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Bachelor's Thesis

Talousjohtaminen

The Impact of the Financial Crisis on Momentum and Book-to-Market anomalies: Evidence from Europe

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Contents

1. Introduction

The existence of market anomalies have been a target for many studies around the world ever since the 1960s when the concept for the Efficient Market Hypothesis was created. There have been a lot of studies about anomalies especially in North America, yet Europe seems to be less explored on these matters. In my bachelor's thesis I am going to examine whether two specific anomalies, Momentum and Book-to-Market anomalies, exist and moreover, how these two anomalies behaved during the Financial Crisis in Europe.

According to Taylor (2008) there were many reasons for the Financial Crisis. The most important reasons probably were the housing boom in the United Stated and some government actions and interventions all around the globe. Soon the Crisis became global and hit Europe largely in 2008. As a consequence the continent went into recession, for example real GDP in Europe dropped by 4% in 2009, as unemployment rates, instability in the financial markets, and gearing rates blossomed. (European Commission 2009) The Financial Crisis, followed by the Euro crisis also arguably had a bigger effect on Europe than any other continent, so it is a rather interesting subject to examine the possible excess returns in the Old World.

The theoretical background of this paper is based on the Capital Asset Pricing Model and the Efficient Market Hypothesis. The Capital Asset Pricing Model is the oldest significant theory used to determine the rate of return of an asset and even though the model has its own shortcomings, it is still widely used as a benchmark by researchers and financial executives around the globe (Mullins 1982). The Efficient Market Hypothesis basically states that all the information concerning a security is already included in the price. According to the hypothesis, all excessive returns are a proof that anomalies exist. Studies seem to show that in practice the Efficient Market Hypothesis doesn't hold, yet it is a good benchmark in the area of finance.

This paper provides a test concentrating on finding these previously mentioned anomalies, and furthermore, how they behaved during the Financial Crisis. The test is executed by applying the Capital Asset Pricing Model into the linear regression model by using the data provided. Therefore things such as the reasons for possible anomalies as well as valuating the used data as valid or invalid are set aside.

The rest of the paper is organized as follows. Chapter 2.1 presents the theoretical background of the Capital Asset Pricing Model in general, the model for time-series regression, and the empirical results of a number of previous studies. Chapter 2.2 introduces the Efficient Market Hypothesis and anomalies in general and takes a deeper look at the two specific anomalies examined in this paper. Chapter 3 discusses the data, the research methods, and provides an overview of the data with a descriptive analysis. The actual regression analysis is executed in Chapter 4, and Chapter 5 sums up the results and conclusions.

2. Theoretical background

2.1. Asset Pricing

Asset pricing theories are considered to have been born in the mid-1960s when William Sharpe (1964) and John Lintner (1965) created a theory called Capital Asset Pricing Model, hereafter CAPM. Despite its old age, CAPM is still widely used as a benchmark in applications such as estimating the cost of capital for a company or evaluating the performance of investment portfolios. It is the most common – and often the only – asset pricing model taught in MBA courses. (Fama & French 2004; Jensen, Black & Scholes 1972)

The Capital Asset Pricing Model is built on the model of portfolio choice by Harry Markovitz (1959). In this model an investors chooses a portfolio at time t-1. This portfolio produces a stochastic return at time t. Markovitz made assumptions that investors are risk-averse and when choosing among portfolios, they only care about the mean and variance of their portfolio. This will lead the investor choosing so called "mean-variance-efficient" portfolios. Thus the investor maximizes the expected return given variance and minimizes the variance of portfolio return, given expected return. Because of this, Markovitz's theory is often referred as "mean-variance model". (Fama & French 2004)

According to Falkenstein (2009), Markovitz was the first to introduce the now standard method of graphing asset's volatility-return space, which is shown in figure 1.

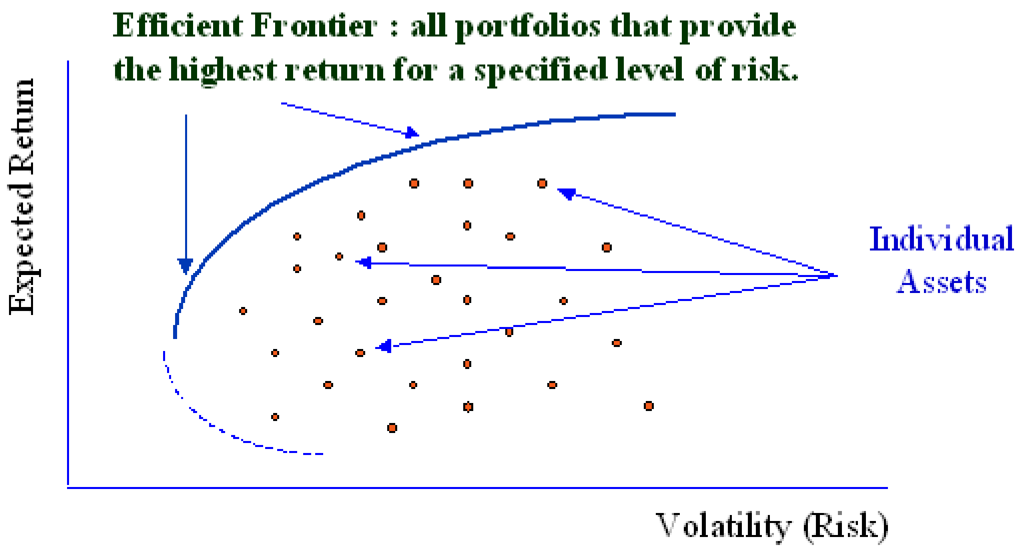

Figure 1. Markovitz's Efficient Frontier. (Falkenstein 2009)

The portfolios on the frontier are efficient because higher (expected) return cannot be achieved without adding volatility to portfolio. Hence portfolios on the Efficient Frontier guarantee the highest return with a given volatility and the other way round.

2.1.1. Capital Asset Pricing Model

According to Robert Korajczyk (1999), analyses show that the total variance, in other words risk, of an asset can be divided to two components: other one of them being a component that is correlated with the previously introduced mean-variance-efficient portfolios and the other one being a component that is uncorrelated with the mean-variance-efficient portfolios. (Korajczyk 1999)

At this point there are assumptions to be made. According to Michael Jensen (1972), these assumptions are:

1. All investors are risk-adverse and choose among portfolios based on mean-variance-effectiveness
2. There are neither taxes nor transaction costs
3. All investors have the same information regarding parameters of the joint probability distribution of all security returns, and

4. All investors can borrow and lend at the same given risk-free rate. (Jensen 1972)

Jensen's assumptions are really simplified when considering investor's decisions in practice. Especially assumptions 2 and 3 seem to be pretty far away from the real life. These assumptions are heavily related to the Efficient Market Hypothesis, which is introduced in chapter 2.2.

Dividing the risk into the two mentioned components starts with Markovitz's Efficient Frontier. Adding a risk-free rate of return to the Efficient Frontier figure, the total risk can be divided as follows.

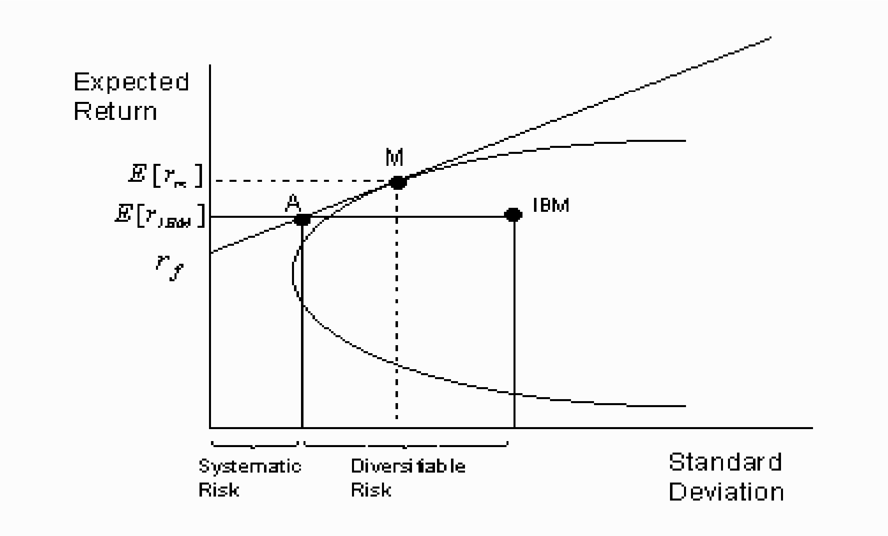

Figure 2. Individual stock's (IBM) relation to the Efficient Frontier (Falkenstein 2009)

CAPM connects the risk-free rate of risk to the Efficient Frontier stating that there are two ways to receive an expected return of a stock, or in this case, IBM's stock: hold shares of IBM or hold a composite portfolio *A*. As can be seen from the figure, a risk-adverse investor (according to assumption 1, all investors are risk-adverse) prefers portfolio *A* over an investment solely in IBM because it guarantees the same expected return with less volatility. Hence a single stock, IBM, always carries a bigger risk than portfolio A, and because of this, a risk-adverse investor should never own a portfolio containing only one stock. As a result the total risk of IBM can be decomposed into 2 parts: systematic volatility, which states the minimum volatility required to earn that specific expected return, and diversifiable volatility, which means the portion of the volatility that can be eliminated without sacrificing any expected return. This part of volatility can be eliminated simply by diversifying. Hence an investor is rewarded with the expected return for bearing only systematic risk and not rewarded for bearing diversifiable risk since it can be eliminated at no cost (assuming that assumption 2 holds). (Falkenstein 2009)

Falkenstein (2009) stated that theoretically every asset has the same marginal value, because in a large diversified portfolio only covariance σ matters. Putting all together, the formula for Capital Asset Pricing Model looks like this:

$$E(r_i) = r_f + \beta_i(E(r_m) - r_f) \qquad (1)$$

,where $E(r_i)$ is the expected return for asset i, r_f is the risk-free rate of interest, $E(r_m)$ is the expected return of the market portfolio, and β_i , or beta, defines the risk and can also be illustrated as follows:

$$\beta_i = \frac{\sigma_{im}}{\sigma_m^2}$$

According to Falkenstein (2009), Beta β is the ratio of covariance over the variance, or in other words the coefficient of the stock i in the market portfolio (OLS regression model). So the amount of risk can be measured via beta (Falkenstein 2009). In general we can state that a security or a portfolio with a higher beta is riskier than a security or a portfolio with lower beta because they have a tendency to vibrate more widely than the market, so the return exhibits a greater dispersion versus the market return (Cunningham 1994).

Graphically CAPM, or as Falkenstein (2009) calls it, Security Market Line, can be illustrated as follows.

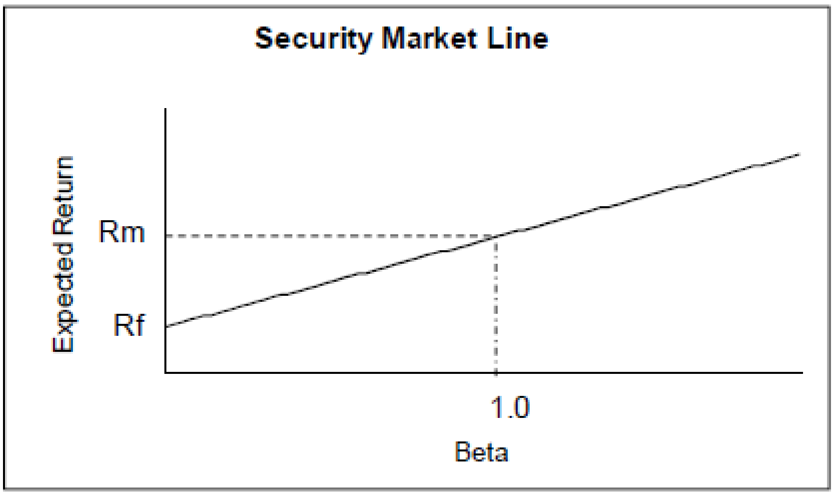

Figure 3. Capital Asset Pricing Model. (Falkenstein 2009)

CAPM is consistent only during one period of time. There are a few tricks required in order to make it suitable for several time periods. These tricks are introduced in the following chapter.

2.1.2. Capital Asset Pricing Model for Time-series Regression

According to Fama & French (2004), the one of the many contradictions in CAPM is that it is based on unrealistic assumptions. One of these unrealistic assumptions is that it assumes investors only care about the mean-variance efficiency of the portfolio during one period. In this paper, for obvious reasons, it is needed to modify CAPM in order to examine it for time-series regressions. Though CAPM is generally for one time-period, it can be modified for time-series regression.

Jensen was the first to discover that the relation between market beta and expected return also implies a time-series regression test so that CAPM would no longer have to be only for one time-period. CAPM shows that the average excess return (difference between the portfolio's return and the risk-free interest rate, $r_i - r_f$) is completely explained by the average realized risk-premium ($\beta(r_m - r_f)$). Jensen added the so-called Jensen's Alpha (α_i) to the CAPM formula. Jensen's Alpha is the intercept term in the time-series regression and it should be zero for each portfolio (assuming that CAPM holds). So modifying CAPM formula as shown above and adding Jensen's Alpha, CAPM becomes suitable for time-series regression and it looks like this:

$$r_{it} - r_{ft} = \alpha_i + \beta_{iM}(r_{Mt} - r_{ft}) + \varepsilon_{it} \quad (2)$$

,where r_{it} is the return for stock i at time t, r_{ft} is the risk-free rate of interest at time t, α_i is Jensen's Alpha, β_{iM} is the portfolio beta, r_{Mt} is the return of the market portfolio at time t, and ε_{it} is the residual of stock i at time t. (Fama & French 2004)

2.1.3. Previous Research

Though CAPM is a good benchmark for measuring risk and asset prices, previous empirical research is often in contradiction with the theory. Jensen, Black, and Scholes (1972) found out that in their research high-beta securities had significantly negative intercepts and low-beta securities had significantly positive intercepts, contrary to the predictions of the model. They were led to reject the hypothesis that Jensen's Alpha was equal to zero. (Jensen, Black & Scholes 1972)

Probably the most famous critics of CAPM are Fama and French, who have published a number of studies to criticize CAPM. According to them (2004), "Unfortunately, the empirical record of the model is poor – poor enough to invalidate the way it is used in applications. The CAPM's empirical problems may reflect theoretical failings, the result of many simplifying assumptions. But they may also be caused by difficulties in implementing valid tests of the model. For example, the CAPM says that the risk of a stock should be measured relative to a comprehensive "market portfolio" that in principle can include not just traded financial assets, but also consumer durables, real estate, and human capital. Even if we take a narrow view of the model and limit its purview to traded financial assets, is it legitimate to further limit the market portfolio to U.S. common stocks, or should the market be expanded into bonds, and other financial assets, perhaps around the world?"

According to Fama and French (2004), the empirical tests have shown that there are a number of contradictions in the CAPM. In addition to the previously mentioned shortcomings, stock prices seem to have information about expected returns that are left unnoticed by market betas. They stated that the traditional CAPM doesn't explain expected returns well enough. Instead adding ratios indicating size, earnings-price, debt-equity, and book-to-market add to the explanation of expected stock returns provided by market beta. (Fama & French 2004)

It seems that the further CAPM is examined, the further from real life it slides. For example Jensen (1969) found the CAPM at least somewhat true holding, merely judging the mutual funds as inefficient. In the 1970s several factor models became common overriding the traditional CAPM (Fama & French 2004). Nowadays it is hard to find a study that is not absolutely crushing the CAPM as an old and invalid theory. For example Bartholdy and Peare (2002) found out that CAPM's ability to explain differences in stock returns was very poor, varying from 0,01% to 11,73%, and being 3% on average across the time interval. Yet the CAPM is commonly used, and, according to Fama and French (2004), it is still useful as a benchmark and as an introductory to risk and asset valuation.

So the problem with the CAPM seems to be either a weakness in theory, or in its empirical implementation. Though this is not examined in this paper, it is good to bear in mind that the possible anomalies may well be caused by the shortcomings of CAPM instead of the existence of the actual anomalies.

2.2. Market Efficiency and Anomalies

According to Schwert (2002), "anomalies are empirical results that seem to be inconsistent with maintained theories of asset-pricing behavior. They indicate either market inefficiency (profit opportunities) or inadequacies in the underlying asset-pricing model." After anomalies are documented and analyzed in the academic literature, they seem to vanish, reverse, or soften. This raises a question whether anomalies existed in the past and have been arbitraged away after publication, or are simply statistical delusions that attracted academics' attention. (Schwert 2002)

In this paper two anomalies, Momentum and Book-to-Market, are examined. Before introducing them theoretically, it is needed to take a look at market efficiency which sets the theoretical ground for anomalies.

Many have suggested that the development of the Efficient Market Hypothesis has been scientifically uncommon. The proof came first in 1900, when the famous French mathematic Louis Bachelier investigated the linear correlation in prices of options and futures traded on the French Bourse. He was the first to state that the price changes behaved randomly. Bachelier's work was forgotten in the academic circles until the 1960s. In 1965 Paul Samuelson introduced a theory to explain this randomness which was proofed over 60 years before. (Cunningham 1994)

According to Cunningham (1994) the concept of the Efficient Market Hypothesis was born in the mid-1960s. Back then a number of economists tried to explain several empirical studies by stating that successive changes in security prices are random. Based on these studies they came to conclusions stating that there cannot be any accurate predictions of future changes in security prices since there is no pattern to the price history of these securities. Based on this lack of pattern, the Efficient Market Hypothesis states that the change in price of a security can be explained with changes in information concerning that security. Public security prices reflect to all information about a security, not just price histories. (Cunningham 1994)

According to studies there are three different forms of efficiency: the weak form, the semi-strong form, and the strong form. The weak form holds that a current price for a security fully reflects all historical information about the security. The semi-strong form holds that a current price for a security fully reflects all publicly available information about the security. The strong form holds that a current price for a security fully reflects all available information – public or not – about the security. Furthermore since all price changes are caused by new information, it is impossible to predict which way the prices are going, unless one has a crystal ball of course. If the strong form holds, then it doesn't matter which security investors invest their money since all the price changes are random. (Cunningham 1994)

In this paper it is assumed that the strong form of market efficiency holds per se. In other words it is not possible to generate above-normal returns on the market since all the information is already included in the price. However the problem with the Efficient Market Hypothesis is that it doesn't provide any ways of determining what that means. So what does it mean when all the information is included in the price of a security? Market efficiency analysis needs a separate model to define that, and this is where previously introduced Capital Asset Pricing Model comes in handy. Nevertheless, when using CAPM, the problem is the so-called joint-hypothesis problem. This means that we can never be sure if rejections in model testing are caused whether by market inefficiency or by inadequately specified CAPM. Many empirical tests show that the problem is mainly in the successor than in the predecessor. However in this paper we assume that CAPM is adequate, so if there are any model rejections, they are caused by market inefficiencies, or in other words, anomalies. (Cunningham 1994)

2.2.1. Momentum Anomaly

Moore and Pihippatos (2010) defined momentum as "a generic term used to describe the relationship between past observations and subsequent future observations". It can be divided into three: price momentum, earnings momentum and directional momentum. Price momentum refers to negative and positive short-term correlation of stock prices, earnings momentum describes post-earnings information drift, and directional momentum considers higher moments of price patterns. Several researches have shown the existence of all three anomalies in real life. (Moore & Philippatos 2010)

According to Jegadeesh and Titman (2001), researches show that there is remarkable evidence that stocks that perform the best over a specific time period (usually from 3 to 12 months) tend to do well in the following time period. Then again, stocks that perform the poorest over the time period tend to do poorly in the following time period. (Jegadeesh & Titman 2001)

When exploring for Momentum anomaly, CAPM comes in handy – again. A portfolio is constructed longing on the highest lagged returns and shorting on the lowest lagged returns. After this numbers are placed to the CAPM. If Jensen's alpha is significant, there is a momentum effect. (Jegadeesh & Titman 2001)

2.2.2. Book-to-Market Anomaly

According to Mohanram (2004), a number of researches have been made in the field of Book-to-Market anomaly. Book-to-market ratio can be defined as the ratio of the book equity of a company to its market equity. By Book-to-Market anomaly it is meant that on average, firms with low book-to-market ratio seem to earn significant negative excess returns, whereas firms with high book-to-market ratio seem to earn significant positive excess returns. Stocks with low book-to-market ratio are commonly referred as growth stocks since they tend to have experienced a strong performance in prior periods. Stocks with high book-to-market are often referred as value stocks since they typically underperformed in prior periods. If excess returns, positive or negative, do exist, these can be defined as anomalies. This procedure is similar with examining Momentum anomaly. (Mohanram 2004)

Respected economists Fama and French (1992) as well as Lakonishok, Sheifer and Vishny (1994) have demonstrated the book-to-market effect in their papers. Both of these papers came to conclusions that there is a significant positive correlation between a company's book-to-market ratio and future stock performance. (Mohanram 2004)

When comparing the two anomalies, it seems as if Book-to-Market was more examined in the early history of anomaly research. Momentum anomaly appeared in the academic literature a bit later, but it seems to have been a trendy object for research ever since. Therefore a hypothesis for the empirical part is that Momentum anomaly is bigger than Book-to-Market. This is because as Schwert (2002) (see chapter 2.2.) stated, when new anomalies pop up in the academic literature, they seem to vanish, reverse, or soften. Since Momentum anomaly was found a bit later, it could be that it is more visible when considering the time interval for this paper.

3. Research Methods and Data

The data used for the quantitative research, linear regression analysis to be specific, in this paper is from Kenneth R. French's data library. The data for Europe includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. All returns are in U.S. Dollars including dividends and capital gains and they are not continuously compounded. Time period is from November 1990 until October 2012 and time interval is on a monthly basis. (French 2012)

There are six portfolios formed on size and Book-to-Market values. Stocks are sorted into two market capitalization and three Book-to-Market equity groups at the end of June of each year t. Big stocks are those in the top 90% of June market capitalization and small are those in the bottom 10%. The Book-to-Market breakpoints for big and small stocks are the 30th and 70th percentiles of Book-to-Market for the big stocks in Europe. The data is sorted into six groups, producing six value-weighted portfolios: SG, SN, SV, BG, BN, and BV, where S and B indicate small and big and G, N, and V indicate growth (low Book-to-Market ratio), neutral, and value (high Book-to-Market). (French 2012)

There are also six portfolios formed on size and Momentum. Stocks are sorted into two market capitalization and three lagged Momentum return groups at the end of each month t. Big stocks are those in the top 90% of market capitalization and small are those in the bottom 10%. A portfolio formed at the end of month t-1, the lagged Momentum return is a cumulative return for the stock from t-12 to t-2. The Momentum breakpoints for big and small stocks are the 30th and 70th percentiles of lagged Momentum returns of the big stocks in Europe. The data is sorted into six groups, producing six value-weighted portfolios: SL, SN1, SW, BL, BN1, and BW, where S and B indicate small and big and L, N, and W indicate losers (bottom 30%), neutral (middle 40%), and winners (top 30%). (French 2012)

In the data the risk-free rate equals the U.S. one month T-bill rate. Hence the left side of the CAPM or the excessive return, r_{it}-r_{ft}, (formula 2) is the performance of the portfolio minus the risk-free rate at a given time t, and r_{Mt}-r_{ft} on the right-hand side is the value-weighted market portfolio minus the risk-free rate. After these values are placed to the CAPM, Beta and Jensen's Alpha can be calculated. All the numerical values of the data are in percentages.

One of the research goals in this paper was to examine the effect of the Financial Crisis on the two previously introduced anomalies – assuming these anomalies exist. Setting a specific beginning point for the financial crisis is not very simple. Lehman Brothers filing for chapter 11 bankruptcy protection on the 15th of September 2008 is widely seen as the point when the crisis came to a head (Elliot, 2011; BBC News, 2009). Hence, in this paper September 2008 is used as a turning point when estimating the effect. The effect is examined with a dummy variable. The dummy variable is positioned into the CAPM. It receives a value of zero from November 1990 until September 2008, and a value of one from October 2008 until October 2012.

3.1. Descriptive Analysis

Tables 1 and 2 (table 1 includes Book-to-Market portfolios and table 2 Momentum portfolios) show a descriptive analysis for the whole time period. The risk-free rate of return is already subtracted from the portfolio return, so the left-hand side of the CAPM can be analyzed.

Descriptive Analysis	SG	SN	SV	BG	BN	BV
Mean %	0.184	0.466	0.894	0.372	0.583	0.651
Standard Error	0.347	0.317	0.320	0.297	0.318	0.367
Median	0.615	0.845	0.935	0.560	1.170	1.120
Standard Deviation	5.638	5.151	5.205	4.818	5.175	5.966
Sample Variance	31.795	26.529	27.088	23.209	26.776	35.588
Kurtosis	2.642	3.504	3.431	1.645	1.569	1.957
Skewness	-0.739	-0.858	-0.664	-0.559	-0.618	-0.481
Range	43.83	41.76	43.17	33.32	34.21	46.82
Minimum	-26.03	-26.54	-26.73	-20.57	-20.1	-25.09
Maximum	17.8	15.22	16.44	12.75	14.11	21.73
Sum	48.65	122.93	235.99	98.24	153.82	171.9
Count	264	264	264	264	264	264

Table 1. Descriptive analysis for Book-to-Market portfolios (time interval from November 1990 to October 2012).

Descriptive Analysis	SL	SN1	SW	BL	BN1	BW
Mean %	-0.113	0.583	1.241	0.253	0.597	0.736
Standard Error	0.396	0.296	0.326	0.413	0.299	0.320
Median	-0.015	0.95	1.58	0.605	1.01	1.11
Standard Deviation	6.429	4.814	5.296	6.716	4.852	5.197
Sample Variance	41.335	23.177	28.046	45.103	23.543	27.007
Kurtosis	4.718	4.724	1.943	3.451	1.711	1.008
Skewness	-0.121	-0.909	-0.763	-0.151	-0.632	-0.367
Range	61.77	42.27	38.12	61.52	34.28	34.05
Minimum	-30.37	-27.03	-23.21	-29.44	-21.12	-16.85
Maximum	31.4	15.24	14.91	32.08	13.16	17.2
Sum	-29.74	154.01	327.65	66.92	157.55	194.34
Count	264	264	264	264	264	264

Table 2. Descriptibe analysis for Momentum portfolios (time interval from November 1990 to October 2012).

As can be seen from the tables, the means for each portfolio, excluding portfolio SL, are positive, so portfolio returns averagely have been above risk-free rates.

According to Brooks (2005) normal distribution can be tested by Bera-Jarque test. The test can be executed by testing whether the coefficient of skewness and the coefficient of excess kurtosis (the kurtosis for normal distribution is 3 so its excess kurtosis (kurtosis – 3) is zero) are jointly zero. The Bera-Jarque test statistic is given by:

$$W = T[\frac{b_1^2}{6} + \frac{(b_2-3)^2}{24}] \quad (3)$$

, where *T* is the sample size, b_1 is kurtosis, and b_2 is skewness. (Brooks 2005)

The test statistic null hypothesis is that the distribution of the series is symmetric and mesokurtic (distribution is similar or identical to the kurtosis of a normally distributed data) (Brooks 2005). The Bera-Jarque test statistics are as follows.

	Bera-Jarque	P-value (2 degr. of freedom)
SG	25.456	<0.001
SN	35.216	<0.001
SV	21.430	<0.001
BG	33.945	<0.001
BN	39.343	<0.001
BV	22.167	<0.001

Table 3. Bera-Jarque test statistic for Book-to-Market portfolios.

	Bera-Jarque	P-value (2 degr. of freedom)
SL	33.125	<0.001
SN1	69.081	<0.001
SW	37.926	<0.001
BL	3.253	0,197
BN1	35.833	<0.001
BW	49.581	<0.001

Table 4. Bera-Jarque test statistics for Momentum portfolios.

As can be seen from the tables, the p-values for Bera-Jarque test statistics show that the null hypothesis is rejected; the data is not normally distributed, excluding portfolio BL, which seems to be the only normally distributed portfolio. The residuals seem to be negatively skewed and leptokurtic. This implies that the inferences about the coefficient estimates could be wrong. This is good to bear in mind when considering the results of this paper.

Standard deviations for Momentum portfolios receive bigger values than for Book-to-Market portfolios, stating that Momentum portfolios are more volatile. Ranges as well as variances support this statement receiving higher values in most of the portfolios.

Now let's take a look how these characteristics react when the data is divided into two: the first one being the time series before the beginning of the crisis and the other one after it.

Descriptive analysis	SG	SN	SV	BG	BN	BV
Mean %	0.049	0.437	0.913	0.279	0.599	0.739
Standard Error	0.347	0.295	0.285	0.297	0.303	0.320
Median	0.390	0.850	0.940	0.490	1.120	1.220
Standard Deviation	5.086	4.325	4.182	4.357	4.439	4.698
Sample Variance	25.870	18.706	17.493	18.982	19.701	22.074
Kurtosis	2.090	2.214	1.764	1.238	1.928	1.605
Skewness	-0.833	-0.796	-0.242	-0.451	-0.736	-0.604
Range	34.160	29.400	31.510	28.060	30.430	31.110
Minimum	-21.050	-17.820	-17.330	-15.710	-16.320	-16.950
Maximum	13.110	11.580	14.180	12.350	14.110	14.160
Sum	10.470	93.910	196.290	59.990	128.820	158.930
Count	215.000	215.000	215.000	215.000	215.000	215.000

Table 5. Descriptive analysis for Book-to-Market portfolios before the Financial Crisis (time interval from November 1990 to September 2008).

Descriptive analysis	SG	SN	SN	BG	BN	BV
Mean %	0.779	0.592	0.810	0.781	0.510	0.265
Standard Error	1.092	1.124	1.199	0.929	1.096	1.403
Median	1.060	0.810	0.620	1.320	1.340	-0.790
Standard Deviation	7.644	7.870	8.392	6.506	7.673	9.818
Sample Variance	58.429	61.939	70.421	42.330	58.871	96.392
Kurtosis	2.161	1.771	1.120	1.256	-0.163	-0.301
Skewness	-0.686	-0.790	-0.736	-0.771	-0.399	-0.213
Range	43.830	41.760	43.170	33.320	33.820	46.820
Minimum	-26.030	-26.540	-26.730	-20.570	-20.100	-25.090
Maximum	17.800	15.220	16.440	12.750	13.720	21.730
Sum	38.180	29.020	39.700	38.250	25.000	12.970
Count	49.000	49.000	49.000	49.000	49.000	49.000

Table 6. Descriptive analysis for Book-to-Market portfolios after the beginning of the Financial Crisis (time interval from October 2008 to October 2012).

Book-to-Market portfolios seem to receive averagely higher profits after the beginning of the Financial Crisis (the only notable exception is portfolio BV, which receives a significantly higher average profit before the Financial Crisis). Portfolios are also notably more volatile after the beginning of the Financial Crisis. Standard deviations, variances, and ranges support this statement.

Descriptive analysis	SL	SN1	SW	BL	BN1	BW
Mean %	-0.192	0.563	1.310	0.153	0.592	0.805
Standard Error	0.359	0.264	0.327	0.365	0.278	0.319
Median	0.060	0.950	1.570	0.610	0.990	1.200
Standard Deviation	5.265	3.874	4.792	5.350	4.074	4.673
Sample Variance	27.724	15.009	22.959	28.620	16.601	21.833
Kurtosis	3.876	2.381	1.105	2.502	1.015	0.940
Skewness	-0.419	-0.681	-0.624	-0.619	-0.615	-0.267
Range	43.990	28.840	29.090	39.640	25.240	32.050
Minimum	-22.890	-17.230	-15.820	-20.150	-13.180	-14.850
Maximum	21.100	11.610	13.270	19.490	12.060	17.200
Sum	-41.330	121.030	281.750	32.860	127.330	173.160
Count	215.000	215.000	215.000	215.000	215.000	215.000

Table 7. Descriptive analysis for Momentum portfolios before the Financial Crisis (time interval from November 1990 to September 2008).

Descriptive analysis	SL	SN1	SW	BL	BN1	BW
Mean %	0.237	0.673	0.937	0.695	0.617	0.432
Standard Error	1.448	1.107	1.022	1.560	1.059	1.015
Median	-1.130	1.000	1.750	-2.050	1.120	0.870
Standard Deviation	10.135	7.750	7.155	10.922	7.415	7.108
Sample Variance	102.724	60.067	51.196	119.290	54.983	50.524
Kurtosis	1.925	2.188	1.643	0.830	0.272	0.088
Skewness	0.017	-0.871	-0.819	0.040	-0.540	-0.389
Range	61.770	42.270	38.120	61.520	34.280	31.810
Minimum	-30.370	-27.030	-23.210	-29.440	-21.120	-16.850
Maximum	31.400	15.240	14.910	32.080	13.160	14.960
Sum	11.590	32.980	45.900	34.060	30.220	21.180
Count	49.000	49.000	49.000	49.000	49.000	49.000

Table 8. Descriptive analysis for Momentum portfolios after the beginning of the Financial Crisis (time interval from October 2008 to October 2012).

As can be seen from tables 7 and 8, Momentum portfolios seem to act similarly than Book-to-Market portfolios. Average returns at the latter time interval are generally higher though more stable. Momentum portfolios after the beginning of the Financial Crisis also are highly more volatile than before. This can be easily seen from the values for standard deviations, variances and ranges. Skewness in general is closer to zero at the latter time interval; two of the portfolios even receive a positive value, which differs from the previous Bera-Jarque table, since all of portfolios do not receive negative values for skewness.

As can be seen from tables 5-8, the Financial Crisis seems to have had some kind of an effect to the excess returns of the portfolios. From a statistical point of view however, only assumptions can be made at this point. A further examination is needed in order to find out whether there were actual abnormal returns.

3.2. Linear regression based on Capital Asset Pricing Model

Regression analysis describes and evaluates the relationship between a given variable and one or more other variables. It tries to explain the movement of a variable (y) by reference to movements in one (x) or more other variables ($x_1, x_2, \ldots, x_k$). In an econometric research it can be described almost certainly as the most important tool. The link between the linear regression model and CAPM is that the CAPM equation (formula 2) is written in the similar form as the linear regression model. Hence the examination of CAPM can be done by applying the linear regression model. (Brooks 2005)

According to Brooks (2005), there are certain requirements or assumptions concerning the linear regression model. These relate to the error term as follows:

1. $E(\varepsilon_t)=0$, meaning that the error terms have zero means,
2. $var(\varepsilon_t)=\sigma^2 < \infty$, meaning that the variance of the error terms is constant and finite over all values of the dependent variable, or in other words the error terms are homoscedastic,
3. $cov(\varepsilon_i, \varepsilon_j)=0$, meaning that the error terms are statistically independent of one another, or in other words there is no autocorrelation, and
4. $cov(\varepsilon_t, x_t)=0$, meaning that there is no relationship between the error terms and the corresponding x variables, or in other words the x variables are non-stochastic. (Brooks 2005)

Jensen was the first to systematically test the performance of mutual funds, and more specifically to test any “beat the market” in 1968. He used Ordinary Least Square (OLS) time series regression similar to what is given in formula 2. The parameter α_i, or Jensen’s Alpha, defines whether the fund outperforms or underperforms the market index. Hence the null hypothesis is given by: H_0: $\alpha_i=0$. A positive and a significant α_i suggests that the fund has earned an abnormal return in excess of the return given by CAPM (market-required return for the fund to given riskiness). (Brooks 2005)

4. Results

4.1. Anomalies during the whole time interval

In the first model of this paper, estimates based on CAPM are estimated via linear regression in order to examine whether anomalies exist in general during the time interval from November 1990 to October 2012. R-square (R^2) describes how well the regression line fits the set of the data, *F-test* measures the significance of the model, Jensen's Alpha (α) measures the possible excess return, P-value for Jensen's Alpha ($P\text{-}value_{\alpha}$) measures the statistical significance of α, Beta (β) measures risk, and P-value for Beta ($P\text{-}value_{\beta}$) measures the statistical significance of β. All these are estimated for every portfolio.

	R Square	F-test	α	$P\text{-}value_{\alpha}$	β	$P\text{-}value_{\beta}$
SG	0.780	<0.001	-0.311	0.059	0.983	<0.001
SN	0.843	<0.001	-0.004	0.973	0.933	<0.001
SV	0.684	<0.001	0.466	0.011	0.849	<0.001
BG	0.919	<0.001	-0.087	0.309	0.911	<0.001
BN	0.976	<0.001	0.075	0.137	1.008	<0.001
BV	0.927	<0.001	0.080	0.421	1.133	<0.001

Table 9. Regression analysis for Book-to-Market portfolios (time interval from November 1990 to October 2012).

	R Square	F-test	α	*P-value$_α$*	β	P-value$_β$
SL	0.783	<0.001	-0.678	<0.001	1.122	<0.001
SN1	0.834	<0.001	0.146	0.229	0.867	<0.001
SW	0.733	<0.001	0.791	<0.001	0.894	<0.001
BL	0.845	<0.001	-0.360	0.029	1.218	<0.001
BN1	0.960	<0.001	0.124	0.040	0.938	<0.001
BW	0.803	<0.001	0.273	0.057	0.919	<0.001

Table 10. Regression analysis for Momentum portfolios (time interval from November 1990 to October 2012).

As can be seen from Table 7, the estimates are highly significant according to R-Square and F-test. Jensen's Alpha receives values unequal to zero for every portfolio. However Jensen's Alpha is statistically significant in only five cases: portfolios SV, SL, SW, BL, and BN1. Jensen's Alpha varies between these portfolios from -0.68 to 0.79. Notable is that in two cases out of five portfolios seem to have underperformed and in three cases outperformed, or have "beaten the market". Only one of these portfolios is a Book-to-Market portfolio and four of them are Momentum portfolios. This implies that there seems to be more excess returns among Momentum portfolios. Betas for all of the portfolios were statistically significant.

So one of the six Book-to-Market portfolios, SV, seems to receive an excess return of 0,47%. Notable is that the Beta for portfolio SV is 0.85, so the portfolio does not only beat the market, but it also seems to be less risky than the market in general.

Four out of six Momentum portfolios, SL, SW, BL, and BN1, received statistically significant excess returns of -0.68%, 0.79%, -0.36%, and 0.12%. Betas for these portfolios are 1.12, 0.89, 1.21, and 0.94. Portfolios that have been underperforming seem to also have higher betas and hence be more risky than the ones that have beaten the market. In fact, these market beaters seem to outperform the market averagely in riskiness as well. This actually implies similarities with the research by Jensen, Black and Scholes (1972) (introduced in chapter 2.1.3). Portfolios having negative coefficients and high betas are the opposite of what CAPM suggests in theory.

4.2. Anomalies and the Financial Crisis

The second part of the empirical research is executed by adding a dummy-variable to the previous linear regression model. The dummy-variable receives a value of zero for the time interval before the Financial Crisis, and it receives a value of one for the time interval after the beginning of the Financial Crisis. According to Brooks (2005), a dummy variable is used in the same way as other explanatory variables and the coefficients of the dummies can be interpreted as the average differences in the values of the dependent variable for each category. After modifying the Formula 2 a bit, the regression model including a dummy variable is as follows:

$$r_{it} - r_{ft} = \alpha_i + \beta_{iM}\left(r_{Mt} - r_{ft}\right) + \beta_i D_t + \varepsilon_{it} \tag{3}$$

, where β_i is the coefficient for the dummy-variable, and D_t is the dummy-variable itself, receiving exact values of 0 (before the Financial Crisis) or 1 (after the beginning of the Financial Crisis).

The statistical variables are pretty much the same as in table 7. R-square is replaced by Adjusted R-square since it suits better for a model with more than one explanatory variable. Also a Beta for the dummy variable (β_{dummy}), and its p-value indicator ($P\text{-}value_{dummy}$) are added.

	Adj. R^2	F-test	α	P-value$_{\alpha}$	β	P-value$_{\beta}$	Dummy	P-value$_{Dummy}$
SG	0.781	<0.001	0.466	0.004	0.796	<0.001	-0.588	0.119
SN	0.842	<0.001	0.110	0.425	0.904	<0.001	-0.147	0.645
SV	0.681	<0.001	-0.230	0.245	0.805	<0.001	0.076	0.867
BG	0.920	<0.001	0.223	0.024	1.010	<0.001	-0.514	0.025
BN	0.975	<0.001	-0.075	0.171	0.968	<0.001	0.079	0.529
BV	0.928	<0.001	-0.100	0.284	0.819	<0.001	0.382	0.078

Table 11. Dummy-regression for Book-to-Market portfolios.

	Adj. R^2	F-test	α	P-value$_{\alpha}$	β	P-value$_{\beta}$	Dummy	P-value$_{Dummy}$
SL	0.782	<0.001	0.639	<0.001	0.698	<0.001	-0.306	0.415
SN1	0.833	<0.001	-0.036	0.798	0.962	<0.001	-0.113	0.731
SW	0.732	<0.001	-0.570	0.002	0.820	<0.001	0.300	0.472
BL	0.844	<0.001	0.399	0.004	0.694	<0.001	-0.383	0.227
BN1	0.960	<0.001	-0.101	0.149	1.024	<0.001	-0.032	0.843
BW	0.802	<0.001	-0.200	0.200	0.875	<0.001	0.320	0.372

Table 12. Dummy-regression for Momentum portfolios.

As can be seen from Table 8, the estimates are highly significant according to Adjusted R-square and F-test. The dummy-variable is however statistically significant for only one portfolio. It can be stated that the only portfolio having a statistically significant impact due to the Financial Crisis was portfolio BG. The portfolio had a coefficient of -0.51, as can be seen from the table. Otherwise the dummy-variables were not statistically significant, so it can also be stated that the Financial Crisis seems to have had no impact on 11 out of 12 portfolios. Portfolio BG received a statistically significant Jensen's Alpha of 0.22, so this particular portfolio received an abnormal return of 0,22% during the time interval.

As stated in the introduction, in this paper it is assumed that these assumptions hold since the research goal is in examining the anomalies, not in examining whether the data is valid for using in a research or not. However there are a few facts good to bear in mind when considering the results of this paper. Assumption 1 concerning the linear regression model (see chapter 3.2.) holds in every case since there is a constant term included in the regression equation (Brooks 2005). The residual plot graphs for the portfolios (not graphed in this paper) suggest that there is some heteroscedasticity in the data, yet not much. A few values for autocorrelation was calculated (not graphed in the paper) selecting portfolios randomly. The results were that there was significant autocorrelation in some of the portfolios that were examined.

5. Conclusions

In this paper two things are examined: Firstly, whether Book-to-Market and Momentum anomalies exist during the time period and secondly, whether the Financial Crisis had any effect on these anomalies. The research was made by applying the Capital Asset Pricing Model into the linear regression model.

The results were contradictive. Anomalies were found in one Book-to-Market portfolio out of six, and four Momentum portfolios out of six. When the dummy variable was added into the model in order to examine the effect of the Financial Crisis, the results were significant in only one Momentum portfolio.

Book-to-Market portfolios seem to be pretty anomaly-free. Only one portfolio, SV ("Small Value"), had a statistically significant excess return of 0.47% during the whole time interval. Other five portfolios didn't seem to have any statistically significant excess returns. The Financial Crisis had an effect on one of the portfolios, BG ("Big Growth"). Jensen's Alpha received a value of 0.22% stating that the Financial Crisis had a positive effect on the excess return of the particular portfolio.

There clearly were more excess returns available among the Momentum portfolios than among the Book-to-Market portfolios during the whole time interval. Portfolios SL ("Small Losers"), SW ("Small Winners"), BL ("Big Losers"), and BN1 ("Big Neutrals") had statistically significant Jensen's Alphas of -0.68%, 0.79%, -0.36%, and 0.12% during the whole time interval. This means that portfolios Small and Big Losers had negative excess returns, and portfolios for Small Winners and Big Neutrals positive excess returns. The Financial Crisis didn't have any statistically significant effect on the portfolios.

According to this paper, there were minor Book-to-Market and Momentum anomalies in Europe on time interval from November 1990 to October 2012. The effect of the Financial Crisis was smaller, almost petty. Only one portfolio received statistically significant return of 0.22% due to the Financial Crisis. When considering the results, it is important to bear in mind a few facts. Firstly, empirical researches show pretty distinct evidence that the Capital Asset Pricing Model fails to explain the price varieties of stocks in general. Secondly, the validity of the data was somewhat ignored. For example, the data was not normally distributed, which means that the linear regression model used might have been biased. In addition, heteroscedasticity and autocorrelation of the data were only shallowly examined. For further research it would be interesting to see how the results would change if the data was properly processed. Also it would be really interesting to compare the results gained using Capital Asset Pricing Model with the results gained using a several-factor model, such as Fama-French Three-Factor Model.

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