Titman (2001). They delete these observations, because their effect on the portfolios can be big, while they represent a small part of the total market cap. Fama and French (2008) make the same conclusion by explaining that microcaps (securities in the lowest 20% market cap) can have a high impact on the returns of equally weighted portfolios. Around 60% of the securities are microcaps, yet they represent only 3% of the market cap. In the data from CRSP there are a few firms that have zero shares outstanding in some of the months. These months are deleted, since the securities in these months cannot be bought and therefore cannot be a part of the momentum strategy.

The data consist of the following variables:

- Permno: company code
- Date: the last day of the month, starting at 31 January 1990 and ending at 31 December 2016
- Price: the price in dollars at the last date of the month
- Shares: numbers of shares outstanding

### Descriptive statistics

The dataset has a total of 23,198 securities and 1,757,024 observations of the variable price during the 27 years. The highest security price is from the A class security of the firm Berkshire Hathaway. As can be seen in table 1, at 30 December 2016 this security was worth no less than 244,121 dollars. When Berkshire and Hathaway is ignored, the highest security price is 4736 dollars in December 2007. This big difference can be one explanation for the large standard deviation of 1468.44 for the variable price, since the standard deviation without the security of Berkshire and Hathaway is 45.72. Although the security of Berkshire and Hathaway is an outlier, it is included in the dataset because the stocks will be selected on their percentage return and not on their price.

***Table 1:*** *Descriptive statistics for price, number of shares and market cap.*

| *Observations* | *Mean* | *Standard deviation* | *Minimum* | *Maximum* |
|---|---|---|---|---|
| Price | 44.275 | 1468.442 | 5 | 244,121 |
| Number of shares | 77,881.3 | 308,811.7 | 1 | 1,110,000,000 |
| Market cap | 2,904,569 | 13,700,000 | 2334 | 751,000,000,000 |

As shown in table 1, the standard deviations of all three variables researched are extremely high. This can be explained by the big difference in the price and market cap of the securities. Except the lowest decile market cap and prices below 5 dollar, all securities are included in the dataset. This leads to a dataset with small firms with a market cap of 2334 dollars and firms like Apple Inc. with a market cap of 751 billion. The variables in table 1 are not directly used for the tests, so their high standard deviations do not threaten the quality of the results. As will be described in the methodology section, only the percentage return of the stocks will be directly tested. In other words, the percentage difference between prices is tested and not price itself.

## IV. Methodology

This section discusses the methodology used in this research to test and answer the hypotheses and research question. First the formulas for the variables that are created are given. After that the formation of the portfolios that are used for the tests is covered. Finally, the last two paragraphs explain how the two hypotheses are tested.

### Formulas

To test the hypotheses, the variables discussed in the former chapter are used to create new variables:

- The market cap of firms:

$$market_{cap} = price \times shares$$

- The return in the last J months:

$$past_{return} = (price[n] - price[n-J]) \div price[n-J]$$

- The monthly return the best-performing securities will produce:

$$return_{buy} = (price[n+K] - price[n]) \div price[n]$$

$$monthly_{return\_buy} = \left(return_{buy} + 1\right)^{(1 \div K)} - 1$$

- The return the worst-performing securities will produce:

$$return_{sell} = (price[n] - price[n+K]) \div price[n]$$

$$monthly_{return\_sell} = (return_{sell} + 1)^{(1 \div K)} - 1$$

- The monthly return for the total portfolio:

$$monthly_{return\_total} = \left(monthly_{return\_buy} + montly_{return\_sell}\right) \div 2$$

- Compounded return per year:

$$yearly_{return} = (monthly_{return} + 1)^{12} - 1$$

All the variables are generated in the program Stata. Eventually, the variables $monthly_{return\_buy}$, $monthly_{return\_sell}$ and $monthly_{return\_total}$ are used to test if the returns are significant different from zero. In the next paragraph will be discussed how the variables are used to form the portfolios.

### Formation of the portfolios

To test if there is price momentum in the US stock market, a different portfolio is made every month. The portfolios are formed in the same way as Jegadeesh and Titman (1993) do. At the end of each month, securities are ranked based on their returns in the last J months. These returns are calculated as a percentage growth in prices. Then the securities are ranked in ascending order and grouped into ten

deciles, where 1 is the decile with the worst-performing securities (the losers) and 10 is the decile with the best-performing securities (the winners). These deciles are equally weighted, which means that they have the same amount of securities. After the ranking, the winners are bought and the losers are sold short. This portfolio is hold for K months. After K months the portfolio closes the short sell of the losers and sells the winners. For 27 years, this strategy is repeated every month. Both J and K vary from 3, 6, 9 to 12 months, leading to 16 different strategies. To summarize with an example: at the end of January, a 3-month/3-month (J-month/K-month) strategy ranks the securities based on the returns from the end of October till the end of January. Then the securities in the highest decile are bought and the securities in the lowest decile are sold. This position is unchanged until the end of April, when it closes the portfolio of January. Since the strategy is repeated every month and the holding period is 3 months, the total portfolio consists of three parts. In this case after the formation in January, the total portfolio consists of parts formed in January, December and November.

### Testing the first hypothesis

For all sixteen strategies the average monthly return of the momentum strategy is calculated for the total portfolios with the formula presented above. To test the first hypothesis, this study performs three One-Sample t-test per strategy that tests if the values of the variables $monthly_{return\_buy}$, $monthly_{return\_sell}$ and $monthly_{return\_total}$ are unequal to zero. Although it is a simple test, there is chosen for a One-Sample t-test since it tests if the strategies result in returns that are significant different from zero. If the returns are positive and the test results are significant different from zero, it can indicate that the momentum strategies are profitable in practice. For the tests, a 5 percent significance level is used.

The strategy that is significant different from zero and has the highest average return of all 16 strategies, is considered as the best strategy. In this research, the best strategy from the One-Sample t-tests is used to examine the difference between the returns in different size groups.

### Testing the second hypothesis

The first hypothesis tests if the momentum strategy is profitable in the whole US stock market. The second hypothesis tests if there is a difference in the average returns between firms of different sizes. For the second hypothesis, ten equally weighted groups of securities are created based on the market cap of firms. Since the lowest decile is excluded from the data, as described in the data section, nine deciles are used for the tests. These groups are considered as nine different datasets and the momentum strategy is studied in all the groups. The portfolios are formed in the same procedure as described above, however, 2 strategies are used instead of 16. The best strategy chosen in the first hypothesis is used, because the t-test

has shown that it resulted in the highest return when firms are not divided into different size groups. Secondly, the 6-month/6-month strategy is used, since Jegadeesh and Titman (1993) used this strategy to test for a difference in returns between size groups. The authors argue that the results of the 6-month/6-month strategy are comparable and representative for the other strategies. For instance, the four strategies where J=6 all lead to a return around 1%, with a spread of 0.18% between the highest and lowest return of the strategy with J=6. In contrast, the four strategies with J=12 have a spread of 0.63%.

To test the second hypothesis, a One-Sample t-test is performed for every size group to test if the average returns are significant different from zero. Afterwards, the returns of the nine groups will be compared to each other to examine the relationship between the momentum strategy and firm size. This will be done by investigating if there is a decreasing pattern in the returns as Hong, Lim and Stein (2000) described, or if there is no clear relationship between market cap and returns.

## V. Results

In this section the results for the two hypotheses are presented and discussed. First the results of testing the price momentum strategy in sixteen combinations of J and K are discussed and interpreted. Afterwards, the results of the price momentum strategy in different size groups are presented.

***Table 2:*** *test results for the sixteen combinations of past return period J and holding period K. The monthly returns (percentage returns/100%) and the test statistics are presented in the table.*

| *Monthly returns (percentage returns/100%) and test statistics* | | K=3 | K=6 | K=9 | K=12 |
|---|---|---|---|---|---|
| J=3 | Winners | 0.0043 | 0.0045 | 0.0051 | 0.0046 |
| | | (2.01) | (3.13) | (4.56) | (4.79) |
| | Losers | -0.0207 | -0.0199 | -0.0195 | -0.0182 |
| | | (-8.91) | (-10.46) | (-11.36) | (-12.38) |
| | Total | -0.0082 | -0.0077 | -0.0072 | -0.0068 |
| | | (-9.59) | (-10.66) | (-10.76) | (-11.05) |
| J=6 | Winners | 0.0047 | 0.0046 | 0.0040 | 0.0031 |
| | | (2.19) | (3.20) | (3.45) | (3.16) |
| | Losers | -0.0224 | -0.0209 | -0.0195 | -0.0202 |
| | | (-9.12) | (-9.72) | (-12.64) | (-12.75) |
| | Total | -0.0088 | -0.0082 | -0.0077 | -0.0085 |
| | | (-8.96) | (-9.04) | (-12.32) | (-12.52) |
| J=9 | Winners | 0.0049 | 0.0035 | 0.0025 | 0.0017 |
| | | (2.31) | (2.37) | (2.15) | (1.68) |
| | Losers | -0.0228 | -0.0213 | -0.0209 | -0.0224 |
| | | (-9.09) | (-10.04) | (-12.47) | (-12.21) |
| | Total | -0.0090 | -0.0089 | -0.0092 | -0.0103 |
| | | (-8.83) | (-9.81) | (-12.95) | (-12.71) |
| J=12 | Winners | 0.0028 | 0.0014 | 0.0007 | 0.0002 |
| | | (1.32) | (0.96) | (0.58) | (0.17) |
| | Losers | -0.0221 | -0.0200 | -0.0214 | -0.0229 |
| | | (-9.03) | (-12.57) | (-13.29) | (-13.20) |
| | Total | -0.0096 | -0.0093 | -0.0104 | -0.0113 |
| | | (-9.22) | (-13.65) | (-14.59) | (-14.52) |

### Results of testing the price momentum strategy

The results of the sixteen tests are presented in table 2. The table shows the monthly returns for the winner portfolios, the loser portfolios and the total portfolios. The portfolios of the winners have been bought and the portfolios of the losers have been used for short selling. The portfolios have been held for K months and the past returns have been calculated based on the past J months. Beneath the monthly returns, the test statistics from every test is added to show if the outcome of the tests are significant different from zero.

While observing the results, it is remarkable to note that every combination of K and J leads to a loss instead of a profit for the total portfolios. The losses of all sixteen total portfolios are significant different from zero since the absolute value of the t statistic is higher than 1.96. The strategy that has the lowest loss is the 3-month/12-months (J-month/K-month) strategy. The average return per month for this combination is -0.68%, which is equivalent to a compounded return of -7.86% per year. The return per year is calculated with the formula presented in the methodology section. The 12-month/12-month strategy turns out to have the highest loss of -1.13% per month and -12.75% per year. Interesting to note is that the losses get bigger when J increases. For instance, the losses of all four strategies with J=9 are higher than the losses of the strategies with J=6.

Just as the total portfolio, the profits for the losers portfolios are negative and significant different from zero for all strategies. The losses are all around 2% per month. However, some winner portfolios lead to positive returns instead of losses. Most strategies are significant different from zero, except all four strategies where J=12 and the 9-month/12-month strategy. The profits of these strategies are small and thus not significant different from zero. Since these strategies are not significant different from zero, they do not result in positive returns.

### Interpretation of the results from hypothesis 1

When the total portfolios are taken into consideration, the conclusion can be easily made that the price momentum strategy does not result in positive returns in the US stock market during the years 1990 till 2016. However, when the winner and loser parts of the portfolios are examined on their own, it is interesting to note that the winner portfolios can be used to gain profits. The loser portfolios all result in significant losses. A negative return on a loser portfolio means that the prices of these stocks went up after they are used for short selling. In other words: the stock prices of the worst performing stocks tend to go up after they dropped in the past months. The losses of the loser portfolios are the cause of the negative returns of the total portfolios, because the losses are larger than the profits from the winner portfolios for all sixteen combinations of J and K. This implies that the stock prices of the winner portfolios do not

outperform the stock prices of the loser portfolios since both prices rise. The positive returns of the winner portfolios imply that the prices of stocks that increased in value in the past J months tend to increase more in the following K months. To answer the first hypothesis: a momentum strategy does not lead to positive returns, following the results of this study. Nevertheless, when only the winner decile is used for the strategy, it results in positive returns which are significant different from zero for eleven of the strategies.

### Results of testing the price momentum strategy in different size groups

The price momentum strategy does not result in returns higher than zero for the total portfolios. However, the winner portfolios of the strategy lead to positive returns. For this reason, the best strategy from the winner portfolios is used as the best strategy for the following test. The 3-month/9-month strategy has the highest return for the winner portfolios of 0.51% per month and 6.29% per year as is shown in table 2.

The results of the returns of the price momentum strategy in different size groups are presented in table 3. The returns have been investigated for nine different deciles of the market cap of firms. The first decile has been excluded from the test since it was deleted from the dataset.

***Table 3:*** *the monthly returns (percentage return/100%) and test statistics for every decile of market cap.*

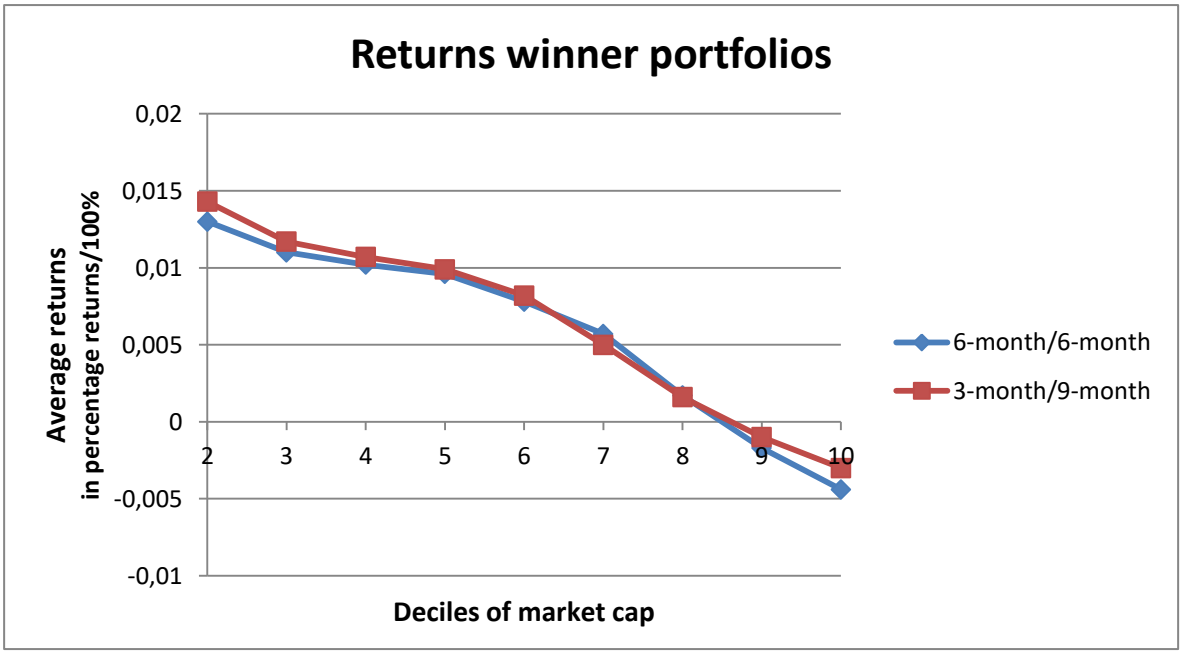
| | Decile | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| K=6 | Winners | 0.0130 | 0.0110 | 0.0102 | 0.0096 | 0.0078 | 0.0057 | 0.0017 | -0.0017 | -0.0044 |
| J=6 | | (10.60) | (9.04) | (7.81) | (6.75) | (4.89) | (3.58) | (1.06) | (-1.07) | (-2.78) |
| | Losers | -0.0397 | -0.0327 | -0.0307 | -0.0271 | -0.0223 | -0.0161 | -0.0128 | -0.0108 | -0.0100 |
| | | (-16.40) | (-16.95) | (-15.51) | (-13.81) | (-11.40) | (-8.54) | (-6.57) | (-6.37) | (-5.23) |
| | Total | -0.0134 | -0.0109 | -0.0103 | -0.0087 | -0.0073 | -.00524 | -0.0055 | -0.0063 | -0.0072 |
| | | (-11.94) | (-12.72) | (-12.27) | (-11.32) | (-8.71) | (-7.30) | (-6.73) | (-8.83) | (-8.35) |
| K=9 | Winners | 0.0143 | 0.0117 | 0.0107 | 0.0099 | 0.0082 | 0.0050 | 0.0016 | -0.0010 | -0.0030 |
| J=3 | | (12.82) | (12.00) | (10.35) | (9.06) | (6.88) | (4.03) | (1.24) | (-0.68) | (-2.20) |
| | Losers | -0.0356 | -0.0311 | -0.0302 | -0.0246 | -0.0221 | -0.0165 | -0.0123 | -0.0106 | -0.0082 |
| | | (-15.81) | (-18.26) | (-14.18) | (-14.31) | (-11.08) | (-8.33) | (-6.81) | (-6.84) | (-5.44) |
| | Total | -0.0107 | -0.0097 | -0.0098 | -0.0074 | -0.0070 | -0.0058 | -0.0054 | -0.0058 | -0.0056 |
| | | (-10.10) | (-14.01) | (-11.04) | (-10.72) | (-8.34) | (-7.14) | (-6.71) | (-8.06) | (-8.02) |

At first sight, the returns seem comparable to the returns from the former tests since the loser and total portfolios result in losses and the winner portfolios result in profits. For both the 6-month/6-month and the

3-month/9-month strategy, the total portfolios and the loser portfolios result in negative returns that are significantly different from zero. When the winner portfolios are studied, table 3 shows that the positive returns decrease when the market cap increases. From the second till seventh decile the returns shrink continuously. The returns of the eighth and ninth decile decrease as well when they are compared to the former decile, but they are not significant different from zero. In the tenth decile, the returns are even negative and significant different from zero.

When studying the returns of the loser portfolios in table 3, it is remarkable that the returns are increasing when the deciles of the market cap increase. The returns become less negative in higher deciles. This is contrary to the winner portfolios since they become less profitable in higher deciles. This implies that the spread between the returns on the winner and loser portfolios becomes smaller for higher deciles. For example, in the 6-month/6-month strategy the spread in the second decile is 5.27%, whereas it is only 1.44% in the tenth decile.

***Figure 1:*** *Average monthly returns for the winner portfolios from the second decile till the tenth.*




As can be seen in figure 1, the differences between the 6-month/6-month and the 3-month/9-month strategy are small for the winner portfolios. The patterns of the decreasing returns are the same, just as the insignificant returns of the seventh and eight decile and the negative returns of the tenth decile. From the second till the sixth decile, the returns of the 3-month/9-month strategy are larger than the returns of the 6-month/6-month strategy, but this difference is small. The highest average return belongs to the second decile in the 3-month/9-month strategy. It has an average return of 1.43% per month and 18.58% per year.

To compare it with other size groups: the average return of the seventh decile, which is the last decile that is positive and significant different from zero, is 0.50% per month and 6.17% per year. Comparing the returns in the different size groups with the returns of the first tests is interesting as well. In the first tests the price momentum strategy is tested for the whole market and not for different size groups. The highest return in the first tests was 0.51% per month and 6.29% per year. This is smaller than the returns for the second till sixth decile for the two strategies presented in.

### Interpretation of the results from hypothesis 2

The second test shows that the returns of the winner portfolios decrease when the firm size increases. Since the size groups have been made with the market cap of the firms, the results imply that the momentum strategies are more profitable for firms with smaller market caps. Thus, if prices increased in the past, their growth in the future is larger for small firms. One explanation of these results could be the underreaction of prices, as is discussed in the literature research. Since information about smaller firms tends to reach the public slower, the benefits from a momentum strategy might be greater for these firms (Hong, Lim & Stein, 2000). To answer the second hypothesis: for the winner portfolios there is a decreasing pattern for returns when the market cap of a firm increases. This might point at a relationship between stock prices and the market cap of firms. However, the loser portfolios become less negative when the market cap of firms increases. Although this is notable, this might still point at an underreaction of prices since the losses are bigger at small firms.

The results of the two hypotheses show that adopting a price momentum strategy for the winner portfolios results in positive returns, although they decrease with size. For this reason, in practice it might be most profitable to implement the strategy in the smaller deciles of market cap. Buying the winner portfolios in the second till seventh decile leads to the highest returns, according to the results of this research.

## VI. Discussion

This chapter compares the results of this research with the existing literature and tries to explain the differences. Subsequently, the limitations of this study are discussed.

### Comparing the results with existing literature

The results of the first hypothesis are just partly corresponding with the existing literature on price momentum. For instance, Jegadeesh and Titman (1993) and Rouwenhorst (1998) found positive returns for all sixteen tests. In the research of Jegadeesh and Titman (1993) the positive returns are all significant different from zero, except for one combination of J and K. This is a substantial difference from the results presented above since the returns of all total portfolios are negative. The negative returns of the total portfolios are caused by the negative returns of the loser portfolios. The negative returns of the loser portfolios imply that the prices of stocks which performed bad in the past tend to increase in the following months. The reason why the prices increase on the short term is not clear. Therefore it might be relevant to examine possible explanations for the negative returns for further research.

In addition, the best strategy in the research of both Rouwenhorst (1998) and Jegadeesh and Titman (1993) is the 12-month/3-month strategy, whereas in this research all the strategies with J=12 are highly negative. Even the winner portfolios do not have profitable returns for these four combinations with J=12 since the returns are not significant different from zero.

The last notable observation is that the returns for the winner portfolios are higher in the existing literature. For example, in the research of Jegadeesh and Titman (1993), the 3-month/3-month strategy leads to the lowest return for the winner portfolios. The return of that strategy is 1.4% per month. At the same time, the highest return on the winner portfolio in this research is equal to only 0.51% per month. This difference is visible in the paper of Lee and Swaminathan (2000) as well. The returns of the winner portfolios in their results range from 1.40% to 1.88% per month. Jegadeesh and Titman (1993) tested price momentum in the years 1980 till 1989 and Lee and Swaminathan (2000) in the years 1965 till 1995. One possible explanation for the difference between the returns is that they are tested in different time spans. The financial crisis of 2008 might have had an effect on the returns observed in this study. However, the price momentum strategy is tested in 27 years and the differences between the returns in this research and former research are big. For this reason, the financial crisis alone probably cannot explain the difference. It is possible that the methods used to form the portfolios are not completely identical, as will be discussed in the limitations of this research.

The results of the second hypothesis are more comparable with the existing literature. Although the returns of the total and loser portfolios are still negative, the decreasing pattern of the returns for the winner portfolios is corresponding with the findings of Hong, Lim and Stein (2000). The authors notice that the returns of the momentum strategy decrease when they are investigated in a higher decile of market cap. The returns peak at the third decile with a return of 1.43% per month. After that the returns decrease and almost reach zero at the tenth decile. Although this seems to follow the same pattern as the results discussed above, it should be interpreted with caution since only the winner portfolios of this research are corresponding with the existing literature. The return of 1.43% per month outlined by Hong, Lim and Stein (2000), is the return for the total portfolio. The peak discussed by the authors is only visible for the winner portfolios in this research and not for the total portfolios.

Finally, Fama and French (2012) also observed that the spread between the winner and loser portfolios becomes smaller when the market cap increases. This is corresponding with the results of this study for the test in different size groups. Rouwenhorst (1998) observed this matter as well. The results of his research show that in the smallest decile the winner portfolios outperform the loser portfolios with 1.45%. The spread declines when the deciles of market cap increase, just as observed in the results of this research.

### Limitations

Although this research has been executed with care and attention, there are still some limitations. First of all, it is possible that this research missed out on steps of the methodology created by Jegadeesh and Titman (1993), leading to different returns for the price momentum strategy. The impact of this limitation depends on the importance of the missed step. It has been hard to completely understand the methodology Jegadeesh and Titman (1993) used for their research. The section where the authors explain how the portfolios are formed and the variables are transformed to test the returns is short. After reading other papers that perform the same test, it became clearer how the data has been transformed. However, this research might still miss an important step. Secondly, this study is unable to explain the negative returns that are completely different from existing literature. The lack of time made it difficult to examine the causes from the negative returns in a deeper manner since testing behavioral causes is difficult to do in practice. Finally, this research compares the returns in different size groups, without testing if the returns are significant different from each other. It might be interesting to test this in a formal way, for example by performing a regression of the market cap of firms and other relevant variables on the returns of the price momentum strategy.

## VII. Conclusion

This research investigates if the price momentum strategies are profitable in the US stock market during the years 1990 till 2016. It has been tested if the returns of the winner, loser and total portfolios are significant different from zero. Additionally, the relationship between the size of firms and the returns of the momentum strategy has been examined.

The results of this research do not accept the first hypothesis since the conclusion that the price momentum strategy leads to positive returns cannot be made. All sixteen combinations of J and K that have been tested, result in negative returns that are significant different from zero for the loser and total portfolios. However, some winner portfolios lead to positive returns. Five out of sixteen returns are not significant different from zero for the winner portfolios, but the other eleven returns are positive and significant different from zero. The strategy which gains the highest average return for the winner portfolios is the 3-month/9-month (J-month/-K-month) strategy.

Remarkable in this research is that the returns of the loser portfolios and thereby the winner portfolios are entirely different from the results of existing literature. Many papers, like those of Jegadeesh and Titman (1993) or Rouwenhorst (1998), show that price momentum results in positive returns. For further research it would be interesting to find an explanation for this difference. Besides, it could be relevant to test if there is price momentum in the years 1990 till 2016 in different markets than the US stock market. Testing the strategy in a different market might show if the negative returns of this study are present in other markets.

When the returns of the price momentum strategy are tested in different size groups, the returns of the loser and total portfolios remain negative in all size groups. The returns of the winner portfolios are positive and significant different from zero in the second till seventh decile of market cap and show a decreasing pattern. The highest return belongs to the second decile. After the peak, the returns decrease continuously when the decile of market cap increases and the returns of the tenth decile are even negative. This decreasing pattern is observed in both strategies that are used for the test: the 3-month/9-month and 6-month/6-month strategy. Finally, the results of the second hypothesis show that the spread between the returns of the winner and loser portfolios becomes smaller when the market cap deciles increases.

The negative returns of the loser and total portfolios in the second test are not corresponding to former research. However, the decreasing pattern of the returns for the winner portfolios is comparable with the findings of Hong, Lim and Stein (2000). For further research it would be relevant to study the cause of the relationship between the firm size and the returns from price momentum.

To answer the research question: adopting the price momentum strategy does not lead to positive returns in the US stock market from the years 1990 till 2016. Nevertheless, price momentum can be used to gain positive returns that are significant different from zero by buying the winner portfolios. There seems to be a relationship between the returns of the winner portfolios and the market cap of firms since the returns decrease for every decile of market cap.

The price momentum strategy is still relevant to study since the sources of the anomaly are debatable and the relationship between price momentum and other anomalies is not explained yet. Besides, the CAPM is still used by investors and Universities. This study contributes to the research on price momentum by studying a different time span than Jegadeesh and Titman (1993) used for their tests. In this way, this research presents new results that could be useful to investigate the sources of the price momentum returns.

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