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EVALUATING VALUE INVESTMENT:

AN ANALYSIS OF THE GERMAN STOCK MARKET

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Supervisors: Prof. Dr. Roland Müller

Prof. Dr. Avo Schönbohm

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Author: Fabian König

(Student ID No: 454504)

ABSTRACT

In this study we follow the idea of value investing and evaluated its historical performance in the German stock market. We analysed historical financial statements of HDAX companies and performed a backtest for different value investment strategies.

The two simple value indicators book-to-market ratio and earnings-to-price ratio were used to classify stocks as value stocks. Furthermore we tested two value strategies that consider qualitative elements, a growth in sales strategy and a strategy based on the magic formula.

The study of 16 investment periods suggests that value investment out-performed the German market during the observed time frame. This is especially true for the strategies that combine value and qualitative elements.

I would like to take the opportunity to thank Björn Kijl from the University of Twente and my first supervisor Prof. Dr. Roland Müller for valuable feedback on the topic during the thesis process. Furthermore I would like to thank the Collaborative Research Center 649 of HU Berlin for providing access to several economic databases.

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1. Introduction

1.1. Problem background

Many ambitious investors in stocks aim to beat the market. By picking the right stocks at the right time outstanding returns can be generated. When looking at famous and successful investors today, one personality stands out as a shining star: Warren Buffett. With his investment style of buying companies at low prices, improving them and realizing long term increases in the stock price, he has become the most successful investor with regards to the capital he started off with (Farrington, 2015). As CEO of the holding company Berkshire Hathaway Inc. he invites his investors to the famous annual meetings, dubbed as 'Woodstock for Capitalists'. Even though some news journals do not see Buffett as a pure value investor (Forbes, 2013), he is still very well known for factoring the value investment principles into his investment decisions. And as the most famous disciple of value investment inventor Benjamin Graham, he is always connected with this investment style.

With the book *'Security Analysis'*, published by Benjamin Graham and David L. Dodd in 1934, the idea of fundamental analysis of a company for the purpose of investing in securities was first introduced to a wider audience. Investment decisions during that time were mostly made by insider trading or speculation. In contrast to that, the book suggests to analyse the investment object carefully and refer to fundamental analysis in order to determine the intrinsic value of a company. A fundamental analysis is normally executed by examining different quantitative and qualitative factors that emerge from the financial statements published by a company. Investment objects should only be bought at a significant discount to the examined intrinsic value of the company. An investment approach with this concept in mind is termed value investing. The early ideas of Graham still remain the basis of this investment approach today, while some variations in interpretation exist.

Graham did further research on this topic and with the publishing of his book *'The Intelligent Investor'*, in 1949, he created a second standard reference for value investing. Focus areas of this book are risk mitigation by diversification and the introduction of a character called Mr. Market. This highly emotional person, sometimes irrational but still most of the time efficient, symbolizes the market. Graham points out that the short term fluctuations of the market are good for speculators, because they

can anticipate its change and profit from it, but intelligent investors should look for long term securities at suitable prices (Graham and Zweig, 2003, p. 203).

In contrast to the emotional fluctuation of the market stated by Graham, Eugene Fama describes a model of market equilibrium, where prices fully reflect all available information (Fama, 1970, p. 414). Fama defines this informational efficiency in asset markets as efficient market hypothesis (EMH). The EMH implies, that predictions on future stock prices are impossible and therefore performing better than the market by picking the right stocks is impossible.

These two different concepts already show the vital discussion among researchers and economists on how markets behave. An ultimate truth about market behaviour has not been identified yet. But most researchers agree that value investing generated superior returns in the USA in the past. The explanations for the outperformance of value stocks are manifold (La Porta et al., 1997, p. 859). We will evaluate value investing in its traditional form as well as some modern manifestations of this investment philosophy for the German market.

1.2. General Motivation

In 2015 we are facing abnormally low interest rates. From 2008 on central banks in western economies started to decrease interest rates for short term loans dramatically. This, among a series of other actions, was a response to the panic that arose from the instability in the financial system. Starting in the US market and soon affecting the whole western world, this financial crisis was the most challenging economic decline since the Great Depression. At the time of the crisis, low interest rates seemed to be a temporary expedient (The Economist, 2013), and in November 2015 US Federal Reserve interest rates were at a level near zero[1] while the European Central Bank's rates remain static on a level tight above zero (ECB, 2015). Investments in fixed income assets seemed to be less charming in the year 2015 as they do not generate the same returns as they did 10 years ago. I am still following these developments and see the issues that arise. Investors have been looking for alternative investment possibilities. Personally I detected stocks as one alternative for generating reasonable returns while keeping risk at acceptable level. My personal interest in stock markets in general and my enthusiasm about processing data are the basic motivation for writing

[1] Federal Reserve announced an rise in US interest rates in December 2015 (The Guardian, 2015)

this thesis. Stock markets seem to be unpredictable. As a student in business intelligence and process management I am facing the challenge of predicting future outcomes with sometimes huge amounts of historical data all my student life. Whether it is about the Titanic disaster and predicting the probability of survival based on passenger data[2] or the probability of bankruptcy of a company based on company financial data. The challenge always was to invent a model based on historical data in a defined context. But financial markets seem to be different, much more complex. The huge amount of data available and the challenge to gain some information out of it made this topic so interesting for me.

2. Research Question

An investment strategy in finance can generally be described as plan for capital allocation among different investment assets, like stocks, bonds or real estates (Maginn, 2007, p. 814). More specifically a strategy for stock investments is a certain set of rules applied to a stock selection process in order to form a portfolio. This set of rules can consist of one or a combination of different elements. Examples for those elements can be investment in a specific country/region or sector (e.g. telecommunication or healthcare) only, investment based on an analysis technique (fundamental, technical) or the limitation on a defined company size.

In this study we will conduct fundamental analysis in order to follow the general idea of value investment in stocks. We will evaluate slightly different value investment strategies for the German market.

The development and evaluation of new investment strategies have been the central motivation driving extensive research over the last decades. With regard to value investing the publication of Fama and French (1992) on *'The cross-section of expected stock returns'* had an influential impact. Fama and French state that value investing outperforms the market at a higher level of risk, which caused a lot of researchers to try and prove or refute this statement. In recent years major publications[3] on pure value investing approaches, based only on one single indicator, have been rare. We define for the purpose of this study investment approaches based on one single indicator as one-dimensional.[4] Research on mixed approaches of stock selection based on value

[2] See Kaggle competition: Titanic: Machine Learning from Disaster (https://www.kaggle.com/c/titanic)
[3] A table on major publications in the past is provided at the end of section 3.4.
[4] The term one-dimensional classification was used in Lakonishok et al., (1994)

and quality are increasing and getting more attention. Mixed approaches classify a stock not only based on one single indicator, but combine several indicators in order to classify a stock. Most of the studies examine data from the US market. A remarkably high amount of studies are conducted at US universities and data from the US market is easily accessible. Several studies examine data from outside the USA, but the German market is only part of a few studies.[5] Those that did research on the German market typically focused on the DAX30, which represents the 30 major German stocks, i.e., those that have the highest traded market capitalisation. Mid-sized companies, listed in the MDAX in Germany, are typically omitted, while studies from the US market showed that mid-sized companies have a massive impact on investment strategies.[6] The burst of the Dotcom Bubble in 2000 as well as the eruption of the financial crisis in 2007 mark two major market crashes of the last decades. Being hard for some investors, these crises offer unique opportunities for research.

Having this in mind, the author of this thesis will answer two arising questions:

(1) Did simple value strategies, based on one-dimensional classification, outperform the German market during the time period 1999 – 2015

(2) Can the consideration of qualitative indicators improve simple value investing strategies

3. Literature Review

The literature review continues the discussion on market efficiency started in the introduction and delivers a detailed review on literature and evidence for the efficient market hypothesis including research examples on market anomalies. Afterwards value investing is defined and a selection of scientific examples for evidence on value investing using different value measures on markets worldwide are presented.

The review has been executed by reviewing the following databases: Social Science Research Network (http://ssrn.com/en/), JSTOR (http://www.jstor.org/), Springer Link (BSEL source), EBSCOhost (BSEL source). Based on the topics of interest, we searched for the keywords ‘efficient market’, ‘market efficiency’, ‘market anomalies’, ‘value investing’, ‘value investment’. Furthermore books in the libraries at Berlin School

[5] For recent studies on value investing specifically in Germany/Europe see Bird and Whitaker (2003) or Friesenegger and Riegler-Rittner (2009)

[6] French and Fama (1992) or Piotroski (2000) argue that the approach of fundamental analysis of financial statements data has the highest impact on companies of low level of interest for analysts

of Economics and Law (BSEL) and TU Berlin have been used for research. The findings were rated by overall relevance, measured by the amount of times the document has been cited, and the publication medium.[7]

Part one and two of the literature review give insights into the mentioned fields by illustrating relevant and important papers on the topic efficient market hypothesis and explain proofed market anomalies. Part three explains value investing as seen by researchers and economists and describes its characteristics. Part four gives a detailed view on studies on value investing. For this part detected literature has been screened and tested for specific relevance to the research question. Plenty of papers address the research question of stock price development based on company's valuation. Unfortunately almost all famous studies focus on the US market and only provide evidence for stocks traded at the New York Stock Exchange (NYSE). In order to get a worldwide overview while still considering outstanding science, the ten most cited papers investigating the US market were taken into account as well as seven more papers investigating markets other than the US. Not all examined papers share the same measurement for identifying value stocks. To cope with this variety of indicators they are already mentioned and briefly explained in part three and the usage of selected indicators in science as well as the outcome of these studies is described in part four.

A comprehensive summary on research and evidence on value investing was executed by Chan and Lakonishok (2004). The detailed look on value investing, in part four, focuses on recent studies. New perceptions, higher information flows and the usage of automated trading on the stock markets seem to make some of the older literature obsolete.[8] Therefore literature being older than 25 years was avoided but not generally excluded.

3.1. Efficient Market Hypothesis

In the late 1960s Eugene Fama and several other researchers started demonstrating that prediction on stock price developments, in the short term, is impossible. These findings resulted in an influential survey paper (Fama, 1970) that led to the

[7] Journal of Finance, Journal of Asset Management, Journal of Business Finance & Accounting, Journal of Financial Economics and Journal of Investment Management were seen as most relevant for this topic by the author

[8] E.g. regulation of price disparity on different exchange markets through algorithmic trading or influences of high frequency trading on short term price formation

development of the efficient market hypothesis (EMH) by Fama. This hypothesis was honoured as one part of the Nobel Prize in Economic Science in 2013. The EMH states that stocks are traded at their fair value. All known information is already reflected by a security's price and arising information is immediately incorporated in prices for a security. Fama distinguishes three different forms of market efficiency:[9]

1. Weak form: Price development cannot be predicted by analysing past stock price developments. This implies that technical analysis, the forecasting of stock prices based on the study of historical price development, does not lead to new information.
2. Semi-strong form: Publicly available information are already incorporated in stock prices and thus have no influence on future stock price development. This implies that fundamental analysis, the analysis of the finical statements of a company (incl. company value, asset values etc.), is not suitable for predicting future stock price development.
3. Strong form: All information is already priced into the cost of a security. This means that all publicly and privately available information is already reflected by the current stock price and monopolistic access to information does not lead to any benefit in determining the future development of a stock price.

This hypothesis has been a cornerstone in modern financial theory since its release. One of its conclusions is that beating the market is not possible. This means that a selection of stocks does on average not generate higher returns than the overall market.

Fama and French (2010) find recent evidence for this fact. The performance of actively managed mutual funds in the US is almost equal to the market performance. Taking cost of active management into account only few funds generated higher returns than the benchmark market. This means that most so called experts of investment companies are not beating the market. Further evidence of this is given by Barras et al. (2010) when investigating the performance of US domestic-equity funds. They measured the *'alpha'* generated by funds over time. Alpha specifies the percentage an asset, e.g. a fund, performed better than a benchmark (e.g. a stock market index). Luck is quantified with a measure built on the false discovery rate in their paper. Lucky funds are described as funds having a significant estimated alpha, while the true alpha is

[9] Explanation based on Schwager (2013, p. 13)

very little. For the time frame between 1975 and 2005 over ¾ of observed funds generated an alpha of zero, while only 2.1% have a positive alpha. The 2.1% generating a positive alpha do indicate that a few funds outperform the market, but the large majority don't generate a positive alpha.

In line with the EMH is the random walk hypothesis in finance first brought to a wider audience by Malkiel, (2007) in his book *'A Random Walk Down Wall Street'* originally published in 1973. A random walk could be generally described as the movements of an object on a lattice that jumps at discrete time steps to new, randomly chosen sites (Lawler and Limic, 2010, p. 9). It is not clear where the object will be after a certain time. The same is true for stock prices. The random walk hypothesis in finance describes the fact, that the development of prices on stock markets is not predictable for the short-term. Like the movements of the object on the lattice, forecasting of the development of stock prices in one or the other direction is not possible. Malkiel (1995) states that professional investment managers do not perform better than the market. His research suggests that on average equity mutual funds underperform benchmark portfolios, even if management cost is not included. Furthermore his study points out that *'survival bias'* has been highly underestimated in studies that emphasise the performance of mutual funds (Malkiel, 1995, p. 549). Survival bias refers to the logical error of overseeing those cases where the person or thing is not occurring anymore and one is concentrating on the ones that survived. In the context of analysing funds or stocks, bias can arise by excluding those that go out of business over time (Cornell, 1999, p. 60).

These papers in line with a huge number of other studies all suggest that we have a fully efficient market for trading stocks and that stock picking is not a worthwhile thing. Most fund managers do not generate a positive alpha and have no capabilities to predict what the market will do next. The price development of stocks is random based on information available today and performing better than the market is impossible. Both hypothesis, EMH and random walk, share the same unambiguous message: Beating the market is not possible.

But still plenty of researchers have a contrary opinion on market behaviour and give evidence for their opinion. The next paragraph provides examples where the market did not function in an efficient way.

3.2. Anomalies in the Market

The theory on the informational efficient market states that prices quickly adjust to new information and prices instantaneously reflect all available information. Scientific literature documents the existence of patterns in stock returns that show a deviation from the efficient market hypothesis. Empirical tests executed by Bondt and Thaler (1985) show that stock markets overreact to unexpected and dramatic events. By forming loser and winner portfolios based on the excess returns of the prior 3 years, they found evidence that the performance of the loser portfolios after 36 months was much better than the one of winner portfolios. On average the loser portfolios generated about 25% higher returns than the winner portfolios. Barberis et al. (1998) also detect inefficiency in markets when investigating over- and underreactions to news announcements. They find, that a consistent pattern of good or bad news announcements generated an overreaction on prices in the respective direction. On the other hand they find evidence for an underreaction on single positive earnings announcements. These irrational reaction to news is in line with the sentiment of Mr. Market presented in Graham's work.[10] Among researchers there is consensus that over- and underreaction exists, and Fama (1998) argues that market efficiency still sustains when both reactions occur randomly in the same quantity.

Agrawal and Tandon (1994) document various seasonal effects. Seasonal effects show abnormal returns in a specific time-wise pattern, e.g. on a specific weekday, date or in a certain month. Using data from 18 different countries they were able to confirm several effects already observed in the USA.[11] A January effect with abnormal increasing stock prices in January was validated for the majority of observed countries in their study. Other patterns like the Friday-the-thirteenth[12] or the Monday effect cannot be confirmed for all countries, but at least for some. For a few seasonal patterns researchers give good explanations while others seem to ebb away without an explanation. A later study on the Friday-the-thirteenth effect showed evidence for the existence of this effect in the majority of the 19 observed countries. Lucey (2001)

[10] Kahneman and Tversky (1982) give in addition an explanation of miss judgement from a psychological point of view. They describe this behaviour and name it representativeness bias in their work.

[11] Evidence for seasonal effects within a week/month/year for the US market are shown by Lakonishok and Smidt (1988) or Gibbons and Hess (1981). Due to the fact that both studies are older than 25 year we renounce on a detailed review

[12] Kolb and Rodriguez (1987) show evidence of a Friday-the-thirteenth effect in the USA

discovered statistically different returns on Friday the 13th, i.e. that in general returns are higher. But the explanation for this effect remains unclear.

Summarising these studies we can see that researchers find evidence for patterns that do not follow the efficient market hypothesis. By the pure amount of deviations we cannot assign these patterns to data fishing or noise only.

Financial market phenomenons like the ones mentioned above are classified as market anomalies, because they are not in line with the efficient market hypothesis. Typically empirical tests start at a certain point in time (t=0) with forming a portfolio and compare the returns of the portfolio at a later point in time (t>0) with the estimated residual portfolio returns (Bondt and Thaler, 1985, p. 795). Most studies use the capital asset pricing model (CAPM)[13] for describing the relationship between risk and return and determining the estimated returns. If the estimated returns and the detected returns are significantly different from each other, an anomaly might exist.

Fama (1998) argues that models for estimating returns, like the CAPM, are always incomplete descriptions of the average predicted returns during the observed time frame. He shows, that a lot of anomalies disappear when using alternative models for calculating estimated returns.

This ongoing controversy among researchers shows how difficult and contentious the discussion on incorporating risk into expected returns is. This results partly from the complexity of the markets in general and the inability to completely cover the intricacy related to risk and returns in models. But the discussion furthermore shows that the hypothesis of the efficient market is not falsifiable. When verifying the efficient market hypothesis, expected returns are calculated by a model and compared with the resulting returns. In case of distinction between expected and real returns, one can come either to the conclusion that markets are inefficient or that the model used for calculating the expected returns is incorrect.

'Value effects' are also seen as market anomalies. In this case value refers to the valuation of a company based on different financial ratios and the effects that arise from the valuation for the development of future stock prices. The semi-strong form of the EMH states that all publicly available information is already incorporated in stock prices. But especially portfolios based on stocks having a high book-to-market ratio are proofed to perform different from their expected performance. Therefore this

[13] For further information on CAPM see Treynor (1961) or French (2003)

phenomena is not in line with the EMH. The following paragraph gives a definition of value investing and introduces different measurements for determining the value of a company.

3.3. Value Investing

When investment based on valuation was mentioned for the first time by Graham, he did not mention the discovery of a market anomaly at all, but established a behavioural guideline for investors. During that time there was no rumour about efficient markets, but a lot of speculation and guesswork on the stock markets. Graham emphasises the importance of fundamental analysis before investment decisions are made. He established a framework with core principals and analytical tools. With the initiation of different ratios like the price-earnings ratio, saying that a stock's price should be considered as a certain number of times its current earnings (Graham and Dodd, 2005, p. 496), he developed the fundamental basis for value investing. Stock selection based on a margin of safety is another major principle mentioned first in Graham's book *'The Intelligent Investor'*. This margin is described as a significant lower intrinsic value compared to the current market price. By making investment decisions with this principle in mind, the effects of decreasing market prices are less damaging. An intelligent investor should only buy a stock that is worth more to pay for while being reasonable optimistic about the company's future (Graham and Dodd, 2005, p. 372).

The concept of value investment comes in various forms and can be interpreted slightly different. The leading idea behind value investing is, to find companies that are undervalued by the market at the time of capital expenditure. Investing in those companies opens an opportunity to generate magnificent returns on the long term, as the market is expected to adjust the undervaluation. The varieties in defining value investment results from the different determination of the intrinsic value of a company. The intrinsic value is normally calculated using a ratio consisting of a company internal number of the finical statements in combination with the market value, determined by the stock's price, in order to categorize stocks. The following list provides the most common ratios:

- Book-to-market (BM): The book-to-market ratio shows an investor what he would receive for one euro invested, if all the assets of the company were sold. The book value of a company is part of the balance sheet and calculated as total assets (deducing intangible assets e.g. goodwill) minus liabilities and

preferred stocks. For a ratio above one the company seems to be undervalued by the market and interesting for value investors. A ratio below one indicates overvaluation of the company. A ratio equal to one indicates a fair price for the value of a company. If the company was liquidated at a ratio level of one the investor would receive the same amount of money he invested.

- Earnings-to-price (EP): The earnings-to-price ratio is a measurement of the company's current performance. It shows the earnings as a percentage of the company's current stock price. The higher this ratio the better the performance of a company based on its market value. This ratio has already been mentioned by Graham in a different form. He suggested to measure the reciprocal ratio, price-to-earnings (PE), which follows the rule not to invest in stocks that cost more than a certain number of times of the company's current earnings.
- Cash-flow-to-price (CP): The cash-flow-to-price uses the operating cash-flow as means to measure the company's valuation. While earnings are affected by depreciation or other non-cash factors the cash-flow focuses on the amount of cash generated. Both ratios, CP and EP have in common to give an indication on the company's current performance relative to its stock's current price.

The above mentioned ratios are often calculated inverse by analysts or researchers. For ordering a portfolio of stocks based on these ratios this does not make a difference. Calculation of ratios as the mentioned ones or possible variations requires a fundamental analysis of information published by publicly traded companies. These information need to be processed and compared with the cost of a company at the market.

The investment manager and book author Seth Klarman gives a suitable definition of value investing:

> *"Value investing is the discipline of buying securities at a significant discount from their current underlying values and holding them until more of their value is realized. The element of a bargain is the key to the process. In the language of value investors, this is referred to as buying a dollar for fifty cents. Value investing combines the conservative analysis of underlying value with the requisite discipline and patience to buy only when a sufficient discount from that value is available." (Klarman, 1991, p. 64)*

In recent years combined approaches of value investing and qualitative aspects of a company are getting more and more attention. The idea is to not only search for stocks at a bargain price, but also incorporate qualitative aspects like growth in sales or operating efficiency into the stock selection process. The qualitative aspect of stocks is already part of Graham's stock selection process, as mentioned by Novy-Marx (2013). Graham emphasizes that, in order for an investment object to be viable, it needs to achieve minimum qualitative criteria as well as a good valuation (Graham and Zweig, 2003, p. 348).

The next paragraph presents examples of testing value investment strategies in different countries using the above mentioned ratios for classifying value stocks. The tests have been conducted by applying the strategy to historical data. It includes simple value investing approaches as well as combined approaches.

3.4. Evidence for Value Investing

Over the years, value investing has been subject to extensive research. Especially the publication of Fama and French (1992) brought new scientific interest to this topic. They point out that in their observed time frame value investing performed better than investments in *'growth stocks'.* The on average higher returns of value stocks are associated with a higher risk. For benchmarking and measurement of risk they used size as well as book-to-market ratio as indicators. This is a fundamentally different approach than the established CAPM used in most studies. The term growth stocks is used to describe stocks that have opposing features to value stocks. While value stocks are characterized by high book-to-market ratios, growth stocks generally have a low book-to-market ratio. This means, that investors are willing to pay a higher upcharge compared to the book value of the company. Growth stocks are often also called glamour stocks. For value investors those stocks seem to be overvalued.

Lakonishok et al. (1994) found evidence for higher returns of value stocks compared to growth stocks, while appearing not to be riskier when using a conventional approach for measuring risk. As indicators for a simple one-way classification of value and growth stocks they test several ratios separately: the book-to-market-, cash-flow-to-price-, and earnings-to-price ratio. In addition they classify stocks as growth or value with a multi-variable approach using indicators of past performance and expected performance.[14]

[14] Details on this approach are not discussed in this context due to complexity. For a detailed description on the two-/multi-dimensional classification see Lakonishok et al. (1994, p.1552 et seqq.)

They find evidence for an average 10% higher return of value stocks over growth stocks for some indicators tested. The paper names cognitive biases in investors' behaviour as one reason, caused by overestimating future growth rates for glamour stocks.

The mentioned studies were based on data from the US market. Capaul et al. (1993) found evidence for a *'value premium'* on markets outside the US as well. Value premium describes the outperformance of a portfolio of low valuation stocks (value) over a portfolio of stocks with higher valuation (growth). For their study they collected data from France, Germany, Switzerland, the UK, Japan and the US for the time frame of 1981 – 1992 and performed an analysis based the price-to-book ratio (P/B)[15] as a valuation indicator. By differentiating value stocks, characterised by a low P/B ratio, from growth stocks, characterised by high P/B ratios, their research suggests that value stocks outperform growth stocks on average. This is true for all observed countries and both absolutely and after adjustment for risk.

The Chicago based researcher Piotroski (2000) published a paper with an enhanced value investing approach. He provides evidence that only a fraction of identified value stocks outperform the market in a two year period. To harness this finding he examines an accounting based method for separating a portfolio of value stocks into expected winners and losers. With buying only the expected winners he achieved significant higher returns, while it worked best for companies with a small market capitalisation. Similar to simple value approaches the root portfolio is formed based on companies with high book-to-market ratios. To identify expected winners he invented a measure, called F_SCORE, which consists of different financial variables and is used to give an indication on the company's future performance. Piotroski's F_SCORE is the sum of 9 equally weighted binominal measures, which can lead to a maximum score of 9 and a minimum score of zero. As high book-to-market companies are normally financially distressed, he screens the company's balance sheets for signs that indicate a financial recovery. These signals are in the areas of (1) profitability, (2) leverage, liquidity, and source of funds and (3) operating efficiency.[16] With a portfolio formation of high F_SCORE stocks only, he backtested an annual increase of 7.5% in returns compared

[15] P/B is the reciprocal of the explained book-to-market ratio
[16] For a detailed list of all 9 measures see appendix.

to the root portfolio containing all high book-to-market firms. His test sample is based on 14043 observations for the time period 1976 – 1996 (Piotroski, 2000, p. 35).

The best seller *'The little book that beats the market'* by Joe Greenblatt published in 2005 brought new attention for investment in value stocks to a non-scientific audience. The book does not qualify for a scientific work nor does it explain methods. Greenblatt goes for a combined approach of value and quality for identifying stocks worth to buy. He invented a formula, known as the *'magic formula'*. The formula is based on two major financial indicators, earnings yield and return on capital. With this formula the reader of his book is supposed to find good companies at bargaining prices. For applying the formula on a specific market, one has to exclude foreign companies, very small companies and those operating in the utilities or financial sector first. The remaining companies are ranked equally by highest earning yields and highest return on capital. The reader of the book should now place an investment in the 20 – 30 top ranked companies and re-balance the portfolio on a yearly basis. Backtesting this formula for the time period of 1988 – 2004 in the US brought average yearly returns of 30% compared to 12% of the reference market S&P500 (Greenblatt, 2005, p. 54). There is some criticism on the book[17] and the term 'magic formula' does not immediately suggest a scientific background. But the formula in dead takes two simple, efficient inputs to pick the right stocks. Referring to Greenblatt an investor should only buy good companies (having a high ROC) at bargain prices (shown by a high earnings yield).

Bartov and Kim (2004), Larkin (2011) and Novy-Marx (2013) all examine a mixture of value approaches while adding a certain proportion of quality to their selection process for portfolio formation.

As discussed in this paragraph, there is no standard rule on how value stocks can be identified. About half a dozen financial indicators are used to differentiate value stocks from growth stocks or the rest of the market. In recent years studies using a combined approach of value and quality are getting more recognized. The following table provides some of the findings to a selection of papers. It lists the financial indicators that were used to identify value stocks and provides the geographical region of the

[17] Several blog posts suggest that the calculation of generated returns, presented in Greenblatt's book, are not replicable with the proposed method. They all point out that the formula beats the market as the book title suggests or at least that quality aspects like return on capital outperform the market. See Croft (2013) and Carlisle (2012)

stocks investigated on. Papers are selected based on the scientific relevance, medium of publication, year and relevance to the research question. The author furthermore tries to cover all common value indicators and important geographical regions.

Author	Title	Year	Main Findings	Quote	KPIs*	Time frame	Markets
Rosenberg et al.	Persuasive evidence of market inefficiency	1985	Abnormal performance can be obtained with significant results for a pure B/M strategy. A portfolio with high B/M companies outperforms one with low B/M companies. This implies furthermore that the market prices for the observed time period and stocks were inefficient.	A book/price strategy [...] lead[s] to the "inescapable conclusion" that prices on the NYSE are inefficient.	B/M	1973 - 1984	USA
Chan et al.	Fundamentals and Stock Returns in Japan	1991	The cross-sectional approach of this paper with four KPIs suggests that a outperformance of the market in Japan can be achieved by forming portfolios of value stocks	Of the four variables considered, the book-to-market ratio and cash flow yield have the most significant positive impact on expected returns	B/M, C/P, E/P, Size	1971 - 1988	Japan
Fama and French	The Cross-Section of Expected Stock Returns	1992	There is a value premium during the observed time frame. Higher returns of value stocks can be attributed to a fundamental higher risk of those investments	The systematic patterns in fundamentals gives us some hope that size and book-to-market equity proxy for risk factors in returns, related to relative earning prospects, that are rationally priced in expected returns	B/M, E/P; Size	1962 - 1989	USA
Capaul et al.	International Value and Growth Stock Returns	1993	During the time period observed value stocks, characterized by low price-to-book ratios, generate a superior performance compared to growth stocks for all observed countries	[..] suggest the existence of a significant "value-growth factor" in each country [...] Value stocks outperformed growth stocks on average [...]	P/B	1981 - 1992	France, Germany, Switzerland, UK, Japan,USA

				both absolutely and after adjustment for risk			
Lakonishok et al.	Contrarian Investment, Extrapolation, and Risk	1994	A strategy of investing in value stocks outperforms an investment in growth stocks, while appearing to be not riskier when using a conventional approach for fundamental risk	[...] Market participants appear to have consistently overestimated future growth rates of glamour [growth] stocks relatively to value stocks	B/M, C/P (+GS), E/P	1968 - 1990	USA (NYSE; AMEX)
La Porta et al.	Good News for Value Stocks: Further Evidence on Market Efficiency	1997	Value stocks generate superior returns over growth stocks. This is the result of misjudgement made by investors and the evidence is inconsistent with a risk-based explanation.	[...]expectational errors about future earnings prospects play an important role in the superior return to value stocks.	B/M, C/P (+GS), Size	1971 - 1993	USA (NYSE; AMEX; Nasdaq)
Brouwer Van Der Put Veld and Jeroen	Contrarian investment strategies in a European context	1997	Value stocks do outperform growth stocks for all four variables tested. One observed reason for this is the fact that those stocks do not underperform in bad years	The difference in return is especially remarkable for the CF/P [C/P] ratio (20.8%)	E/P, C/P, B/M, dividend yield	1982 - 1993	France, Germany, Netherlands, UK
Kargin	Value investing in emerging markets: risks and benefits	2002	A comparison among the emerging markets with an investment in value markets generates higher profits as an investment in all emerging markets while not increasing risk significantly	Prediction of emerging markets returns by book-to-price ratio, earnings-to-price ratio and past change in price allows us to generate significantly higher investment returns	P/B, E/P, add.	1976 - 2000	Diverse markets

Truong	Value investing using price earnings ratio in New Zealand	2009	Consistently superior returns can be generated by investing in value stocks with low price -to-earnings ratios in New Zealand	[superior returns] may indicate a mispricing phenomenon in the New Zealand market	E/P	1997 - 2007	New Zealand
Beukes	Value Investing: International Comparison	2011	The value premium for most tested KPIs is even higher in South Africa then it is for comparable results from studies in first world countries	[...] A “Third World” premium, which reflects the greater risk exposure with which investors in smaller, less liquid markets have to contend	B/M, C/P, E/P, GS	-	South Africa
Fama and French	Size, value, and momentum in international stock returns	2012	An outperformance of value stocks can be surveyed for the four regions examined in this paper. This value premium decreases with size, except for Japan	Integrated pricing across regions does not get strong support in our tests. [...] Even local models are less successful in tests on portfolios formed on size and momentum	B/M, size	1989 - 2011	North America, Europe, Japan, Asia Pacific (USA, Canada,)
Piotroski	Value investing: The use of historical financial statement information to separate winners from losers	2000	A pure book-to-market strategy can be increased by additional financial statement analysis. Especially investments in small and mid-sized companies show a superior performance with this approach	[...] evidence suggests that the market does not fully incorporate historical financial information into prices in a timely manner	B/M, add.	1976 - 1996	USA, unsp.

Bartov and Kim	Risk, Mispricing, and Value Investing	2004	For the purpose of this paper a value strategy generates a better stock return performance then a glamour (growth) strategy. The simple value strategy is modified by considering an additional factor	[...] Value stocks are those with high book-to-market ratios and low accruals and glamour stocks are those with low book-to-market ratios and high accruals	B/M, add.	1980 - 1998	USA
Larkin	Can individual investors capture the value premium?	2011	All tested value strategies have significantly higher returns than the value-weighted market portfolio over the sample period. Furthermore the strategies all have a higher volatility and tend to consist of smaller stocks	[...] Individual investors who are able to tolerate occasional underperformance should consider using a GARP [Growth At Reasonable Price] or value strategy in at least a portion [...]	B/M, Size, add	1998 - 2006	USA
Novy-Marx	The quality dimension of value investing	2013	This paper brings evidence to the fact, that a strategy of selecting only value stocks with certain level of quality performs better than reference models	Buying high quality assets without paying premium prices is just as much value investing as buying average quality assets at discount prices.	B/M, add.	1963 - 2012	USA
Greenwald	Value Investing: From Graham to Buffett and Beyond	2001	Using a combined formula of earnings yield (value) and return on capital (quality) the author states average yearly return can be more than doubled compared to the benchmark market		P/E, ROC, add.	1988 - 2004	USA

Table 1: Literature Review

***KPIs**: B/M: Book-to-market ratio | P/B: Price-to-book ratio | E/P: Earnings-to-price ratio | P/E: Price-to-earnings ratio | CF/P: Cash-flow-to-price ratio | Size: Size of a company measured by market capitalization | ROC: Return on capital | GS: Growth in sales | add.: Additional indicators

4. Methodology

4.1. Research Design

The preferred method in testing investment strategies is *'backtesting'*. All studies in the literature review back tested their theory with historical data. Backtesting describes the process of testing a certain model using historical data to assess the performance or accuracy of the model. This is a very commonly used method in the financial sector, but also in other areas like in meteorology to evaluate climate models. For the purpose of this thesis we use backtesting to conduct analyses on time series data in order to support or deny our research questions. A model for a stock selection process results in a certain set of rules, which can be applied to form a portfolio at a certain point in time. When such a set of rules is applied repetitively over a long time period, one can define this as an investment strategy. Different models for value investing and combined approaches of value and quality arise from the research questions. The different resulting investment strategies are evaluated in the results part of this study for the entire time horizon. We use historical data and simulate the different investment strategies in order to evaluate their performance over time. Investment decisions are always made on the information available at the point in time the decision is realized. By doing this we are able to simulate real investments and receive simulated returns for the investments. For a longer time frame we can simulate how the strategy would have performed, if we invested. The generated returns can then be compared for different strategies. Using the method of backtesting moreover has some overall advantages, namely the method is commonly known, can be performed with the data available and generates sufficient comprehensive results.

The models that we tested were all based on already known strategies as reviewed in the literature review. Development and optimisation of new models with backtesting is always limited by potential overfitting. I.e. patterns may be found in the data that just arise by accident and have no any economical relevance. Moreover simple models cannot fully reflect the highly complex environment of stock markets, with manifold influencing, independent variables. These facts as well as the limitations in the extent of a master thesis in mind are the reasons for evaluating models already established.

Companies on the German stock market typically close their fiscal year by the end of the calendar year.[18] The financial statements (including balance sheets, income statements etc.) are normally published within the first three months of the following year. In order to avoid a '*look-ahead bias'* by simulating the purchase of stocks based on information that has not been available at the time of portfolio formation, we formed the portfolios on the first trading day of April each year *(t)* based on the information provided in the financial statements of the last year *(t-1)*. Stocks remain in the portfolio for an entire year and performance is measured on the first trading day of April the following year *(t+1)*. The performance is measured by comparing the stock prices at portfolio formation with the prices at portfolio liquidation und computing the resulting return. The process of portfolio formation and liquidation is repeated on a yearly basis for the entire time period. For each indicator we form one separate portfolio every year. The different portfolios were formed based on the different indicators, which are presented in detail in the next paragraph. All stocks were equally weighted in the portfolios, without taking market capitalisation into account. This approach was chosen because of the enormous differences in market capitalisation between DAX30 heavyweights and small TecDAX companies, which might result in very low numbers of stocks for some portfolios (Brouwer Van Der Put Veld and Jeroen, 1997, p. 1354). Neither transaction cost nor dividends are part of this study.

This study examines the performance of four value strategies and evaluates if these strategies performed better than the German market for the observed time frame. The returns resulting from backtesting the different strategies are compared to one another and furthermore against a benchmark representing the German market. For this research the benchmark is defined as an equally weighted portfolio of all HDAX constituents at the first trading day in April of the respective year.[19] The returns for each portfolio as well as for the benchmark is measured in two ways:

1. Yearly performance measurement: A randomly chosen amount of money (10,000 EUR) is invested in each portfolio at the starting point and the returns generated are reinvested every year for the entire time period. The yearly change in portfolio value is measured.

[18] For the DAX30 companies only Siemens and ThyssenKrupp have their fiscal year ending by then end of September

[19] Composition of the dataset is described in chapter 'Data and Time Horizon'

2. Overlapping 5 year performance: In order to compare different time frames within the overall interval, the compound annual growth rate (CAGR) for five year periods is calculated. We expect that an investment strategy shows some effects within a 5 year time frame. The time frames are overlapping, which means that every possible five year time frame is covered *(T-4 time frames).* The performance is measured by calculating the CAGR for each of the time frames. The CAGR reflects the compound annual return rate for the returns generated within the time frame.

For both measurements purchasing of stocks is not limited to whole units only, but also fractional units of a share. Main reason for showing a cash measurement is the illustration of gain and loss over time. Furthermore growth rates for time frames different to the chosen five year frames can be calculated easily using the figures from the cash measurement.

The annual returns are calculated as follows:

$$Ra_t = \frac{P_t - P_{t-1}}{P_{t-1}}$$

Ra_t*: Portfolio return in year t*

P_t*: Portfolio value in Euro in year t*

The portfolio value for each year is calculated by summing up

the value of stocks for each company (i) included in the portfolio:

$$P = \sum_{i=1}^{N} (P_i)$$

To measure the returns of overlapping five year time frames as well as to compare the portfolio returns over the entire time period, the compound annual return is calculated as follows. This calculation is equal to the calculation of the CAGR:

$$Rc = \sqrt[n]{(Ra_1 + 1) * (Ra_2 + 1) * \dots * (Ra_n + 1)} - 1$$

Rc*: Compound return*

n: *Number of years observed*

We use different strategies based on various indicators to test annual buy-and-hold returns. As benchmark we calculate the performance of an equally weighted portfolio including all HDAX stocks of the respective year.

4.2. Risk Assessment

Applying a value strategy for portfolio formation implies that only a defined number of stocks are selected from the market to form the value portfolio. These selected stocks might be related to a higher (lower) risk than the rest of the market and therefore higher (lower) returns just reflect a fair compensation for risk. Papers reviewed in the literature review used different models for risk measurement. For the purpose of this study we use volatility of historical returns as a proxy for risk. Volatility is a commonly used and a traditional measure of risk in finance (Lakonishok et al., 1994, p. 1564). We quantify volatility of portfolio returns by the standard deviation (SD). Yearly returns of one portfolio fluctuate very strongly between years and show a dispersion from the average generated returns. To measure this dispersion from the mean, the standard deviation is used in different fields in statistical analysis. For this study the SD gives an indication on how different returns are from the mean return generated over the entire time period. The SD is calculated as follows:

$$SD = \sqrt{\frac{\sum_{t=1}^{T}(Ra_t - M)^2}{T-1}}$$

Ra_t: *Portfolio return in year t*

M: *Mean portfolio return over the entire time period*

T: *Total number of years observed*

Furthermore the *'beta'* of each strategy is calculated. Beta, or beta coefficient, is a measure for the volatility of a portfolio in comparison with the volatility of the market (Fontanills and Gentile, 2003, p. 50). As we compare portfolio returns with market returns, we consequently also compare portfolio volatility with market volatility. A portfolio, where returns fluctuate in the same way as the market returns fluctuate, has the same volatility as the market and a beta of one. Portfolios that show a higher volatility than the market over time have a beta greater than one and portfolios showing

less volatile returns have a beta lower than one. We calculate beta by dividing covariance of portfolio returns and market returns by the variance of market returns.

$$\beta = \frac{cov\ (Rm,Ra)}{var\ (Rm)}$$

$$cov\ (Rm, Ra) = \frac{1}{T - 1} * \sum_{t=1}^{T} (Ra_t - \widehat{Ra}) * (Rm_t - \widehat{Rm})$$

$$var\ (Rm) = \frac{1}{T} * \sum_{t=1}^{T} (Rm_t - \widehat{Rm})^2$$

Ra_t: *Portfolio return in year t*

$\widehat{Ra}$: *Mean portfolio return*

Rm_t: *Market returns in year t*

Rm: *Mean market return*

The standard deviation as well as beta are calculated and compared for both performance measurements, the yearly portfolio returns and the compound annual returns of the overlapping five year periods.

4.3. Indicator Selection

The part 'evidence for value investing' of the literature review lists several indicators (KPIs) that were used by published studies for identifying value stocks. As this thesis does not claim to develop new indicators, but test established ones for another market and a recent time period, we test indicators that provided evidence on the value premium. Following indicators were used most of the time, in the literature reviewed, in this order: book-to-market ratio, earnings-to-price ratio and cash-flow-to-price ratio. Several combined approaches of two-way classification or classification with multiple variables have also been used.

The book-to-market (BM) ratio is the most popular indicator for identifying value stocks among the reviewed research papers. Stocks with a high BM ratio are defined as value stocks, because the underlying company has a high book value compared to its current market value. The BM ratio has been deployed in Fama and French (1992),

Lakonishok et al., (1994) or La Porta et al. (1997) and is furthermore an element of some multi-variable approaches. For the three studies mentioned the ratio has proved to outperform glamour stock for the US market. For the purpose of this study the BM ratio is calculated by dividing the book value per share provided by the annual financial statements not older than one year with the share's price at the first trading day in April. On a yearly basis 20% of the stocks having the highest BM ratio form the value portfolios.

$$BM = \frac{BV_{t-1}}{MV_t}$$

BV: Book Value in fiscal year reporting per share
MV: Market Value first trading day in April per share

The earnings-to-price (EP) ratio has been tested among others by Fama and French (1992), Chan et al. (1991) and Brouwer Van Der Put Veld and Jeroen (1997). A high EP ratio characterises the respective stock as traded at a low price in relation to the earnings the corresponding company generated. For the purpose of this study the EP ratio is calculated by dividing earnings per share provided by the income statement not older than one year with the share's price at the first trading day in April. Value portfolios are formed on a yearly basis using 20% of the companies with the highest EP ratio.

$$EP = \frac{ESP_{t-1}}{MV_t}$$

ESP: Earnings Per Share in fiscal year reporting
MV: Market Value first trading day in April per share

Besides one-dimensional evaluation, based on a single indicator for value, we assess an improvement of value approaches by adding qualitative elements. Investments with the characteristics of simple value investing are combined with elements of quality.

Piotroski (2000, p. 3) points out that companies having a high BM ratio are normally 'financially distressed'. This situation can be caused by various reasons including poor management, unproductive employees, unrealistic budgeting, mismanaged projects or low sales. A growth in sales (GS) within the last year still indicates a good running business and loyal customers. It can be considered positive for the company's survival

and might indicate a turnaround for the business[20]. While Lakonishok et al., (1994) or La Porta et al. (1997)[21] compute growth rates in sale back five years *(t-5)*. We concentrate on the growth rate within the last year *(t-1)*. This is done in order to keep a sufficient time frame, as the first portfolio formation needs to be shifted based on the time frame that is used for growth calculation. The growth in sales is calculated as subtraction of this year's sales *t* to last year's sales *(t-1)* divided by last year's sales *(t-1)*. For portfolio formation we first select 30% of the companies with the highest BM ratio and limit the selected high BM companies to 40% with the highest growth in sales rate. With this selection portfolios are smaller as in the simple BM approach, while still being of sufficient size. Value portfolios are formed on a yearly basis. The GS rate is calculated as follows:

$$GS = \frac{S_t - S_{t-1}}{S_{t-1}}$$

S: Sales in fiscal year reporting

The magic formula developed by Greenblatt (2005) became very famous within the last decade. To incorporate quality, Greenblatt uses Return on Capital (ROC) in his magic formula. ROC is calculated by dividing a company's earnings before interest and taxes (EBIT) by a company's tangible capital employed. The denominator is defined as net working capital (nWC) plus net fixed assets (nFA). For indicating a proper valuation of the investment object, Greenblatt uses earnings yield in his formula. Earnings yield (EY) is a slightly different form of the EP ratio, which still focuses on the performance of a company. The magic formula's earnings yield is calculated by dividing a company's earnings before interest and taxes (EBIT) by the company's enterprise value. We deploy the two factors in the way Greenblatt suggests. Companies are ranked separately by high earnings yield and high return on capital. In case one of the indicators cannot be calculated, the highest rank possible is assigned. For portfolio formation we combine the two indicators equally. Greenblatt suggests to invest in 20-30 companies, for our data sample we invest in 20% of the highest ranked companies. In contrast to the magic formula we will not exclude utilities as they did not

[20] Cases where loss-making activities have been sold, resulting in declining sales, can also indicate a turnaround and are not considered by this approach

[21] Lakonishok et. al. (1994) and La Porta et. al. (1997) both test a contrarian strategy investing in stocks with a low growth in sales rate, while we test for companies with a high increase in sales.

show any clustering when the formula was tested. In line with the magic formula, financials are excluded. Furthermore market capitalisation is not a criteria.

$$ROC = \frac{EBIT}{nWC+nFA}$$

$$EY = \frac{EBIT}{EV}$$

EBIT: Earnings Before Interest and Taxes
nWC (net Working Capital): Total Current Assets - Excess Cash - Total Current Liabilities
nFA (net Fixed Assets): Total Assets - Total Current Assets - Total Intangible Assets
EV (Enterprise Value): Market Value of Common Stocks + Long-Term Debt + Minority Interest + Market Value of Preferred Stocks - Excess Cash

Magic Formula = Rank(Rank(ROC) + Rank(EY))

4.4. Data and Time Horizon

This study examines data for the period from December 1998 to April 2015. We evaluate annual financial statements data in combination with daily stock prices. By using this time period this research covers two major crises affecting the German market. The Dot-com Bubble, with its climax in March 2000, as well as the financial crisis starting in 2008 and the following so called Eurozone crisis (2009) can be observed. The simulated purchase of stocks was performed from April 1999 till April 2015, covering 16 portfolio formations and liquidations. The period includes economic downturns as well as upturns.[22]

We extracted company and stock data from DataStream, which is part of Thomson Reuters. DataStream is an application providing access to financial and macroeconomic data, among others e.g. stock prices, company fundamentals, stock market indices, currencies and economic indicators.

[22] The following article tries to give some explanations on up- or downturns in Germany for the time period observed: The Economist (2014): Why the German economy is in a rut

The data comprises available information for companies of three major German stock indices, the DAX30, MDAX and TecDAX. In line with most research in this area, financial service companies were excluded, because their fundamental variables differ heavily from those of companies in other areas (Brouwer Van Der Put Veld and Jeroen, 1997, p. 1356). DAX30, MDAX and TecDAX are summarized as HDAX. The HDAX summarises the three leading German indices, covering 95% of market capitalisation.[23] Thus, not only huge companies that are highly followed by analysts, but also mid and small sized companies and a variety of branches are represented. Generally the three indices include 110 companies (including financials). In order to avoid the mentioned survival bias, the overseeing of companies that went bankrupt, we also include companies that disappeared in all of the indices. The TecDax stock index was initially set up in 2003. Data from 2003 onwards is taken into account. This has the limitation of losing interesting data from the time of the German new market (NEMAX50), while this data is often incomplete in the source system.

The German market is used as a benchmark for comparing the performance of the different strategies with the market performance. DAX or HDAX could just serve as a benchmark. The commonly quoted DAX index and HDAX index are both performance indices, including dividend payments. The Deutsche Börse Group also provides data on the HDAX price index, excluding dividend payments. But as we exclude companies in financial services the results might suffer from a bias. Therefore market performance is calculated as the equally weighted performance of all HDAX stocks of the dataset for the respective year.

4.5. ETL Processing

All data can be extracted in Excel format from DataStream. One file per company providing the main financial statements data for each year and another file per company providing stock prices for every trading day are provided by the tool. The stock prices are adjusted for stock splits or reverse splits. Lists for extracting several files at one time can be generated, but in order to get data for each company that has been listed during the observed time frame, manual effort has been required.

Data transformation is done in Excel immediately. For the company's financial statements files we used several VBA scripts to transform data. Using VBA has the

[23] As stated by Deutsche Börse Group (HDAX® | DAX-Indices.com, 2016)

advantage of convenient transformation within Excel without changing to another program. Furthermore it allows renaming and converting of the financial statements files to a comma separated values (CSV) output format. The file format CSV is very convenient and can be handled by the majority of programs for data analysis. The process starts with transposing each spreadsheet in order to have the years as rows and each position of the financial statement as a column. This makes calculations within one year easier. Furthermore some irrelevant data is deleted and several fields are renamed. The time series data on stock prices is converted to CSV using a complex PowerShell script.

After transformation we have two files per company, one including the financial statements data with one row per fiscal year and the other one including daily stock prices of the company for the whole time frame. These files serve as raw data for the backtesting implementation done in the statistical computing program R. CSV files can be loaded into R without additional packages which makes this approach overall very suitable. All files are loaded into R using loops. After loading all files, we have two files per company, financial statements as well as price data. For combining financial statements datasets with time series datasets a variable called *'ticker'* is used later on. The ticker serves as unique identifier for each company.

For visualization of the results the business intelligence software Tableau is used instead of R packages. Tableau is a data visualization software, which is easy in usage and preferred by the author.

The used tools, in particular Excel, PowerShell and R, are commonly used and very well know. By using this software bundle we try to fulfil the scientific principles of transparency and reproducibility.

4.6. Backtesting Implementation

The backtesting has been implemented in R. Portfolios, including the respective constituents of the three indices DAX30, MDAX and TecDAX, are formed on a yearly basis. We created yearly slices of the financial statement data of all relevant companies in order to perform the value portfolio formation. Value portfolios for each year are formed for each strategy separately, based on the indicators. For calculation of most indicators, the market value, i.e. stock price * number of stocks issued, of the company at portfolio formation time is needed. Therefore we extract the stock price of the first

trading in April of each company and merge the stock price with the financial statements data of the last year. This can be illustrated as follows:

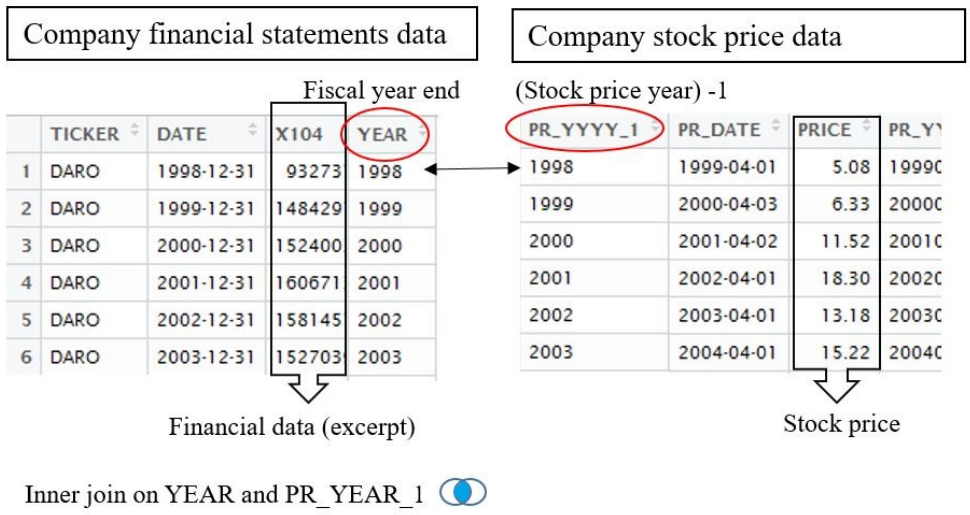

Figure 1: Merge Financial and Price data

Calculation of the ratios and the respective yearly portfolio formation was implemented as follows:

(1) BM: In the financial statements data the book value per share at financial year's close is provided. We calculate the BM by dividing the book value per share by the stock price on the first trading day in April the following year.
This is done for all companies for each year. The yearly portfolios are formed out of the highest 20% of all relevant companies. Missing values are excluded before portfolio formation. The outcome is one dataset per year including the companies we want to invest in.

(2) EP: We calculate the EP by dividing the earnings per share by the stock price on the first trading day in April the following year. The earnings per share (EPS) are calculated by (net income – dividends on preferred stocks) / outstanding shares. The EPS is given in the financial statements data for each fiscal year.
This is done for all companies for each year. The yearly portfolios are formed out of the highest 20% of all relevant companies. Missing values are excluded before portfolio formation. The outcome is one dataset per year containing the companies we want to invest in.

(3) Growth in Sales for high BM companies: The financial statements data incorporates overall sales of the company on a yearly basis. The growth rate is calculated for a company by dividing the difference of this year's sales and last year's sales by last year's sales. The portfolio is formed in two steps. Out of all companies, the 30% that have the highest book-to-market value (as calculated in the one indicator classification) are pre-selected. Out of the pre-selection the portfolio is formed by picking 40% of the companies having the highest growth in sales rates of the last year. The first portfolio can be formed one year after data is available (t_0+1).

(4) Adapted Magic Formula: The approach conducted in this study does not exactly represent Greenblatt's magic formula, e.g. utilities are not excluded, but takes the two leading indicators of the formula into account. We calculate the return on capital and the earnings yield for every company on a yearly basis. All companies are ranked based on the two indicators separately in descending order and a rank number is assigned to each company. We merge both rankings by company and calculate an overall ranking of the companies by summing both assigned numbers. The portfolio is formed using those companies ranked in the top 20%. We generated one dataset per year with the companies we want to invest in.

5. Results

The following paragraph on results is divided into four sections: The first part gives insights into the data used for backtesting by presenting descriptive statistics. The second part presents the main findings of this study including the results that were back tested by applying models for the yearly portfolio formation process over the entire time period, based on the indicators described. We examined four models for portfolio formation, which resulted in four strategies. The four strategies are named similar to the indicators that were used for portfolio formation:

(1) BM – High book-to-market strategy
(2) EP – High earnings-to-price strategy
(3) GS – High book-to-market companies having a high growth in sales strategy
(4) MF – Adapted magic formula strategy

Each strategy is evaluated separately and the yearly returns as well as the compound annual growth rates of five year time frames are compared to the benchmark.

The third part of the results presents risk considerations for all strategies. A summary closes this paragraph.

5.1. Descriptive Statistics

The table below shows two numbers for every strategy. On a yearly basis we counted the number of stocks, where data for the indicator calculation was available (N ALL) and the number of stocks, which were used to form the value portfolio (N VAL). Furthermore we display the average book-to-market value (AVG BM) as well as the average earnings-to-price ratios (AVG EP) for the respective value portfolios of both one-dimensional strategies tested. Average ratios for growth in sales and the magic formula indicators are part of the appendix, as they are not commonly used in the literature reviewed.

YEAR	BM			EP			GS		MF	
	N ALL	N VAL	AVG BM	N ALL	N VAL	AVG EP	N ALL	N VAL	N ALL	N VAL
1999	55	11	0.868	55	11	0.104	-	-	61	12
2000	78	16	1.029	78	16	0.108	61	7	79	16
2001	80	16	1.173	80	16	0.114	74	9	81	16
2002	87	17	1.165	87	17	0.118	74	9	88	18
2003	71	14	2.213	71	14	0.211	67	8	73	15
2004	90	18	1.143	90	18	0.091	67	8	93	19
2005	91	18	0.997	91	18	0.107	83	10	94	19
2006	93	19	0.758	93	19	0.081	88	10	94	19
2007	92	18	0.708	92	18	0.119	85	10	92	18
2008	95	19	0.907	95	19	0.142	88	10	95	19
2009	99	20	2.615	100	20	0.298	90	11	100	20
2010	99	20	1.132	99	20	0.096	94	11	99	20
2011	99	20	1.123	99	20	0.128	93	11	99	20
2012	102	20	1.592	102	20	0.126	95	11	102	20
2013	100	20	1.175	100	20	0.129	94	11	100	20
2014	97	19	0.924	97	19	0.089	93	11	100	20

Table 2: Descriptive Statistics

The number of companies having historical data on the different indicators available increases steadily over time. From 2003 onwards data for TecDAX companies was available, which resulted in a higher overall number of stocks available for investigation. For the BM-, EP- and MF strategy yearly portfolios consisted of 11 to 20

companies. Only the GS strategy by its definition has lower number of stocks included in its yearly value portfolios.

The average book-to-market value differed a lot between 0.708 and 2.213 within the observed time frame of 16 years. E.g. in 2003 the average company in the BM value portfolio had a book value which was 2.213 times higher than the market value of its stocks. The average earnings-to-price ratio ranked between 0.081 and 0.298. E.g. for the year 2009 the earnings of the average company in the EP value portfolio was at a level of 0.298 times its stock price.

5.2. Main Findings:

(1) Book-to-Market Strategy

Book-to-Market Strategy							
Yearly performance					**5 year performance**		
Year	**Investment**	**Divestment**	**One Year Return**	**Market Return**	**Timeframe**	**CAGR**	**Market CAGR**
1999	10000.00	9609.56	-0.0390	0.0726			
2000	9609.56	11148.92	0.1602	-0.0030			
2001	11148.92	12263.01	0.0999	0.0226	1999 - 2004	0.0350	0.0255
2002	12263.01	6297.96	-0.4864	-0.3592	2000 - 2005	0.0522	0.0260
2003	6297.96	11875.34	0.8856	0.6183	2001 - 2006	0.1090	0.1029
2004	11875.34	12393.49	0.0436	0.0754	2002 - 2007	0.1285	0.1342
2005	12393.49	18698.67	0.5088	0.4306	2003 - 2008	0.2608	0.2129
2006	18698.67	22440.73	0.2001	0.1763	2004 - 2009	-0.0041	-0.0208
2007	22440.73	20066.73	-0.1058	-0.1035	2005 - 2010	0.1853	0.0890
2008	20066.73	11632.41	-0.4203	-0.4451	2006 - 2011	0.1119	0.0489
2009	11632.41	29000.07	1.4930	0.8292	2007 - 2012	0.0253	0.0006
2010	29000.07	31782.11	0.0959	0.1863	2008 - 2013	0.0394	0.0401
2011	31782.11	25421.90	-0.2001	-0.0709	2009 - 2014	0.2328	0.2307
2012	25421.90	24345.72	-0.0423	0.0881	2010 - 2015	0.0521	0.1252
2013	24345.72	33122.97	0.3605	0.2870			
2014	33122.97	37380.79	0.1285	0.1684			
Compound annual return:			**0.0859**	**0.0788**	**Mean CAGR:**	**0.1023**	**0.0846**

Table 3: Findings Book-to-Market Strategy

For the 16 years observed a strategy based on high BM stocks generated above market returns in eight years. We can see that the tested BM strategy outperformed the market in eight years, while equally underperformed the market also in eight years. Deploying an one year buy and hold strategy for high BM stocks over the entire time

period resulted in 8.59% compound annual returns. The same strategy deployed for the benchmark portfolio generated compound annual returns of 7.88%.

Simulating the same strategy in different 5 year time frames resulted only in one period generating negative compounding annual returns. This is true for the book-to-market strategy as well as for the market itself. For the time frame 2004 – 2009 average generated yearly returns are negative.

By applying backtesting, we show that an investment strategy based on high BM stocks generated higher returns for the observed time period.

(2) EP Strategy

Earnings-to-Price Strategy							
Yearly performance					5 year performance		
Year	Investment	Divestment	One year Return	Market Return	Timeframe	CAGR	Market CAGR
1999	10000.00	9441.11	-0.0559	0.0726			
2000	9441.11	10801.73	0.1441	-0.0030			
2001	10801.73	10953.31	0.0140	0.0226	1999 - 2004	0.0293	0.0255
2002	10953.31	6610.51	-0.3965	-0.3592	2000 - 2005	0.0836	0.0260
2003	6610.51	11554.22	0.7479	0.6183	2001 - 2006	0.1388	0.1029
2004	11554.22	14106.21	0.2209	0.0754	2002 - 2007	0.1753	0.1342
2005	14106.21	20685.36	0.4664	0.4306	2003 - 2008	0.3079	0.2129
2006	20685.36	24561.79	0.1874	0.1763	2004 - 2009	0.0337	-0.0208
2007	24561.79	25298.44	0.0300	-0.1035	2005 - 2010	0.1342	0.0890
2008	25298.44	13634.60	-0.4611	-0.4451	2006 - 2011	0.1025	0.0489
2009	13634.60	26471.78	0.9415	0.8292	2007 - 2012	0.0636	0.0006
2010	26471.78	33697.07	0.2729	0.1863	2008 - 2013	0.0423	0.0401
2011	33697.07	33424.94	-0.0081	-0.0709	2009 - 2014	0.2543	0.2307
2012	33424.94	31128.28	-0.0687	0.0881	2010 - 2015	0.1340	0.1252
2013	31128.28	42328.48	0.3598	0.2870			
2014	42328.48	49632.74	0.1726	0.1684			
Compound annual return:			**0.1053**	**0.0788**	**Mean CAGR:**	**0.1249**	**0.0846**

Table 4: Findings Earnings-to-Price Strategy

The earnings-to-price strategy showed a better performance than the market in 11 of the 16 investment periods observed. When we analyse the changes within the simulated cash investment of 10,000 EUR initially, it is important to note that the investment dropped by 39% from April 2002 to April 2003. The development resulted in a remaining amount of money of 6,610 EUR at the first trading day in April 2003.

The overall development in one year returns is relatively similar to the book-to-market strategy, while loss and gain are not as distinct. Overall the EP strategy simulated compound annual returns of 10.53% over the entire time period, compared to 7.88% compound annual market returns.

When we look at the compound average performance of the five year subsets, we notice that in none of the time frames a negative CAGR was generated. Even within the years 2004 – 2009, when a negative growth rate for the benchmark was simulated, the EP strategy generated a CAGR of 3.37%. We furthermore observe two outperforming good time frames between 2003 and 2008 and between 2009 and 2014. These outstanding time frames are in line with market returns, even though market rates are lower.

Concluding the results simulated we discover an outperformance of the strategy of investing in high EP companies over the market. Compound annual returns for the yearly performance measurement over the entire 16 year time period were 2.65% higher than the respective market returns.

(3) GS Strategy

Growth in Sales Strategy							
Yearly performance					5 year performance		
Year	Investment	Divestment	1YR Return	Market Return	Timeframe	CAGR	Market CAGR
2000	10000.00	11226.51	0.1227	-0.0030			
2001	11226.51	11971.15	0.0663	0.0226			
2002	11971.15	10301.34	-0.1395	-0.3592	2000 - 2005	0.1629	0.0260
2003	10301.34	17198.54	0.6695	0.6183	2001 - 2006	0.2602	0.1029
2004	17198.54	21267.54	0.2366	0.0754	2002 - 2007	0.3227	0.1342
2005	21267.54	35680.93	0.6777	0.4306	2003 - 2008	0.3312	0.2129
2006	35680.93	48469.37	0.3584	0.1763	2004 - 2009	0.0311	-0.0208
2007	48469.37	43062.32	-0.1116	-0.1035	2005 - 2010	0.2015	0.0890
2008	43062.32	20042.63	-0.5346	-0.4451	2006 - 2011	0.1251	0.0489
2009	20042.63	53257.05	1.6572	0.8292	2007 - 2012	0.0047	0.0006
2010	53257.05	64336.67	0.2080	0.1863	2008 - 2013	0.0260	0.0401
2011	64336.67	49609.56	-0.2289	-0.0709	2009 - 2014	0.2676	0.2307
2012	49609.56	48958.61	-0.0131	0.0881	2010 - 2015	0.0872	0.1252
2013	48958.61	65599.20	0.3399	0.2870			
2014	65599.20	80883.35	0.2330	0.1684			
Compound annual return:			**0.1495**	**0.0793**	**Mean CAGR:**	**0.1655**	**0.0900**

Table 5: Findings Growth in Sales Strategy

For the growth in sales strategy the first investment is simulated for 1st April 2000, one year later than for all other strategies. For making an investment decision based on this strategy, the growth rate in sales has to be calculated. The calculation is based on the comparison of companies' figures of different years. Due to data only being available from 1998 onwards, we calculated first growth rates in sales from 1998 to 1999, resulting in an initial investment decision in 2000.

Looking at the cash development over the 15 years observed, we notice that the overall investment capital never fell below the initial investment of 10,000 EUR. The GS strategy underperformed the market in only 4 out of 15 times. The highest yearly return was simulated for 2009 with an investment in 11 companies (see descriptive statistics). The long-term simulated performance of the measured yearly returns is unusual. The GS strategy generated compound annual returns of 14.95%, which is an uplift of more than 7% compared to market returns.

The simulated five year performance respectively starts in 2000. Within the 11 time frames observed, we backtested five time frames with a CAGR of more than 20%. The

CAGR is lowest for the time frame between 2007 and 2012, while not turning negative at any time.

The growth in sales strategy is an enhancement of the simple book-to-market strategy. By comparing the compound annual returns of both strategies we can conclude that the consideration of growth in sales in the portfolio formation process had a positive effect on returns generated. Simulating the first investment for the GS strategy in 2000 instead of 1999 had a positive effect on the overall performance, because 1999 was characterized by falling stock prices. However, the exclusion of this year cannot serve as single explanation for the good performance of the GS strategy as seen in the following chart that shows value change of BM- and GS portfolios as well as in the benchmark portfolio over the entire time period based on yearly returns:

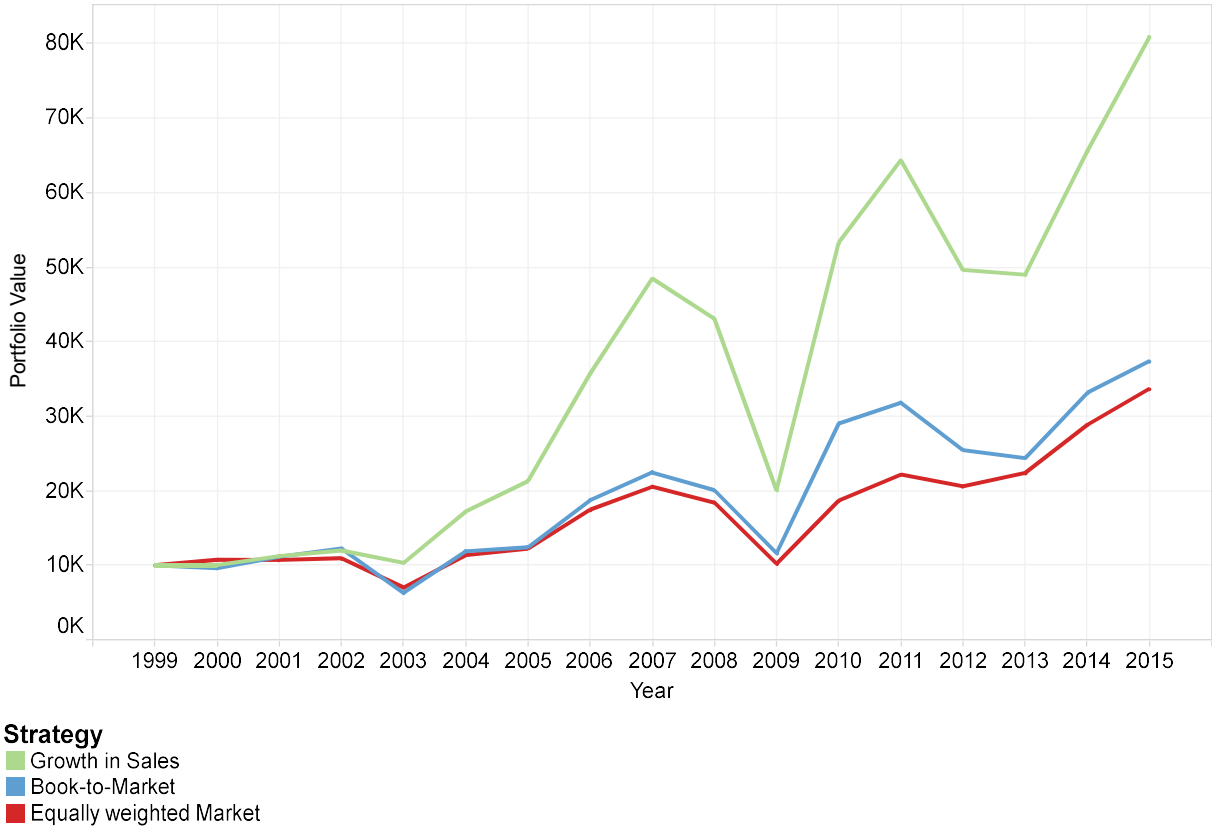

Figure 2: BM vs. GS Portfolio Value

(4) MF Strategy

Adapted Magic Formula Strategy							
Yearly performance					**5 year performance**		
Year	**Investment**	**Divestment**	**One Year Return**	**Market Return**	**Timeframe**	**CAGR**	**Market CAGR**
1999	10000.00	9920.66	-0.0079	0.0726			
2000	9920.66	12655.39	0.2757	-0.0030			
2001	12655.39	14818.40	0.1709	0.0226	1999 - 2004	0.1407	0.0255
2002	14818.40	11874.98	-0.1986	-0.3592	2000 - 2005	0.1759	0.0260
2003	11874.98	19310.10	0.6261	0.6183	2001 - 2006	0.1897	0.1029
2004	19310.10	22302.91	0.1550	0.0754	2002 - 2007	0.2084	0.1342
2005	22302.91	30165.05	0.3525	0.4306	2003 - 2008	0.2248	0.2129
2006	30165.05	38184.62	0.2659	0.1763	2004 - 2009	-0.0164	-0.0208
2007	38184.62	32734.05	-0.1427	-0.1035	2005 - 2010	0.0860	0.0890
2008	32734.05	17779.23	-0.4569	-0.4451	2006 - 2011	0.0770	0.0489
2009	17779.23	33683.62	0.8945	0.8292	2007 - 2012	0.0138	0.0006
2010	33683.62	43708.78	0.2976	0.1863	2008 - 2013	0.0661	0.0401
2011	43708.78	40900.36	-0.0643	-0.0709	2009 - 2014	0.2792	0.2307
2012	40900.36	45090.93	0.1025	0.0881	2010 - 2015	0.1864	0.1252
2013	45090.93	60900.70	0.3506	0.2870			
2014	60900.70	79160.91	0.2998	0.1684			
Compound annual return:			**0.1380**	**0.0788**	**Mean CAGR:**	**0.1360**	**0.0846**

Table 6: Findings adapted Magic Formula

By comparing the simulated annual returns of the adapted magic formula with the ones of the market, we detect an outperformance of the MF strategy in ¾ of the examined years. A further investigation in the negative returns, generated by backtesting the adapted magic formula, does not lead to the conclusion that negative trends are more pronounced when applying this strategy. We can furthermore notice, that the MF strategy generated exceptionally high annual returns within the last two investment cycles (2013: 35.06% and 2014: 29.98%), without a negative return in the previous year. The same is true for 2005 (35.25%) and 2006 (26.59%). Overall the MF strategy generated 5.92% higher compound annual returns than the market over the entire time period of 16 investment intervals.

When looking at the average annual performance in the five year time frames, we observe three times a CAGR above 20% and once a negative CAGR.

The adapted magic formula includes earnings yield as one driving indicator in the portfolio formation process. Even though this indicator is not calculated in exactly the same way as the earnings-to-price ratio, both indicators use last year's earnings to

rank stocks. Therefore we compare the change in portfolio value of the EP- and the MF strategy with each other and with the benchmark. This comparison gives an indication, if qualitative elements, as used in the adapted magic formula, can improve the performance of the one-dimensional EP value strategy. The graph shows a higher portfolio value at the end of the last investment period for the MF strategy compared to the EP strategy.

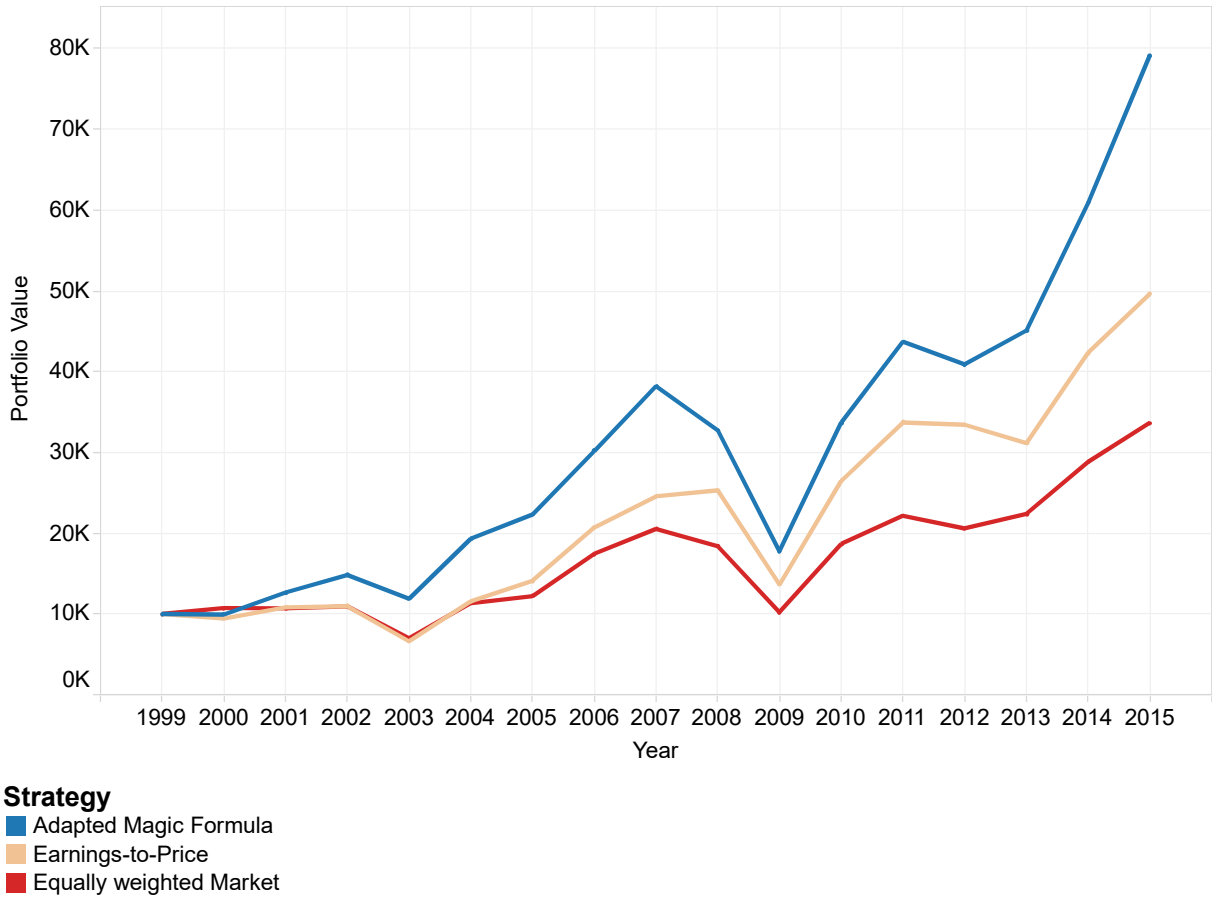

Figure 3: EP vs. MF Portfolio Value

5.3. Risk Consideration

This study used volatility of returns, measured by the standard deviation, as a proxy for risk. The following table presents the standard deviation of the yearly returns for each strategy and the standard deviations of the CAGRs for the five year time frames. Furthermore the beta, for measuring volatility in comparison with the market, is presented:

Strategy	One year return		5 year CAGR	
	SD	Beta	SD	Beta
Equally weighted Market	0.3215	-	0.0801	-
Book-to-Market	0.4847	1.4431	0.0856	0.9377
Earnings-to-Price	0.3623	1.0932	0.0871	1.0318
Growth in Sales*	0.5074	1.4237	0.1200	1.1701
Adapted Magic Formula	0.3233	0.9617	0.0903	0.9579

* Beta calculation with market returns from 2000 onw.

Table 7: Standard Deviation and Beta

The standard deviation observed for the yearly annual returns shows a higher fluctuation of returns among strategies based on the book-to-market ratio. For the BM- as well as the GS strategy volatility in yearly returns was higher compared to the market. The EP strategy showed a slightly higher volatility than the market, while the MF strategy is almost equal to the market in terms of volatility.

The calculated betas on yearly returns suggest, that approaches based on the book-to-market value have a much stronger fluctuation then the benchmark. The book-to-market strategy has a beta of 1.44, theoretically suggesting 44% higher volatility in returns than the market. The growth in sales strategy, which is also based on high BM stocks, generated more volatile returns than the market, too. The earnings-to-price strategy has a beta of 1.09, suggesting that returns were slightly more volatile than the market returns. The adapted magic formula has a beta below one, indicating that the returns were less volatile than the market returns.

The standard deviations for the 5 year CAGR figures for all strategies are much lower than for the annual returns, which indicates a smoothing effect due to more time periods being included. The betas are also much lower for all strategies. Noticeable is the beta below one for the book-to-market strategy.

5.4. Summary

Section four of the results paragraph summarises and links parts of the descriptive statistics, main findings and risk considerations.

The insights on the average book-to-market value gained in the descriptive statistics, in combination with the yearly market returns simulated for the BM strategy, shows a strong correlation between average book-to-market ratio and yearly simulated returns. In 2003 and 2009 the highest annual returns were simulated for the BM strategy. These returns were generated by companies with the, on average, highest book-to-market ratios in the value portfolios. We calculated a correlation coefficient[24] of 0.77, indicating a strong correlation between average book-to-market value of the value portfolios and yearly returns simulated. The correlation for the average earnings-to-price ratios and the yearly returns generated in the respective value portfolio is lower, but still significant, at a level of 0.59.

Negative returns occur very similar for all tested strategies. For the four strategies evaluated we traced negative yearly returns in 1999 (for 3 out of the 3 tested strategies), 2002 (4/4), 2007 (3/4), 2008 (4/4), 2011 (4/4), 2012 (3/4). A maximum negative return was tested for the growth in sales strategy with negative returns of 53.46% in 2008.

Looking at the CAGRs of the four year performance measurement, we see only two time frames for all strategies that generated a negative yearly compound growth rate. For the BM- and the MF strategy negative five year CAGRs were simulated for the time frame 2004 – 2009 (BM: 0.41%; MF: 1.64%). This poor result can be explained by negative influences of the financial crisis at the end of 2007 and in 2008 included in this time frame. The exceptionally high returns between April 2009 and April 2010, generated based on the investment decision in 2009, are not part of this time frame.

Connecting the figures of the risk considerations section with the main findings on simulated returns shows the complete picture of the tested investment strategies. As a comparative illustration on returns and related risk, we illustrate compound annual returns and standard deviations as simulated for all strategies and the market:

[24] Correlation measures the linear relationship between two variables (James et al., 2013, p. 70)

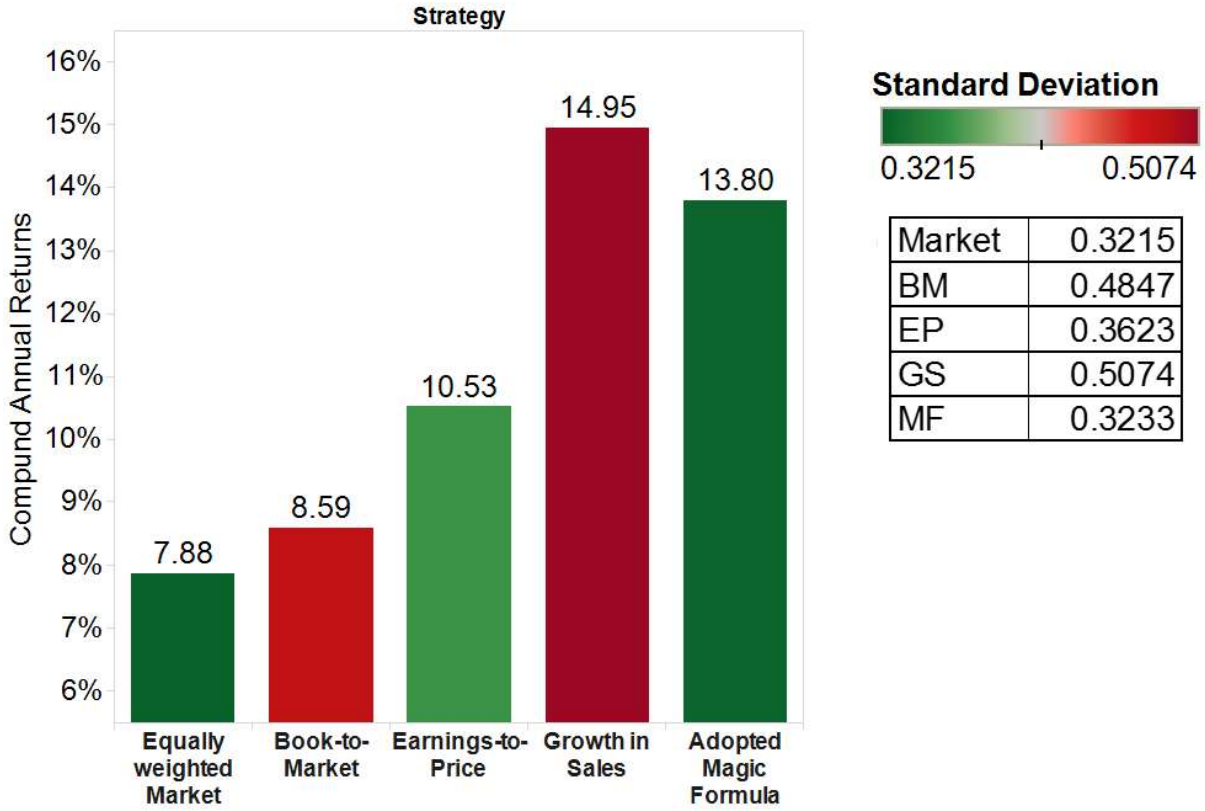

Figure 4: Return and Standard Deviation

This figure illustrates that mixed approaches of value and qualitative elements performed best in our backtest. The consideration of the qualitative elements (GS: growth in sales; MF: return on capital) seems to improve simple value investment approaches. The illustration furthermore highlights the standard deviation related to each strategy. If we assume a normal distribution of returns we can conclude the following:

For the growth in sales strategy returns fell in 95% of the years into an interval of -84.5% to +114.4%[25]

and for the adapted magic formula strategy returns fell in 95% of the years into an interval of -49.56% to +77.16%

[25] Calculation: 0.1495 +/- (1.96 * 0.5074); For an explanation on confidence interval see James et al. (2013, p. 66)

6. Discussion

6.1. Investment strategies

The conducted backtest showed an outperformance of all strategies over the benchmark, representing the German market. The above market returns for one-dimensional strategies are consistent with past findings from the US market conducted by Lakonishok et al. (1994) or the European market examined by Brouwer Van Der Put Veld and Jeroen (1997).

Furthermore we see that an enlargement of the one-dimensional approaches by qualitative indicators lead to higher compound annual returns for the entire time period. A growth in sales strategy in the tested form has not been part of extensive research so far. Compared to the simple BM strategy we simulated a huge improvement in returns by considering a single quantifiable qualitative indicator. Piotroski (2000) also used companies' financial statements data of consecutive years to improve a simple BM strategy.

Greenblatt documented an outperformance of the magic formula over the S&P500. The results for the magic formula simulated in the German market are in line with Greenblatt's findings, even though we only used the same indicators and not exactly the same approach and did not see an outperformance to the same extent.

In line with the efficient market hypothesis, the abnormal performance of a tested value strategy could be explained by a different risk related to the respective portfolio. Measuring risk, with volatility as a proxy, leads to the conclusion, that at least two approaches generated much more fluctuating returns than the market. The BM- as well as the GS strategy both generated higher but also more fluctuating returns than the market. The EP strategy generated 2.65% higher yearly returns at a slightly higher level of volatility than the market. The only strategy that outperformed the market, and at the same time kept volatility in returns at a similar level to the market, is the adapted version of the magic formula. For the German market we can conclude that portfolios based on the two indicators of the magic formula outperformed the market while not being riskier.

The discussion on expected returns in the literature review already showed the difficulties in measuring and quantifying risk. Warren Buffett sees 'quotational declines' (Berkshire Hathaway Inc., 2014, p. 18) as unimportant for long-term investors and

points out that permanent loss of money is much more fatal.[26] Schwager describes other measures for risk and argues that volatility should not necessarily be seen as a proxy for risk, but only as 'the part that can be quantified easily' (Schwager, 2013, p. 103). Volatility might serve as a good proxy for risk for some investors, but various investors have diverse investment horizons, goal and expectations on returns. Volatility is commonly used as a proxy for risk, but only reflects a part of the risk involved.

The strong correlation between book-to-market value and generated returns is something we did not have in mind at the beginning of this research. A closer look on the historical development of the HDAX price index suggests that the high difference in the book-to-market value over the years is mainly driven by the denominator.

6.2. Limitations

For the purpose of this study we used backtesting to evaluate the performance of value strategies for the German market. Besides the already mentioned advantages of backtesting, e.g. being commonly known and applicable with the data available, we also have to mention limitations of this method. By only simulating what would have happened if we had invested, we do not participate in the market. Therefore the investments simulated did not have any impact on the market. With real investments we generate a higher demand for a stock which might have an influence on the price. This effect cannot be avoided, when historical data is processed.

The already mentioned survival bias can be a limitation, when backtesting is performed. The descriptive statistics show that more data for calculating the indicators is available from 2003 onwards. Still, for some companies data is missing. This lack of data might have skewed results to a certain extent. In order to avoid a survival bias, we generally tried to incorporate data for all companies listed in the HDAX at the time of portfolio formation. Furthermore we formed an equally weighted portfolio of relevant stocks as a benchmark to compare returns generated. The quality and completeness of data is essential when performing a backtest.

As any other metric used to quantify a company's value, the examined economic ratios have some specific limitations. The BM value as well as the EP ratio have a branch specific behaviour and can vary a lot among companies operating in different sectors. For some ratios a comparison among different sectors is not appropriate, e.g. a high

[26] See comments of Fieber (2015) on Berkshire Hathaway's annual letter from Warren Buffett

leverage in banks is usual while it has specific motivations in other industries (Fama and French, 1992, p. 429). For this reason banks, insurances and real estate companies have been excluded from the data sample. There might be a dramatic difference among other sectors as well. An analysis on the portfolios of high BM firms did not indicate a sector specific clustering.

We stated in the methodology part of this study that dividend payments and transaction costs are excluded. Indeed, dividend payments are a significant part of the overall returns and charges and fees in conjunction with stock transactions cannot be avoided. This is a limitation shared with a lot of other studies in this area.

The risk assessment was conducted using volatility and beta as quantifiable measurements. Other measures like value at risk, quantifying a worst case scenario, are generally accepted and used in science. Due to limitations in time and extent we did not evaluate other forms of risk assessment.

6.3. Suggestions on further research

Consistent with other studies in this area, we excluded financial service companies in this research. These companies represent a not irrelevant part of the DAX30 constituents. Furthermore some major banks faced tremendous challenges during the financial crisis of 2007 – 2009, which might have had a huge impact on portfolio returns. Brouwer Van Der Put Veld and Jeroen (1997) incorporated a structural correction for countries as well as for industries. It would be interesting to incorporate an industry specific correction and evaluate the returns with financial service companies included.

We measured returns for a one year buy and hold strategy. For long-term investors other holding periods might be more interesting. Further research could investigate on returns generated for other holding periods

Although the time period of 16 years, observed in this study, gives sufficient answers to the questions addressed, it would still be an interesting field of research to enlarge this time period. Historical data availability was limited to a certain extent at the sources that were used for this study. For future studies more data will be available and additional sources might close the gap of missing historical data.

The correlation between BM ratio and generated returns would be an interesting field of further research.

7. Conclusion

The German stock market showed some signs of inefficiency during the time from 1999 to 2014. We detected an outperformance in returns of value stock over the market. The extensively tested book-to-market ratio generated higher returns than the market, while these might be allocated to higher risk in the portfolios. The same is true for the growth in sales strategy, an enlargement of the book-to-market strategy by integrating the growth rate in sales as an indicator. Whereas the tested returns for this strategy offer opportunities for risk oriented investors. The earnings-to-price ratio served very well as an indicator and generated above market returns. The volatility in returns was moderately above the market. The magic formula showed an outperformance that cannot be explained by higher risk. A strategy with the indicators of the magic formula generated 5.92% higher compound annual returns than the market, while volatility in returns was lower. We were not able to find an explanation for these unusual returns.

Therefore we can answer the research questions by stating that one-dimensional value strategies outperformed the market and that an enlargement with qualitative elements made an improvement on returns.

During the financial crisis between 2007 and 2008 all tested value strategies provided stable performance. In a yearly time frame none of the strategies generated positive returns while the rest of the market was falling tremendously. But on five year time frames containing these two years the value strategies overall performed much better than the market.

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APPENDIX

Appendix A: F-Score Piotroski

- Positive return on assets in the current year
- Positive operating cash flow in the current year
- Higher return on assets (ROA) in the current period compared to the ROA in the previous year
- Cash flow from operations are greater than ROA

Profitability

- Lower ratio of long term debt to in the current period compared value in the previous year
- Higher current ratio this year compared to the previous year
- No new shares were issued in the last year

Leverage, Liquidity and Source of Funds

- A higher gross margin compared to the previous year
- A higher asset turnover ratio compared to the previous year

Operating Efficiency

cf.: http://www.investopedia.com/terms/p/piotroski-score.asp

Appendix B: Data Cleaning

MDAX®

Date of change	Date of announcement	Deletion	Addition
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	25/01/2007	Bayer. Hypo- und Vereinsbank	[illegible] & Co
19/03/2007	05/03/2007	Schwarz Pharma	Symrise
[illegible]	[illegible]	[illegible]	[illegible]

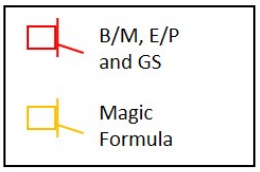
(1) Symrise has been added to the MDAX in Mar. 2007; The company is still listed in the MDAX

(2) The company's stocks first were listed and available for backtesting in 2007, taking data from 2006 into account. Therefore data from 2005 backwards has been deleted

	A	B	C	D	E	F	G	H	I	J
1	TICKER	DATE	104	136	696	993	2408	D011	154	623
2	DSY1	31.12.2002	275408	68589	NA	-46696	32011		-129492	-97507
3	DSY1	31.12.2003	1155195	263561	NA	-68913	134273		-365074	-322589
4	DSY1	31.12.2004	1135845	114265	NA	93160	122199	NA	-117706	-57062
5	DSY1	31.12.2005	1148856	88711	NA	102023	138094	NA	-54091	-52406
6	DSY1	31.12.2006	1229421	80733	NA	156991	198503	NA	-117736	-89848
7	DSY1	31.12.2007	1274458	76067	NA	185838	39279	NA	140262	97436 N
8	DSY1	31.12.2008	1319862	75115	NA	173820	30505	NA	134782	90386
9	DSY1	31.12.2009	1361954	82543	NA	175460	-2337	NA	116719	84349
10	DSY1	31.12.2010	1571890	86651	NA	238922	22094	NA	177490	133500
11	DSY1	31.12.2011	1583647	83371	NA	226633	39088	NA	195881	146535
12	DSY1	31.12.2012	1734934	86355	NA	236893	23211	NA	212539	157492
13	DSY1	31.12.2013	1830386	90039	NA	268996	22805	NA	245854	172335
14	DSY1	31.12.2014	2120107	128211	NA	303730	29799	NA	259710	186767

Appendix C: Indicator Composition

929097	THYSSENKRUPP			
TYPE	DESCRIPTION	30.09.1999	30.09.2000	30.09.2001
104	GESAMTUMSATZ	29794100	37208990	38008000
136	ABSCHREIB.	1529100	1840000	1812000
696	ABSCHREIB. BETRIEBSB. RUECKSTE	NA	NA	NA
993	AUSGEWIES. BETRIEBSGEWINN	158100	827000	544000
2408	NETTOZINSAUFWAND	202300	419000	473000
D011	EXTRAORD./SPECIAL ITEMS			NA
154	AUSGEWIES. GEW. VOR STEUERN	623800	1090000	876000
623	JAHRESUEBERSCHUSS	307900	559000	683000
176	MINDERHEITSBETEILIGUNG.	41000	32000	-4000
625	ERGEBNIS A.GEWOEHN. GESCH.TAET	266900	527000	687000
193	AUSSERORDENTL. POSTEN	0	0	-22000
D012	ORDINARY DIVIDENDS			NA
1300	ERTRAG VOR ZINSEN UND STEUERN	952500	1647000	1468000
1502	EBITDA	2481600	3487000	3280000
2260	VEROEFF. BARGELDERTRAEGE	NA	NA	NA
305	EIGENKAP. UND RUECKLAGEN	8053000	8797000	8786000
306	VORZUGSKAPITAL	0	0	0
307	SUMME D. AKTIENKAP. U.RUECKL.	8053000	8797000	8786000
315	MINDERHEITSBETEILIG.	293300	399000	363000
D036	LONG TERM DEBT			NA
322	GESAMTER KAPITALEINSATZ	14158300	15955000	15873000
339	SUMME DES ANL.VERM. NETTO	11635800	12672000	12167000
344	SUMME DER IMMAT.VERM GEGENST.	4268600	4477000	4096000
364	SUMME DER VORRAETE & UNF.ERZEU	7220900	7496000	6525000
287	FORD.AUS LIEFER.U. LEISTUNG.	6198200	7713000	7104000
375	FLUESSIGE MITTEL	805500	1021000	1258000
376	GESAMTES UMLAUFVERMOEGEN	14748100	16738000	15246000
392	SUMME DER AKTIVA	32536690	35636990	33352000
276	VERBINDL. AUS LIEF.& LEISTUNGE	2811700	3155000	3210000
309	KREDITE M. LAUFZEIT BIS 1 JHR	1186900	1992000	941000
389	SUMME DER KURZFRIST. VERBINDL.	11202800	12025000	7089000
390	NETTOUMLAUFVERMOEGEN	3545300	4713000	8157000
1301	SUMME DER FINANZVERBNDLKTN	6998900	8751000	7665000
1501	NET DEBT	6193400	7730000	6407000
1504	ENTERPRISE VALUE (EV)	16184810	15964660	12635170
MV	MV	9698109	7835664	5865171
219	GESAMTZAHL DER BESCHAEFT.	184770	193316	193516
190	DIVIDENDE JE AKTIE	0,716	0,75	0,6
254	NETTOGEW. JE AKTIE -AUSGEWIES.	0,55	1,02	1,29
794	REINGEWINN U.AUFGELF. ABSCHREI	2,934	3,697	4,064
1308	BUCHWERT PRO AKTIE	15,654	17,099	17,078
D037	MARKET TO BOOK VALUE EX. INTAN			NA
1505	SALES PER SHARE	61,564	72,322	73,875
1015	BARMITTELZUFLUSS: BETRIEBST.	1504500	1329000	2245000
1024	ZAHL.AUSG. GEGENST.D ANLAGEVER	1946200	2008000	2084000
1040	BARMITTELABFLUSS: INV.TAET.	2817900	1788000	1299000
1045	BARMITTELZUFLUSS A.FINANZ.	1438900	609000	-634000
1048	NETTOCASHFLOW	125500	150000	312000



Sales (S)

Earnings Before Interest and Taxes (EBIT)

Total Intangible Assets

Excess Cash

Total Current Assets

Total Assets

Total Current Liabilities

Enterprise Value (EV)

Earnings per Share (ESP)

Book Value (BV)

Appendix D: Average value growth in sales and adapted magic formula indicators

YEAR	GS			MF			
	N ALL	N VAL	AVG GS	N ALL	N VAL	AVG EY	AVG RC
1999	-	-	-	61	12	0.208	0.300
2000	61	7	0.376	79	16	0.212	0.352
2001	74	9	0.384	81	16	0.225	0.365
2002	74	9	0.110	88	18	0.197	0.420
2003	67	8	0.172	73	15	0.294	0.369
2004	67	8	0.074	93	19	0.216	0.469
2005	83	10	0.235	94	19	0.196	0.764
2006	88	10	0.122	94	19	0.171	0.678
2007	85	10	1.849	92	18	0.235	0.898
2008	88	10	0.203	95	19	0.141	0.716
2009	90	11	0.273	100	20	0.234	0.732
2010	94	11	0.035	99	20	0.147	0.930
2011	93	11	0.357	99	20	0.178	0.720
2012	95	11	0.263	102	20	0.200	2.358
2013	94	11	0.121	100	20	0.176	0.800
2014	93	11	0.046	100	20	0.122	2.192

Statutory Declaration

I hereby formally declare that I have written the submitted dissertation entirely by myself without anyone else's assistance. Where ever I have drawn on literature or other sources, either in direct quotes, or in paraphrasing such material, I have given the reference to the original author or authors and to the source where it appeared.
I am aware that the use of quotations, or of close paraphrasing, from books, magazines, newspapers, the internet or other sources, which are not marked as such, will be considered as an attempt at deception, and that the thesis will be graded with a fail.
I have informed the examiners and the board of examiners in the case that I have submitted the dissertation, entirely or partly, for other purposes of examination.

Berlin, _____ _____

Fabian König