ΕΘΝΙΚΟ ΜΕΤΣΟΒΙΟ ΠΟΛΥΤΕΧΝΕΙΟ
ΣΧΟΛΗ ΕΦΑΡΜΟΣΜΕΝΩΝ ΜΑΘΗΜΑΤΙΚΩΝ ΚΑΙ ΦΥΣΙΚΩΝ ΕΠΙΣΤΗΜΩΝ

ΔΙΑΤΜΗΜΑΤΙΚΟ ΠΡΟΓΡΑΜΜΑ ΜΕΤΑΠΤΥΧΙΑΚΩΝ ΣΠΟΥΔΩΝ

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ΤΙΤΛΟΣ ΜΕΤΑΠΤΥΧΙΑΚΗΣ ΕΡΓΑΣΙΑΣ

The cross section of volatility and expected returns of leaders of technology industry (FAANG - Facebook, Apple, Amazon, Netflix, Google)

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30 November, 2020

Declaration

I herewith certify that this thesis constitutes my own work and that all material, which is not my own work, has been properly acknowledged.

Georgios Flegkas

Abstract

The purpose of the master thesis is to investigate the factors which explain optimally the stock returns and volatility of leaders of technology industry (FAANG – Facebook, Apple, Amazon, Netflix, Google).

The first topic focuses on cross-sectional of returns with the factors like market, size, value, momentum, profit, investment, industry, the situation of stock market (bear or bull market) and the impact of the financial crisis in 2008. I show that the volatility acts as a proxy for their interpretation of the returns. Moreover, the optimal model that explains the returns, contains, in addition to volatility, the factors such as investment and industry. I show that the factors like volatility, investment and industry have better performance to explain the returns of leaders of technology industry than the factors like market, size and value.

Finally, the second topic focuses on cross-sectional of volatility with the mentioned factors. I show that the factors such as market, size, value, momentum, profit, investment, industry, the situation of stock market (bear or bull market) and the impact of the stock market crisis in 2008, interpret the volatility of leaders of technology industry.

Keywords: asset pricing, stock returns, volatility, technology industry, FAANG, cross sectional models.

Περίληψη

Ο σκοπός της μεταπτυχιακής διατριβής είναι να διερευνήσει τους παράγοντες που εξηγούν βέλτιστα τις αποδόσεις των μετοχών και τη μεταβλητότητα των ηγετών της τεχνολογικής βιομηχανίας (FAANG - Facebook, Apple, Amazon, Netflix, Google).

Το πρώτο θέμα επικεντρώνεται στη διατομή των αποδόσεων με παράγοντες όπως η αγορά, το μέγεθος, η αξία, η ορμή, το κέρδος, οι επενδύσεις, η βιομηχανία, η κατάσταση της χρηματιστηριακής αγοράς (bear and bull market) και ο αντίκτυπος της χρηματιστηριακής κρίσης το 2008. Στην εργασία, δείχνω ότι η μεταβλητότητα ενεργεί ως πληρεξούσιο για την ερμηνεία των αποδόσεων. Επιπλέον, το βέλτιστο μοντέλο που εξηγεί τις αποδόσεις, περιέχει, εκτός από την μεταβλητότητα του χαρτοφυλακίου, παράγοντες όπως οι επενδύσεις και η βιομηχανία. Δείχνω ότι παράγοντες όπως η μεταβλητότητα, οι επενδύσεις και η βιομηχανία έχουν καλύτερη ερμηνευτική ισχύ για να εξηγήσουν τις αποδόσεις των ηγετών της τεχνολογίας από τους παράγοντες όπως η αγορά, το μέγεθος και η αξία.

Τέλος, το δεύτερο θέμα επικεντρώνεται στη διατομή της μεταβλητότητας με τους προαναφερόμενους παράγοντες. Δείχνω ότι παράγοντες όπως η αγορά, το μέγεθος, η αξία, η ορμή, το κέρδος, οι επενδύσεις, η βιομηχανία, η κατάσταση του χρηματιστηρίου (bear market ή bull market) και ο αντίκτυπος της κρίσης του χρηματιστηρίου το 2008, ερμηνεύουν την μεταβλητότητα των αποδόσεων των ηγετών της τεχνολογικής βιομηχανίας.

Λέξεις κλειδιά: τιμολόγηση περιουσιακών στοιχείων, αποδόσεις μετοχών, μεταβλητότητα, βιομηχανία της τεχνολογίας, FAANG, μοντέλα διατομής.

Contents

1. Introduction

The Capital Asset Pricing Model (CAPM), first introduced by Sharpe (1964) has made a profound impact on the way that investors understand the relationship between price and risk of capital assets. The CAPM simply states that the systematic difference in asset returns can be explained by a single measure of risk, beta. According to the CAPM, the expected return on any risky asset or portfolio of risky assets can be measured by the risk free rate and the market risk premium multiplied by the beta coefficient. Beta represents one of the most widely used concepts in finance. It is used by financial analysts to estimate a stock's sensitivity to the overall market, to identify if a stock is underrated or overrated, to calculate the cost of a capital and to evaluate the performance of assets managers. In the context of the Capital Asset Pricing Model (CAPM), beta is assumed to be constant over time and is estimated via ordinary least squares (OLS).

One of the main research topics in asset pricing in the 1990's has been the work initiated by Fama and French (1992). Fama and French show that the Capital Asset Pricing Model (CAPM) can not explain the cross-section of asset returns in the US. They propose an alternative model which includes, apart from the market factor, a factor related to book-to-market (B/M) which they call HML, and a factor related to size (Market Value) called SMB. However, unlike CAPM, the Fama and French model is not an equilibrium model. The Fama and French model is purely empirically motivated. In a series of articles, Fama and French (1992, 1993, 1995, 1996, 2011, 2015) document that their models do a good job in explaining average equity returns. Nevertheless, it still remains unknown whether their book-to-market and size related factors have any economic interpretation. New researches like Fama and French (2015) and Carhart (1997) show that there are more effects that influence stock returns. This would mean that the three-factor model is not complete to explain stock returns. Therefore Fama and French introduced the five-factor model, a new model that includes two new variables on top of the three-factor model. The two new variables are profitability (RMW) and investment (CMA).

From the above, we can understand these relationships between excess expected returns on an asset or portfolio, and the factors like market risk premium, SMB, HML RMW, CMA and other factors are often questionable due to many obstacles. The CAPM has many problems. As a result, many of the tests, concerning simple CAPM model have failed to give a strong basis for evaluating beta as a reliable measure of systematic risk and this failure was attributed to inefficiency of markets (Fama and French (1992), Lo and MacKinlay (1988)). However, while the Fama and French models have more strength than CAPM, they have also several problems. The strongest problems are those of autocorrelation of residuals and multicollinearity.

This study investigates a range of asset pricing models and factor investing. This is important because a large proportion of global wealth is invested by a certain method. Investors would benefit from a reliable model that can predict returns based on certain risk factors. A few models have already been designed, for example by CAPM, Fama and French and Carhart. The main focus of this thesis will be on models with many risk factors that interpret optimally the returns and volatility of the leaders of technology industry.

This research will estimate the optimal models and their factors for the returns and volatility of technology industry leaders, with data from Yahoo Finance and Kenneth's French data library. We perform a cross-sectional regression. This regression shows the sensitivity of the portfolio's returns to the risk factors. We show that volatility is an important factor in explaining part of the cross-sectional of average returns, it plays a proxy role. Then, we perform a cross-sectional regression for volatility. This regression shows the sensitivity of the portfolio's volatility to the risk factors.

The following chapters give a more detailed description of the performed study. It starts with a literature review which provides an overview of prior research on this topic. The next chapter states the research questions that this thesis will study. After that, the methodology subchapter shows how the different tests are set up and the data subchapter tells what data is used and how it was obtained. Then, the analysis and results chapter describes the test outputs. The study ends by concluding which models best explain the data and the usefulness of the different factors for an investor.

2. Literature Review – Theoretical Background

2.1. CAPM

The CAPM model tries to explain returns by the exposure to the market that a stock has. The model expresses this risk exposure as beta (β). A stock with a high beta has a high market exposure and should move with the market variation with the same weight as its β. The CAPM assumes that returns can be explained by market risk alone, because this is the only risk that investors encounter. Other risks like idiosyncratic risk can be diversified away. This means that investors can avoid this risk by diversifying their portfolio and thus don't require a risk premium for it. The model explains a part of the return but it is quite unreliable because a lot of research (Fama and French 1992, 2015) has shown that market exposure is not the only factor that predicts stock returns and the unexplained parts of the returns in this model are large. The regression equation for the CAPM is the following:

$$R_{i,t} - R_{f,t} = a_i + b_i(R_{M,t} - R_{f,t}) + e_{i,t}$$

where:

$R_{i,t}$ is the return on the capital asset at time t,

$R_{f,t}$ is the risk free rate of interest arising from the government bonds,

$R_{M,t}$ is the return of the market,

$e_{i,t}$ are the residuals

2.2. Fama & French three-factor model

A first factor that was examined is the size of a firm. Research shows that larger firms tend to have lower returns than smaller firms, this is possibly due to the fact that smaller firms are seen as more risk carrying. If this is true, investors require an additional risk premium for smaller stocks. The same goes for the difference between value and growth stocks. Value stocks tend to have higher average returns compared to growth stocks (Fama and French 1992, 1993). Both of these effects aren't taken into account in the CAPM model. Therefore, Fama and French introduced their three-factor model. In this model they add the size and value effects to the CAPM model as new risk factors with their own beta's (β). This means that returns of smaller value stocks can be predicted as higher in the three factor model. This happens because they are expected to pay an additional premium for being small and value stocks. This way the stock return can be predicted more accurate, because more effects are taken into account, but it still misses some effects according to more recent research. The regression equation for the three-factor model is the following:

$$R_{i,t} - R_{f,t} = a_i + b_i(R_{M,t} - R_{f,t}) + s_i SMB_t + h_i HML_t + e_{i,t}$$

where:
$R_{i,t}$ is the return on the capital asset at time t,
$R_{f,t}$ is the risk free rate of interest arising from the government bonds,
$R_{M,t}$ is the return of the market,
SMB_t is the return on the diversified portfolio of small-cap stocks minus the return on the diversified portfolio of large-cap stocks (size factor),
HML_t is the return on the diversified portfolio of high stocks book-to-market to market value minus the return to the diversified portfolio of low stocks book-to-market to market value (value factor),
$e_{i,t}$ are the residuals

2.3. Carhart four-factor model

The Carhart four-factor model instead uses momentum to extend the three-factor model because short term past performance tends to influence current returns as well. In this model higher momentum should yield higher returns. A stock has high momentum when the short term past performance was good. Stocks that underperformed have lower momentum (Carhart 1997). The regression equation for the four-factor model is the following:

$$R_{i,t} - R_{f,t} = a_i + b_i(R_{M,t} - R_{f,t}) + s_i SMB_t + h_i HML_t + m_i MOM_t + e_{i,t}$$

where:
$R_{i,t}$ is the return on the capital asset at time t,
$R_{f,t}$ is the risk free rate of interest arising from the government bonds,
$R_{M,t}$ is the return of the market,
SMB_t is the return on the diversified portfolio of small-cap stocks minus the return on the diversified portfolio of large-cap stocks (size factor),
HML_t is the return on the diversified portfolio of high stocks book-to-market to market value minus the return to the diversified portfolio of low stocks book-to-market to market value (value factor),
MOM_t is the return on the diversified portfolio with prior high stocks performance minus the return to the diversified portfolio of low stocks performance (momentum factor),
$e_{i,t}$ are the residuals

2.4. Fama & French five-factor model

New researches like Fama and French (2015) and Carhart (1997) show that there are more effects that influence stock returns. This would mean that the three-factor model is not complete to explain stock returns. Therefore Fama and French introduced the five-factor model, a new model that includes two new variables on top of the three-factor model. The two new variables are profitability and investment. Research shows that these two variables seem to influence stock returns as well (Fama and French 2015). Companies with higher investments tend to have lower returns than firms with lower investments. Companies with higher profitability tend to have higher returns. The regression equation for the five-factor model is the following:

$$R_{i,t} - R_{f,t} = a_i + b_i(R_{M,t} - R_{f,t}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + e_{i,t}$$

where:

$R_{i,t}$ is the return on the capital asset at time t,

$R_{f,t}$ is the risk free rate of interest arising from the government bonds,

$R_{M,t}$ is the return of the market,

SMB_t is the return on the diversified portfolio of small-cap stocks minus the return on the diversified portfolio of large-cap stocks (size factor),

HML_t is the return on the diversified portfolio of high stocks book-to-market to market value minus the return to the diversified portfolio of low stocks book-to-market to market value (value factor),

RMW_t is the return on the diversified portfolio of robust profit stocks minus the return on the diversified portfolio of weak profit stocks (profit factor),

CMA_t is the return on the diversified portfolio of stocks of conservative companies in terms of investment minus the return on the diversified portfolio of shares of aggressive companies in terms of investments (investment factor),

$e_{i,t}$ are the residuals

2.5. Volatility

Volatility (σ) is a statistical measure of the dispersion of returns for a given asset. In most cases, the higher the volatility, the riskier the asset. Volatility is often measured as the standard deviation between returns from that same asset. It is well known that the volatility of stock returns varies over time. A higher volatility means that an asset's value can potentially be spread out over a larger range of values. This means that the price of the security can change dramatically over a short time period in either direction. A lower volatility means that a security's value does not fluctuate dramatically, and tends to be more steady.

3. Research Questions, Methodology and Data

3.1. Research Questions

The aim of this research is to study what are the factors that explain optimally the returns and volatility of stocks of technology industry leaders (FAANG-Facebook, Apple, Amazon, Netflix, Google). In addition, the study examines the significance of interpretation the volatility of stocks of technology industry leaders as a proxy for the interpretation of returns. Another question is the significance of the bear / bull factor, which refers to the situation in the stock market, to note that the value of this factor, as it is rarely studied in research. Furthermore, we study how important is the role of the technology industry in explaining returns, a factor not found in standard models (Fama & French three-factor model, Carhart four-factor model, Fama & French five-factor model, etc) for explaining expected returns. Finally, we investigate which is the significance-impact of the stock market crisis of 2008 on the returns and the volatility of the shares of leaders of technology industry.

3.2. Methodology

This paragraph describes the creation and statistical tests of the different models used in this study. The models will be tested by a two stages. The first stage is to run cross-sectional regressions to look for a relationship between the risk factors, the returns and the volatility. We estimate the betas of all risk factors. Then the second stage is used to find the optimally models for our data, for this process we need two algorithms, the stepwise technique and the backward technique for each model. Then we examine the correctness of optimally models and search for anomalies. Finally, we can extract information by our models.

3.3. Data

The first step of the process is to collect all the data that is needed for the calculation of the different variables. Firstly, we collected all the close prices for FAANG (Facebook, Apple, Amazon, Netflix, Google) stocks. The data collected for every month, from 01/2000 to 08/2020. These data are obtained from www.yahoofinance.com. We edited the close price for each stock and we extracted the returns of stocks. Subsequently, we constructed a weighted portfolio with these five stocks. Also, we calculated the estimated volatility of portfolio. Then, we collected all factors (market factor minus risk free rate (MktrRF), size factor (SMB), value factor (HML), profit factor (RMW), investment factor (CMA), momentum factor (MOM) and industry factor (IND)) for our models. The data are obtained from https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html. In addition, we added two factors (bear/bull market factor, crsis_2008) depending on the situation of the market. We have bear market from 09/2000-02/2003, 11/2007-02/2009, 02/2020-03/2020 and bull market from 01/2000-08/2000, 03/2003-10/2007, 03/2009-01/2020, 04/2020-08/2020. The crisis_2008 factor declares the influence of crisis at 2008 to the market (stock returns, volatility of stocks, etc).

4. Descriptive Statistics

Firstly, we present the relationships between the stocks that make up the portfolio with the leaders of technology industry that we have constructed. We present the correlations between the returns of stocks and how statistically significant they are (Table 4.1, Figure 4.1).

Figure 4.1

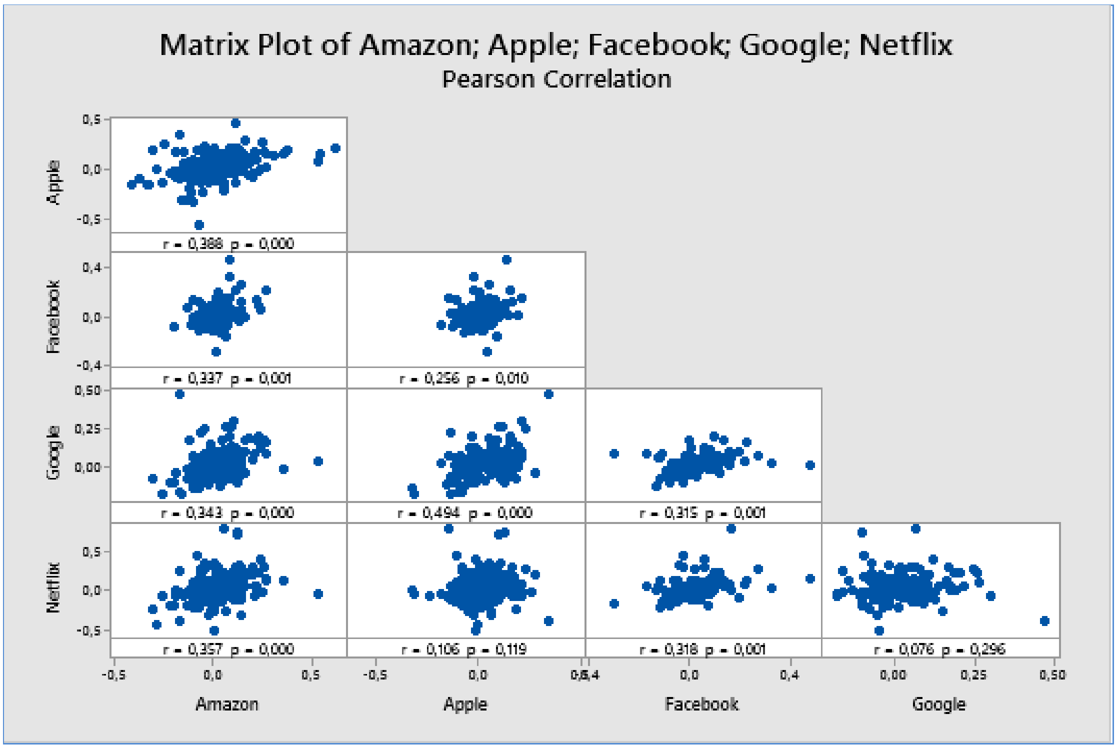


Table 4.1

Correlations

	Amazon	Apple	Facebook	Google
Apple	0,388			
Facebook	0,337	0,256		
Google	0,343	0,494	0,315	
Netflix	0,357	0,106	0,318	0,076

Next, a first thing to look at are the mean returns and volatility of the portfolio with the leaders of technology industry that we constructed (Table 4.2, 4.3 and Figure 4.2, 4.3, respectively). Table 4.4 shows these returns for the equal weighted risk factors.

Table 4.2

Statistics

Variable	Mean	StDev	Minimum	Median	Maximum
Returns	2,664	10,242	-32,563	3,133	41,739

Table 4.3

Statistics

Variable	Mean	StDev	Minimum	Median	Maximum
volatility	21,330	4,538	14,128	20,023	33,616

Figure 4.2

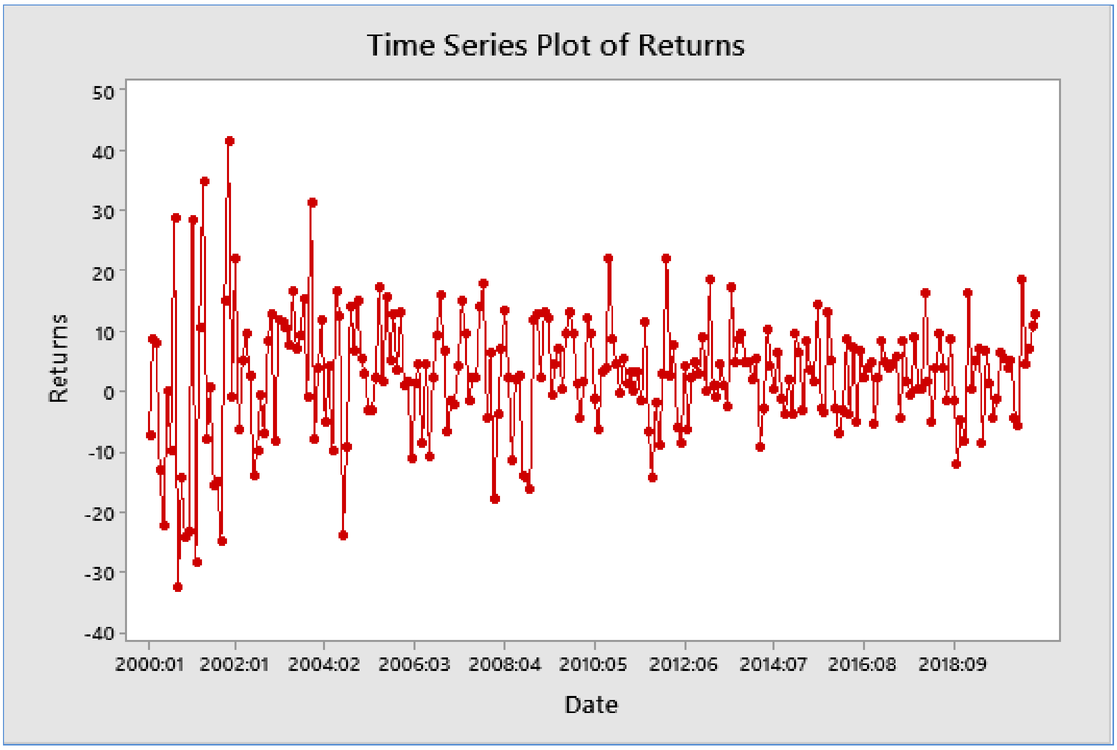


Figure 4.3

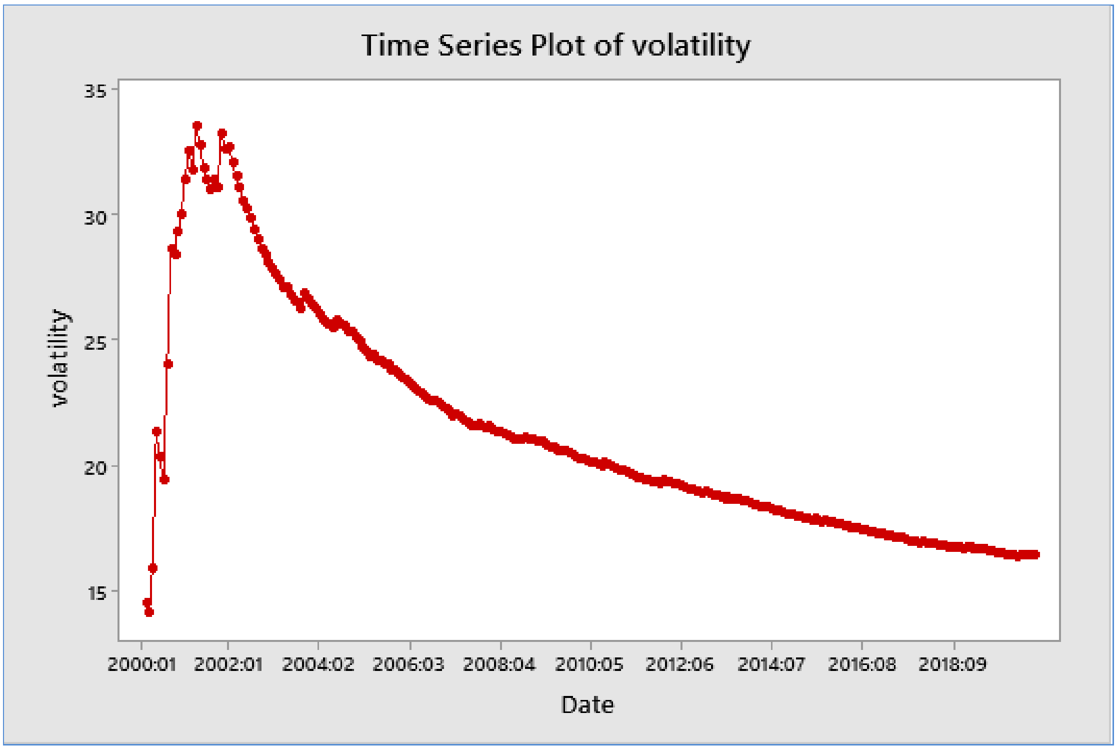


Table 4.4

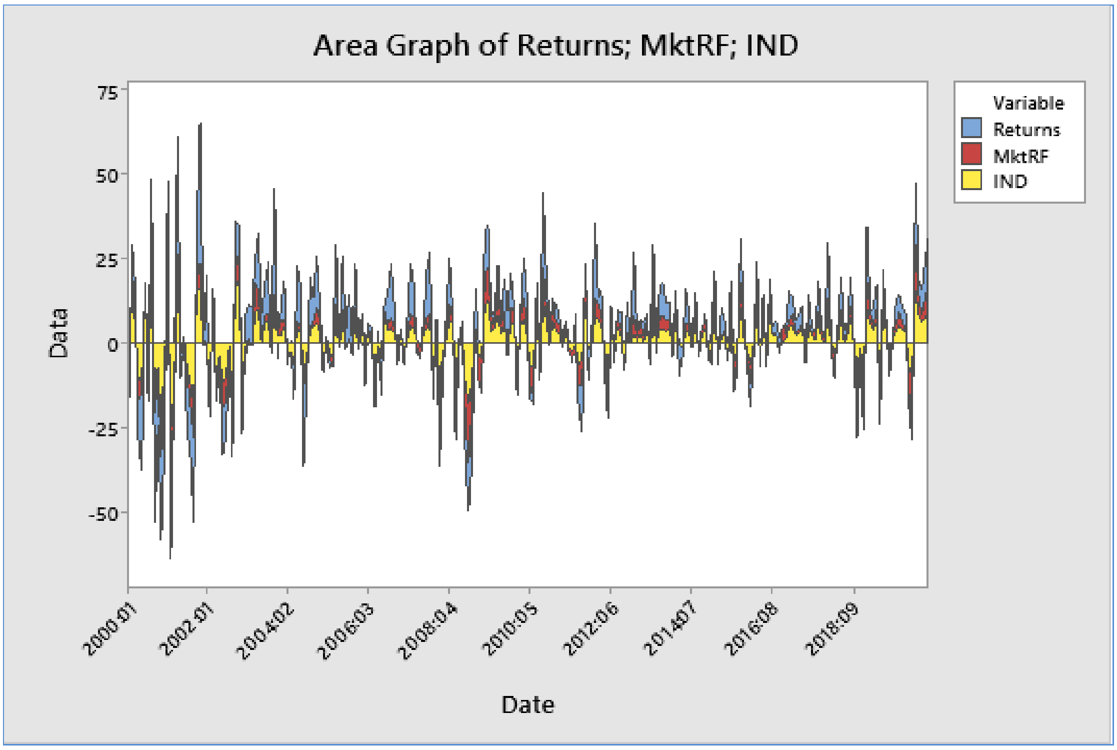
Statistics

Variable	Mean	StDev	Minimum	Median	Maximum
MktRF	0,511	4,526	-17,230	1,135	13,650
SMB	0,228	3,084	-14,860	0,175	18,050
HML	0,077	3,267	-14,110	-0,105	12,600
RMW	0,412	2,924	-18,480	0,425	13,380
CMA	0,250	2,054	-6,550	-0,010	9,560
MOM	0,247	5,293	-34,390	0,365	18,360
IND	0,734	6,938	-25,960	1,290	19,410

As we can watch from Figure 4.2 and 4.3, we can notice that the volatility of portfolio with the leaders of technology industry decrease over the years. This may be due to the technological financial crisis of 2001 and the effects it had on the financial market. Furthermore, the first thing that stands out from the Table 4.4 is the market return. On average the data shows a positive market excess return for the sample period. It is commonly know that the market return for equities is on average positive for the long term. The data reflects this fact by a monthly market return of about 0.511% and a monthly standard deviation of 4.52% on average. A second thing that stands out at this point is the negative median returns for the HML and CMA factors. A factor is in theory expected to contribute in a non-zero way to the returns. A positive contribution is visible in the industry factor. Finally, we present a graph

(Figure 4.4) that show us the level of portfolio returns relative to the market excess returns and the returns of technology industry. Also, the Figure 4.4 shows us that the returns of our portfolio over win the excess returns of market and the returns of technology industry.

Figure 4.4



5. Analysis, Relations and Results

5.1. Analysis of Returns

This chapter will describe the analysis and the results of the regressions stated in the methodology chapter. The first part includes the cross-sectional regressions with all risk factors. We fit the data to a multi linear regression model by setting the Returns as the dependent variable and the other ten variables as explanatory, and we have the following results:

Table 5.1.1

Regression Equation

Returns = -11,65 - 0,479 MktRF - 0,133 SMB + 0,131 HML + 0,184 RMW - 0,630 CMA + 0,1417 MOM + 1,471 IND + 0,559 volatility + 0,0 bear/bull_0 + 0,76 bear/bull_1 + 0,0 crisis_2008_0 + 1,80 crisis_2008_1

Table 5.1.2

Coefficients

Term	Coef	SE Coef	95% CI	T-Value	P-Value	VIF
Constant	-11,65	4,57	(-20,65; -2,66)	-2,55	0,011	
MktRF	-0,479	0,267	(-1,005; 0,048)	-1,79	0,075	8,85
SMB	-0,133	0,165	(-0,458; 0,192)	-0,81	0,420	1,56
HML	0,131	0,210	(-0,283; 0,544)	0,62	0,534	2,85
RMW	0,184	0,221	(-0,252; 0,620)	0,83	0,407	2,50
CMA	-0,630	0,276	(-1,174; -0,087)	-2,28	0,023	1,91
MOM	0,1417	0,0901	(-0,0358; 0,3192)	1,57	0,117	1,38
IND	1,471	0,200	(1,077; 1,864)	7,36	0,000	11,67
volatility	0,559	0,162	(0,240; 0,878)	3,45	0,001	3,27
bear/bull						
1	0,76	1,46	(-2,11; 3,64)	0,52	0,602	2,03
crisis_2008						
1	1,80	1,32	(-0,81; 4,41)	1,36	0,175	2,63

Table 5.1.3

Model Summary

S	R-sq	R-sq(adj)	PRESS	R-sq(pred)	AICc	BIC
6,37385	62,86%	61,29%	10984,3	57,45%	1630,03	1670,80

Table 5.1.4

Analysis of Variance

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Regression	10	16227,8	62,86%	16227,8	1622,78	39,94	0,000
MktRF	1	10117,3	39,19%	130,3	130,27	3,21	0,075
SMB	1	12,4	0,05%	26,5	26,46	0,65	0,420
HML	1	2523,8	9,78%	15,8	15,76	0,39	0,534
RMW	1	151,0	0,58%	28,0	28,02	0,69	0,407
CMA	1	451,4	1,75%	211,9	211,93	5,22	0,023
MOM	1	7,0	0,03%	100,5	100,54	2,47	0,117
IND	1	2276,9	8,82%	2198,5	2198,50	54,12	0,000
volatility	1	600,7	2,33%	484,6	484,56	11,93	0,001
bear/bull	1	12,1	0,05%	11,1	11,07	0,27	0,602
crisis_2008	1	75,2	0,29%	75,2	75,20	1,85	0,175
Error	236	9587,7	37,14%	9587,7	40,63		
Total	246	25815,5	100,00%				

In the table of Coefficients (Table 5.1.2) we observe that variables have high p-values (p-value≥0.05), as a result these variables are not statistically significant, which is a concern for the suitability of model. Also, several variables have large VIF (Variance Inflation Factor). So there is the problem of multicollinearity. The following is the table of correlations of the explanatory variables (Table 5.1.5, Figure 5.1.1):

Figure 5.1.1

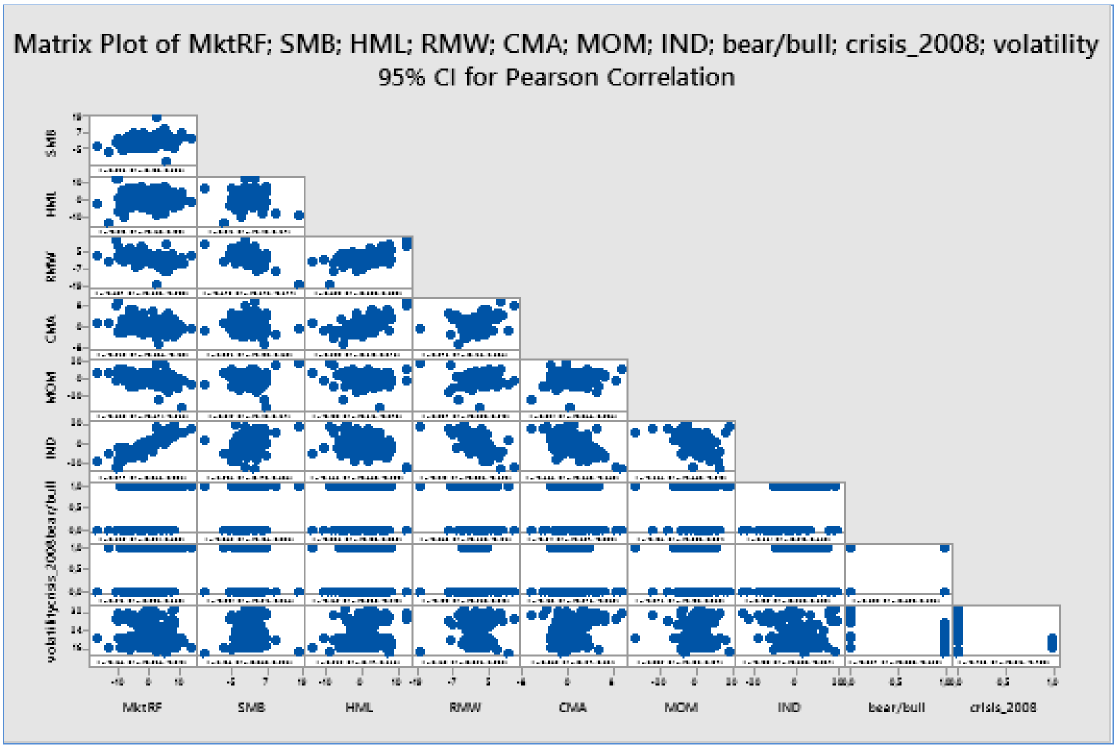


Table 5.1.5

Correlations

	MktRF	SMB	HML	RMW	CMA	MOM	IND	bear/bull	crisis_2008
SMB	0,285								
HML	-0,016	0,013							
RMW	-0,407	-0,479	0,409						
CMA	-0,250	0,025	0,598	0,273					
MOM	-0,368	0,012	-0,198	0,097	0,081				
IND	0,877	0,294	-0,343	-0,610	-0,454	-0,334			
bear/bull	0,392	-0,040	-0,063	-0,246	-0,211	-0,104	0,331		
crisis_2008	0,215	-0,091	-0,142	-0,109	-0,156	-0,075	0,182	0,508	
volatility	-0,144	0,164	0,239	0,148	0,248	0,002	-0,190	-0,607	-0,766

We observe that the variables MktRF-IND have quite high correlation (Table 5.1.5), as a result that there is the problem of multicollinearity.

The model with ten explanatory variables is not optimal, as most of the explanatory variables are not statistically significant. There is also the problem of multicollinearity, as there are explanatory variables that have VIF>5. Finally, as we see in the table below (Table 5.1.6), the model that contains all the variables has a high AIC (1630.25) and a high Cp-Mallows (11.0).

Table 5.1.6

Response is Returns

Vars	R-Sq	R-Sq (adj)	R-Sq (pred)	Mallows Cp	S	AICc	BIC	MktRF	SMB	HML	RMW	CMA	MOM	IND	bear/bull	crisis_2008
1	58,3	58,1	57,3	22,3	6,6323	1639,668	1650,097							X		
1	39,2	38,9	37,9	143,4	8,0046	1732,577	1743,007	X								
2	60,0	59,7	58,4	13,3	6,5070	1631,306	1645,178							X		
2	59,3	59,0	57,9	17,6	6,5618	1635,447	1649,320					X		X		
3	61,6	61,2	59,7	4,7	6,3836	1622,914	1640,212					X		X		
3	60,9	60,4	58,7	9,4	6,4448	1627,628	1644,926	X						X		
4	61,9	61,3	59,4	4,9	6,3725	1623,139	1643,845	X				X		X		
4	61,9	61,3	59,3	4,9	6,3731	1623,181	1643,888					X	X	X		
5	62,2	61,4	59,0	5,3	6,3651	1623,662	1647,759		X			X	X	X		
5	62,1	61,4	58,9	5,6	6,3680	1623,889	1647,986	X				X	X	X		
6	62,4	61,4	58,7	6,0	6,3605	1624,409	1651,879	X			X	X	X	X		
6	62,4	61,4	58,4	6,0	6,3612	1624,467	1651,937	X	X			X	X	X		

7	62,6	61,6	58,6	6,4	6,3521	1624,881	1655,706	X			X	X	X	X		X
7	62,6	61,5	58,4	6,5	6,3534	1624,984	1655,809	X	X			X	X	X		X
8	62,7	61,5	58,2	7,7	6,3570	1626,398	1660,560	X	X		X	X	X	X		X
8	62,7	61,5	58,1	7,8	6,3579	1626,474	1660,636	X	X	X		X	X	X		X
9	62,8	61,4	57,8	9,3	6,3641	1628,101	1665,580	X	X	X	X	X	X	X		X
9	62,8	61,4	57,8	9,4	6,3656	1628,221	1665,701	X	X		X	X	X	X	X	X
10	62,9	61,3	57,5	11,0	6,3739	1630,025	1670,805	X	X	X	X	X	X	X	X	X

Applying the stepwise technique (Table 5.1.8) and the backward elimination technique (Table 5.1.9) get the following optimal model (Table 5.1.7):

Table 5.1.7

Regression Equation

Returns = -5,57 - 0,739 CMA + 1,0725 IND + 0,3578 volatility

Table 5.1.8

Stepwise Selection of Terms

Candidate terms: MktRF; SMB; HML; RMW; CMA; MOM; IND; volatility; bear/bull; crisis_2008

	-----Step 1----		-----Step 2----		-----Step 3----	
	Coef	P	Coef	P	Coef	P
Constant	1,852		-4,62		-5,57	
IND	1,1261	0,000	1,1637	0,000	1,0725	0,000
volatility			0,3021	0,001	0,3578	0,000
CMA					-0,739	0,001
S		6,63227		6,50701		6,38357
R-sq		58,25%		59,98%		61,64%
R-sq(adj)		58,08%		59,65%		61,17%
Mallows' Cp		22,27		13,30		4,74
AICc		1639,67		1631,31		1622,91
BIC		1650,10		1645,18		1640,21

α to enter = 0,15; α to remove = 0,15

Table 5.1.9

Backward Elimination of Terms

Candidate terms: MktRF; SMB; HML; RMW; CMA; MOM; IND; volatility; bear/bull; crisis_2008

	-----Step 1----		-----Step 2----		-----Step 3----		-----Step 4----	
	Coef	P	Coef	P	Coef	P	Coef	P
Constant	-11,65		-10,29		-10,15		-9,71	
MktRF	-0,479	0,075	-0,440	0,088	-0,352	0,114	-0,384	0,080
SMB	-0,133	0,420	-0,145	0,375	-0,128	0,427		
HML	0,131	0,534	0,143	0,494				
RMW	0,184	0,407	0,159	0,462	0,182	0,393	0,255	0,185
CMA	-0,630	0,023	-0,649	0,018	-0,568	0,022	-0,585	0,017
MOM	0,1417	0,117	0,1441	0,110	0,1219	0,147	0,1133	0,173
IND	1,471	0,000	1,454	0,000	1,390	0,000	1,404	0,000
volatility	0,559	0,001	0,524	0,000	0,520	0,000	0,498	0,001
bear/bull	0,76	0,602						
crisis_2008	1,80	0,175	1,81	0,171	1,69	0,197	1,67	0,202
S		6,37385		6,36406		6,35697		6,35207
R-sq		62,86%		62,82%		62,74%		62,65%
R-sq(adj)		61,29%		61,41%		61,49%		61,55%
Mallows' Cp		11,00		9,27		7,74		6,37
AICc		1630,03		1628,10		1626,40		1624,88
BIC		1670,80		1665,58		1660,56		1655,71

	-----Step 5----		-----Step 6----		-----Step 7----		-----Step 8----	
	Coef	P	Coef	P	Coef	P	Coef	P
Constant	-5,77		-5,70		-5,53		-5,57	
MktRF	-0,327	0,128	-0,237	0,241	-0,272	0,176		
SMB								
HML								
RMW	0,241	0,211						
CMA	-0,581	0,018	-0,617	0,012	-0,622	0,011	-0,739	0,001
MOM	0,1058	0,203	0,0955	0,248				
IND	1,370	0,000	1,249	0,000	1,243	0,000	1,0725	0,000
volatility	0,3569	0,000	0,3613	0,000	0,3555	0,000	0,3578	0,000
bear/bull								
crisis_2008								
S		6,36046		6,36804		6,37250		6,38357
R-sq		62,39%		62,14%		61,93%		61,64%
R-sq(adj)		61,45%		61,36%		61,30%		61,17%
Mallows' Cp		5,99		5,56		4,90		4,74
AICc		1624,41		1623,89		1623,14		1622,91
BIC		1651,88		1647,99		1643,84		1640,21

α to remove = 0,1

As we can see from the tables below (Table 5.1.10), all three variables CMA-IND-volatility are statistically significant (p-value<0.05). In addition, for all three variables we have VIF<5, as a result there is no multicollinearity. Finally, the values of the Cp-Mallows and AIC criteria are among the lowest possible (4.7 and 1622.91 respectively).

Table 5.1.10

Coefficients

Term	Coef	SE Coef	95% CI	T-Value	P-Value	VIF
Constant	-5,57	2,02	(-9,55; -1,59)	-2,76	0,006	
CMA	-0,739	0,228	(-1,188; -0,290)	-3,24	0,001	1,30
IND	1,0725	0,0660	(0,9426; 1,2025)	16,25	0,000	1,27
volatility	0,3578	0,0930	(0,1747; 0,5409)	3,85	0,000	1,07

Table 5.1.11

Model Summary

S	R-sq	R-sq(adj)	PRESS	R-sq(pred)	AICc	BIC
6,38357	61,64%	61,17%	10409,7	59,68%	1622,91	1640,21

Table 5.1.12

Analysis of Variance

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Regression	3	15913,3	61,64%	15913,3	5304,4	130,17	0,000
CMA	1	4915,2	19,04%	429,0	429,0	10,53	0,001
IND	1	10394,3	40,26%	10765,9	10765,9	264,19	0,000
volatility	1	603,7	2,34%	603,7	603,7	14,81	0,000
Error	243	9902,3	38,36%	9902,3	40,8		
Total	246	25815,5	100,00%				

Regarding the residuals, we conclude from the following graph that the residuals follow the normal distribution (Figure 5.1.2). Also, from the second graph we conclude that there is a constant variation of the errors (Figure 5.1.3), as it seems that the errors are randomly distributed around zero. In addition, there does not seem to be any autocorrelation problem, as the errors do not follow a pattern in time, they are randomly distributed around zero (Figure 5.1.4) and the Durbin Watson Statistic is D=1.93≅2 (Table 5.1.13). Therefore, the conditions of our model are met.

Figure 5.1.2

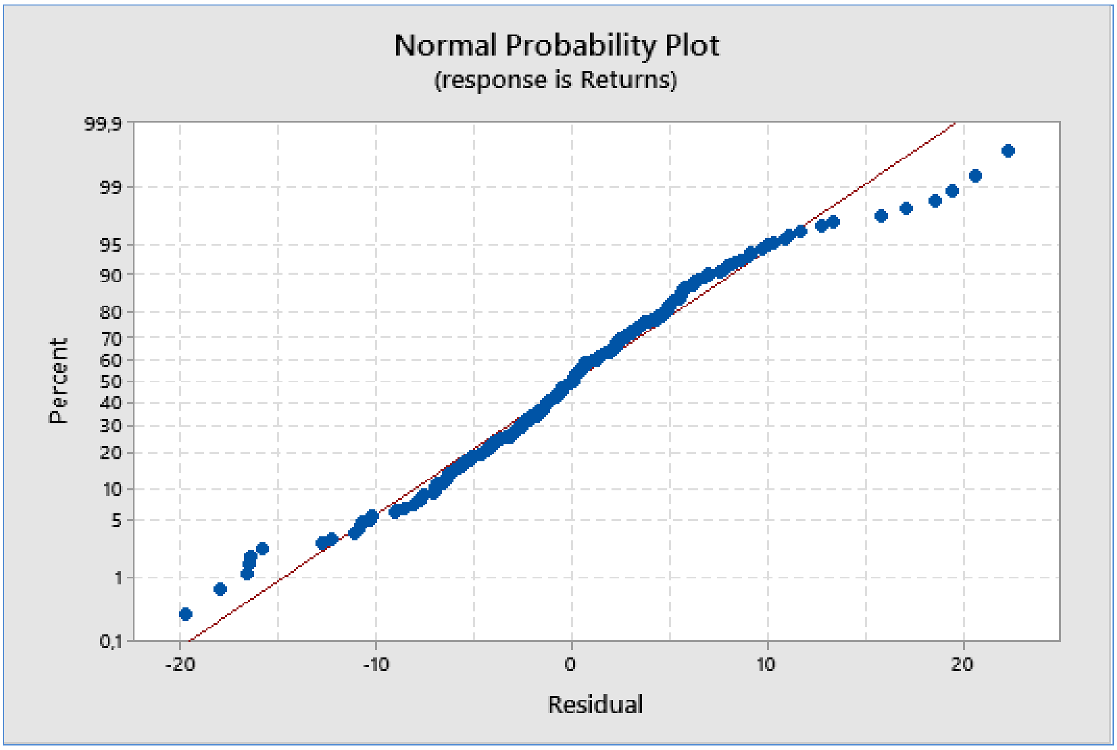


Figure 5.1.3

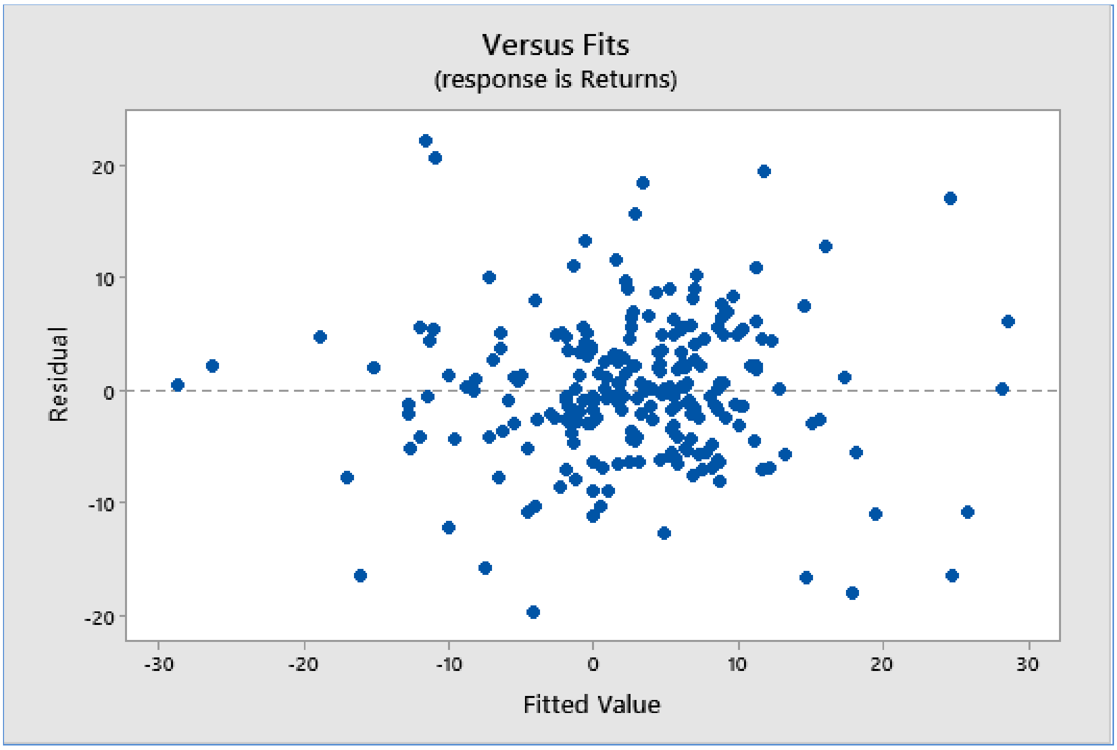


Figure 5.1.4

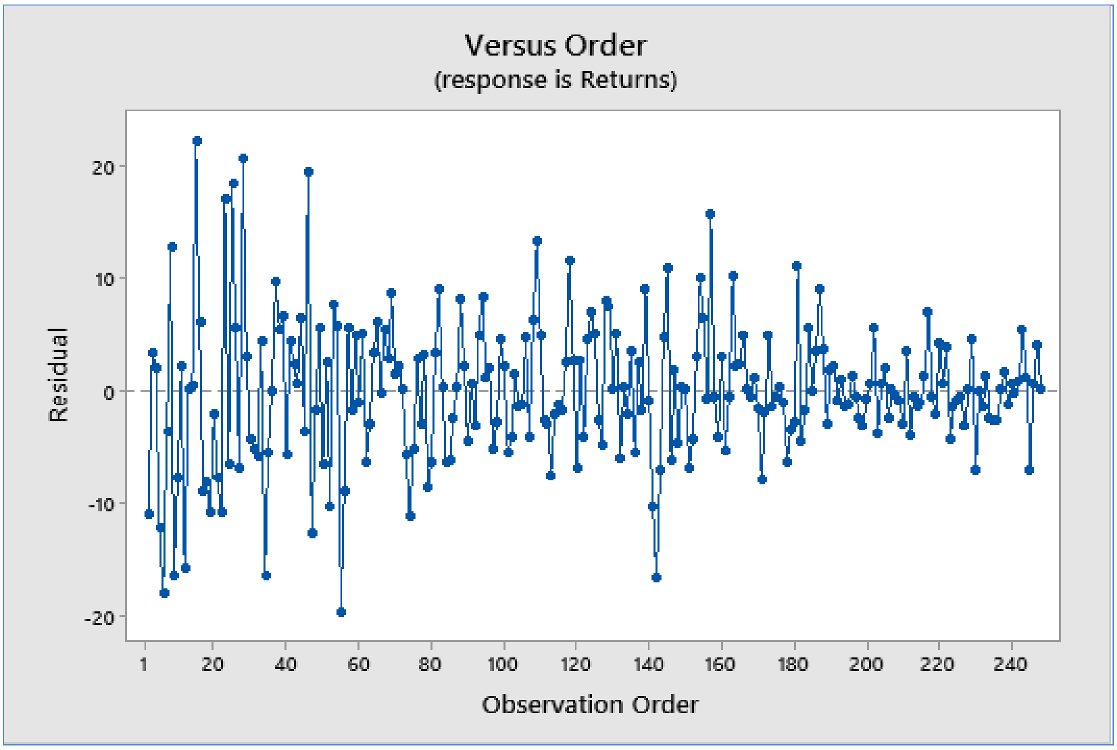


Table 5.1.13

Durbin-Watson Statistic
Durbin-Watson Statistic = 1,93509

Finally, check for points of influence from HI diagram (Figure 5.1.5) and Cook's distance diagram (Figure 5.1.6) in relation to the sequence of observations. The value of HI is called the leverage of the i-th observation. If $HI > \frac{2p}{n}$, where $p = k + 1$ is the number of parameters to be estimated, k is the number of explanatory variables in the model and n is the sample size, then this observation is highly influential. From the HI diagram we have large values in observations 2000:11, 2001:01, 2001:02, 2001:04, 2001:10, 2001:11, 2002:09, 2002:10, 2002:11. The value of Cook's distance (D_i) is called the influence of the i-th observation. If $D_i > 1$, then this observation is highly influential. There aren't observations that beyond the one.

Figure 5.1.5

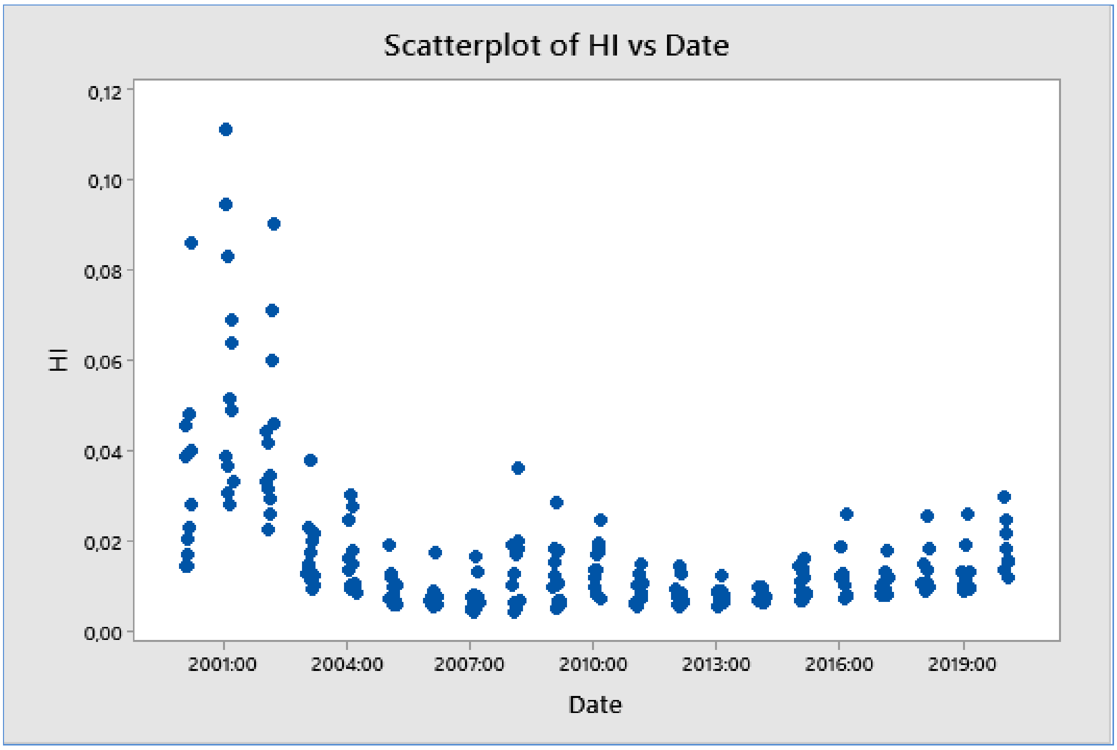
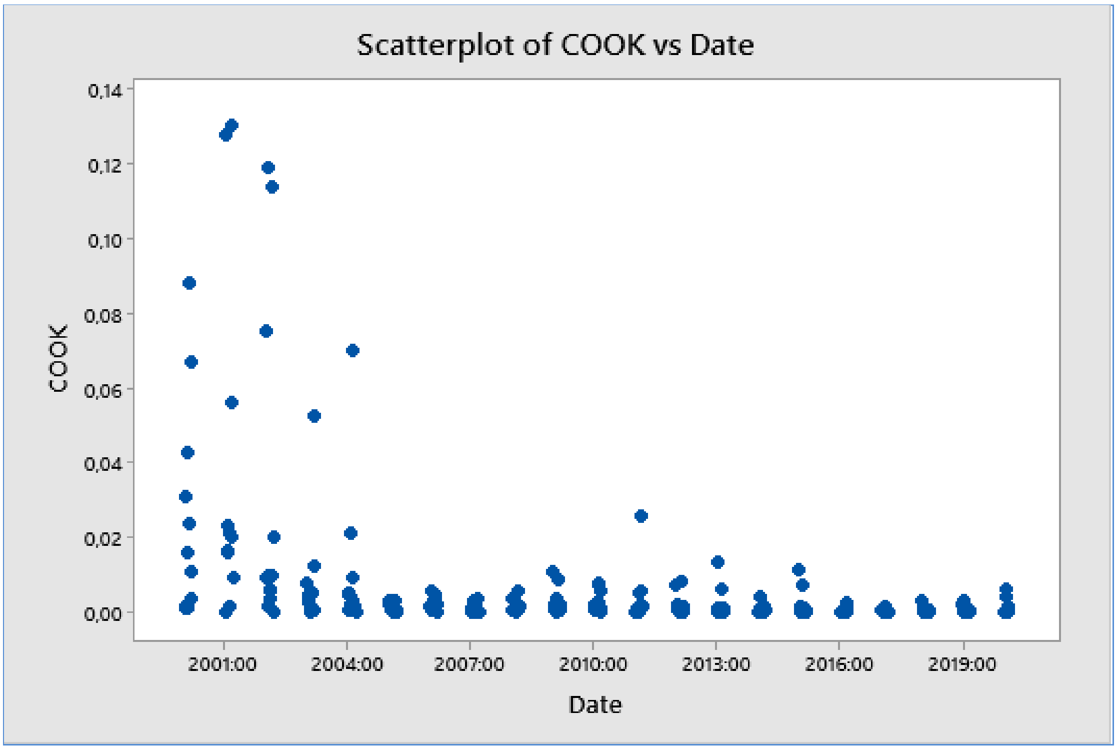


Figure 5.1.6



5.2. Analysis of Volatility

This paragraph will describe the analysis of volatility of portfolio with the leaders of technology industry and the results of the regressions stated in the methodology chapter. The first part includes the cross-sectional regressions with all risk factors. We fit the data to a multi linear regression model by setting the volatility as the dependent variable and the other nine variables as explanatory, and we have the following results:

Table 5.2.1

Regression Equation

volatility = 27,398 + 0,339 MktRF + 0,1181 SMB + 0,0084 HML - 0,0377 RMW + 0,081 CMA - 0,0472 MOM - 0,2009 IND + 0,0 bear/bull_0 - 3,739 bear/bull_1 + 0,0 crisis_2008_0 - 5,550 crisis_2008_1

Table 5.2.2

Coefficients

Term	Coef	SE Coef	95% CI	T-Value	P-Value	VIF
Constant	27,398	0,433	(26,546; 28,250)	63,35	0,000	
MktRF	0,339	0,105	(0,133; 0,546)	3,23	0,001	8,47
SMB	0,1181	0,0657	(-0,0114; 0,2475)	1,80	0,074	1,54
HML	0,0084	0,0841	(-0,1573; 0,1742)	0,10	0,920	2,85
RMW	-0,0377	0,0887	(-0,2126; 0,1371)	-0,43	0,671	2,49
CMA	0,081	0,111	(-0,136; 0,299)	0,74	0,462	1,91
MOM	-0,0472	0,0360	(-0,1181; 0,0238)	-1,31	0,191	1,37
IND	-0,2009	0,0791	(-0,3567; -0,0450)	-2,54	0,012	11,36
bear/bull						
1	-3,739	0,533	(-4,789; -2,689)	-7,02	0,000	1,68
crisis_2008						
1	-5,550	0,390	(-6,318; -4,782)	-14,24	0,000	1,42

Table 5.2.3

Model Summary

S	R-sq	R-sq(adj)	PRESS	R-sq(pred)	AICc	BIC
2,55676	69,41%	68,25%	1849,89	63,48%	1177,61	1215,09

Table 5.2.4

Analysis of Variance

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Regression	9	3515,90	69,41%	3515,90	390,66	59,76	0,000
MktRF	1	104,58	2,06%	68,34	68,34	10,45	0,001
SMB	1	235,71	4,65%	21,09	21,09	3,23	0,074
HML	1	271,28	5,36%	0,07	0,07	0,01	0,920
RMW	1	49,06	0,97%	1,18	1,18	0,18	0,671
CMA	1	28,81	0,57%	3,54	3,54	0,54	0,462
MOM	1	16,34	0,32%	11,23	11,23	1,72	0,191
IND	1	15,92	0,31%	42,13	42,13	6,44	0,012
bear/bull	1	1469,36	29,01%	321,78	321,78	49,22	0,000
crisis_2008	1	1324,83	26,16%	1324,83	1324,83	202,67	0,000
Error	237	1549,27	30,59%	1549,27	6,54		
Total	246	5065,16	100,00%				

In the table of Coefficients (Table 5.2.2) we observe that variables have high p-values (p-value≥0.05), as a result these variables are not statistically significant, which is a concern for the suitability of our model. Also several variables have large VIF (Variance Inflation Factor). So there is the problem of multicollinearity.

Regarding the residuals, we conclude from the following graph that the residuals follow the normal distribution (Figure 5.2.1). However, from the second graph we conclude that there is not a constant variation of the errors (Figure 5.2.2), as it seems that the errors aren't randomly distributed around zero. The last but the most important, there is a strong autocorrelation problem, as the errors follow a pattern in time, they aren't randomly distributed around zero (Figure 5.2.3) and the Durbin Watson Statistic is D=0.33 (Table 5.2.5). Therefore, the conditions of model are not met.

Figure 5.2.1

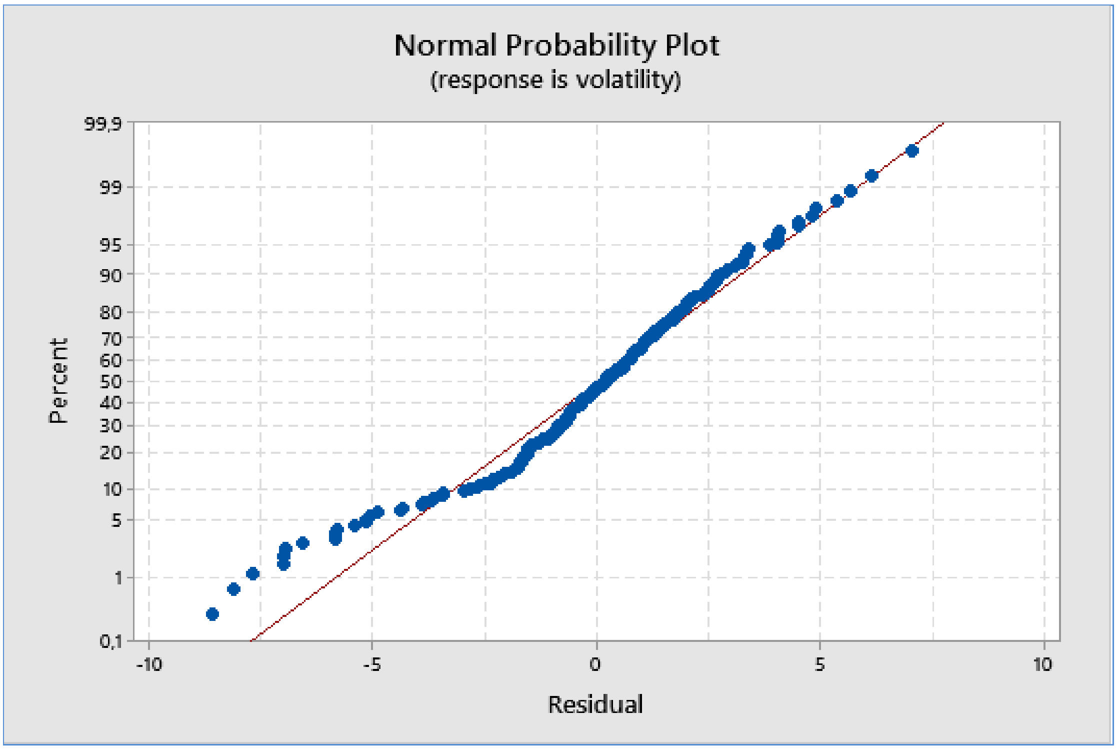


Figure 5.2.2

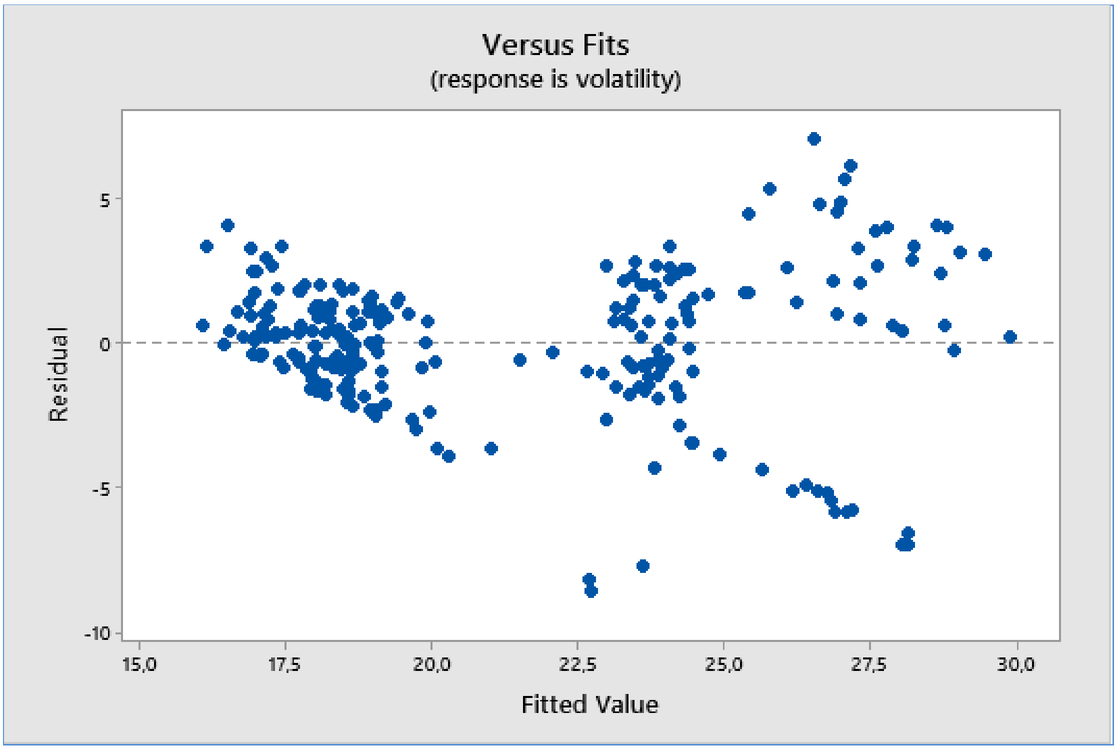


Figure 5.2.3

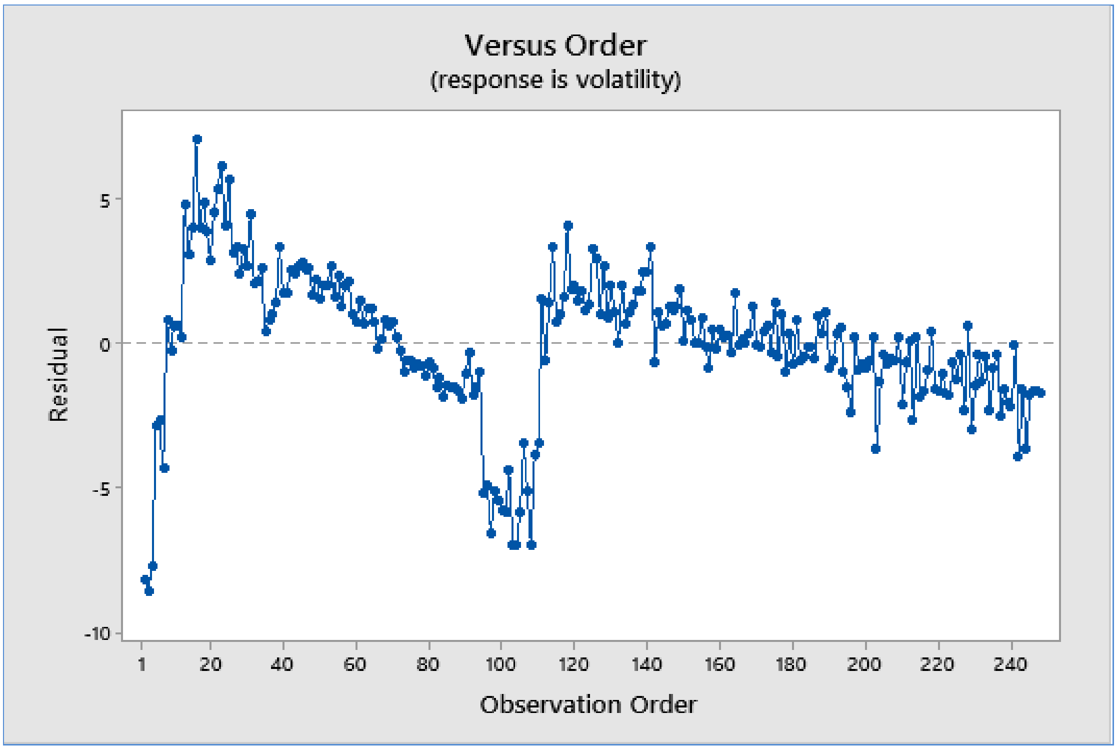


Table 5.2.5

Durbin-Watson Statistic
Durbin-Watson Statistic = 0,331870

The use of Cochrane-Orcutt method solves the autocorrelation problem. We apply the Cochrane-Orcutt procedure for two iterations. At the first iteration, we transform all our variables with the transformation $t\_Y_t = Y_t - \rho_1 Y_{t-1}$, where Y_t is each variable of the model (Table 5.2.1) and ρ_1 is the correlation between the residuals of the model and the lag residuals by a lag ($e_t = \rho_1 e_{t-1} + u_t$). We find that the ρ_1 is 0.8132.Then we run the regression with all transformations variables. The results are the following:

Table 5.2.6

Regression Equation
t_volatility = 5,154 + 0,0395 t_MktRF - 0,0032 t_SMB - 0,0021 t_HML - 0,0553 t_RMW - 0,0044 t_CMA - 0,00033 t_MOM - 0,0322 t_IND + 0,0 bear/bull_0 - 0,622 bear/bull_1 + 0,0 crisis_2008_0 - 1,157 crisis_2008_1

Figure 5.2.3

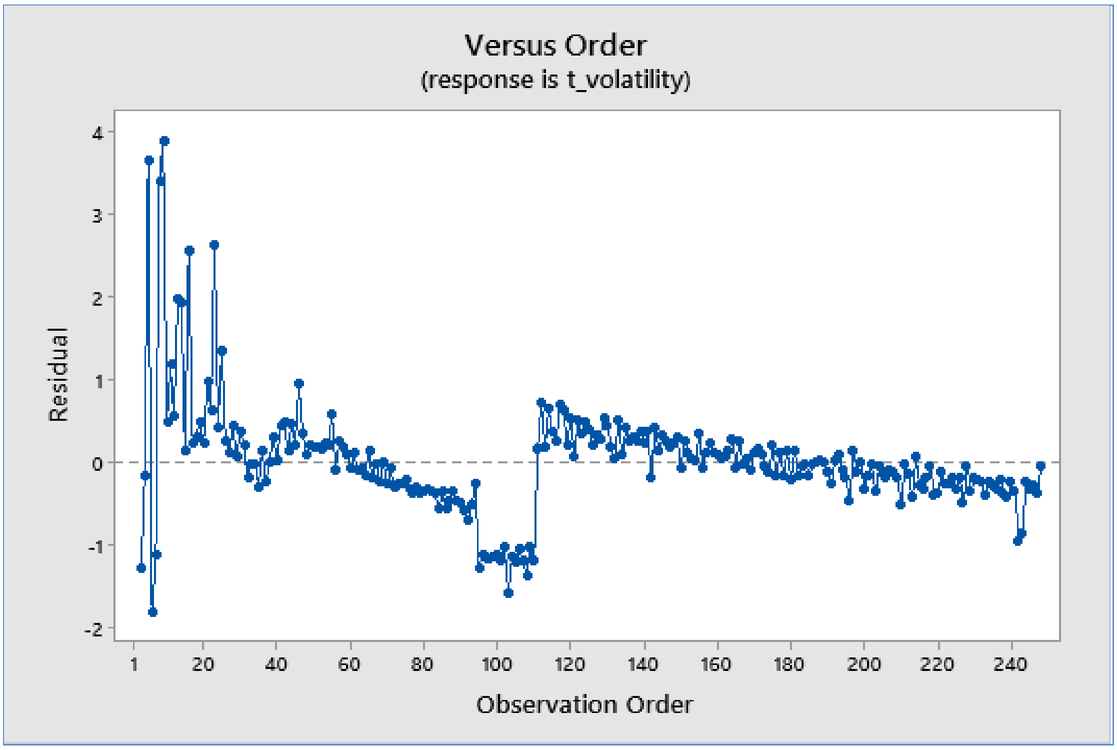


Table 5.2.7

Durbin-Watson Statistic

Durbin-Watson Statistic = 1,08404

The problem of autocorrelation didn't solve (Figure 5.2.3, Table 5.2.7) at the first iteration of Cohrane-Orcutt procedure. At the second iteration, we transform all our variables of transformation model (Table 5.2.6) with the transformation $t2\_Y_t = t\_Y_t - \rho_2 t\_Y_{t-1}$, where t_Y_t is each variable of the model (Table 5.2.6) and ρ_2 is the correlation between the residuals of the transformation model and the lag residuals by a lag ($u_t = \rho_2 u_{t-1} + \varepsilon_t$). We find that the ρ_2 is 0.4507. Then we run the regression with all new transformations variables. The results are the following:

Table 5.2.8

Regression Equation

t2_volatility = 2,7985 + 0,0284 t2_MktRF - 0,01534 t2_SMB + 0,0009 t2_HML - 0,0354 t2_RMW
- 0,0077 t2_CMA - 0,00097 t2_MOM - 0,0224 t2_IND + 0,0 bear/bull_0
- 0,261 bear/bull_1 + 0,0 crisis_2008_0 - 0,6852 crisis_2008_1

Table 5.2.9

Coefficients

Term	Coef	SE Coef	95% CI	T-Value	P-Value	VIF
Constant	2,7985	0,0885	(2,6242; 2,9728)	31,63	0,000	
t2_MktRF	0,0284	0,0136	(0,0016; 0,0553)	2,08	0,038	5,95
t2_SMB	-0,01534	0,00882	(-0,03273; 0,00204)	-1,74	0,083	1,27
t2_HML	0,0009	0,0125	(-0,0236; 0,0255)	0,08	0,940	2,38
t2_RMW	-0,0354	0,0142	(-0,0634; -0,0073)	-2,49	0,014	1,99
t2_CMA	-0,0077	0,0164	(-0,0400; 0,0245)	-0,47	0,637	1,72
t2_MOM	-0,00097	0,00535	(-0,01150; 0,00956)	-0,18	0,856	1,31
t2_IND	-0,0224	0,0105	(-0,0430; -0,0017)	-2,13	0,034	8,63
bear/bull						
1	-0,261	0,115	(-0,489; -0,034)	-2,26	0,025	1,38
crisis_2008						
1	-0,6852	0,0922	(-0,8669; -0,5035)	-7,43	0,000	1,37

Table 5.2.10

Model Summary

S	R-sq	R-sq(adj)	PRESS	R-sq(pred)	AICc	BIC
0,610962	32,92%	30,35%	105,637	19,22%	466,77	504,15

Table 5.2.11

Analysis of Variance

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Regression	9	43,053	32,92%	43,0531	4,7837	12,82	0,000
t2_MktRF	1	0,060	0,05%	1,6214	1,6214	4,34	0,038
t2_SMB	1	0,256	0,20%	1,1287	1,1287	3,02	0,083
t2_HML	1	0,121	0,09%	0,0021	0,0021	0,01	0,940
t2_RMW	1	1,277	0,98%	2,3057	2,3057	6,18	0,014
t2_CMA	1	0,004	0,00%	0,0834	0,0834	0,22	0,637
t2_MOM	1	0,063	0,05%	0,0123	0,0123	0,03	0,856
t2_IND	1	1,476	1,13%	1,6998	1,6998	4,55	0,034
bear/bull	1	19,193	14,68%	1,9121	1,9121	5,12	0,025
crisis_2008	1	20,603	15,75%	20,6028	20,6028	55,19	0,000
Error	235	87,720	67,08%	87,7196	0,3733		
Total	244	130,773	100,00%				

In the table of Coefficients (Table 5.2.9) we observe that variables have high p-values (p-value≥0.05), as a result these variables are not statistically significant, which is a concern for the suitability of model. Also, several variables have large VIF (Variance Inflation Factor). So there is the problem of multicollinearity.

The model with nine explanatory variables is not optimal, as most of the explanatory variables are not statistically significant. There is also the problem of multicollinearity, as there are explanatory variables that have VIF>5. Finally, as we see in the table below (Table 5.2.12), the model that contains all the variables has a high AIC (466.77) and a high Cp-Mallows (10.0).

Table 5.2.12

Response is t2_volatility

Vars	R-Sq	R-Sq (adj)	R-Sq (pred)	Mallows Cp	S	AICc	BIC	t2_MktRF	t2_SMB	t2_HML	t2_RMW	t2_CMA	t2_MOM	t2_IND	bear/bull	crisis_2008
1	28,7	28,4	27,4	8,6	0,61926	464,545	474,950									X
1	14,1	13,8	12,2	59,9	0,67983	510,274	520,678								X	
2	30,0	29,5	27,5	6,1	0,61485	462,100	475,939								X	X
2	29,1	28,5	24,6	9,6	0,61919	465,551	479,390				X					X
3	30,4	29,6	24,8	6,7	0,61439	462,808	480,063				X				X	X
3	30,2	29,4	26,6	7,4	0,61521	463,461	480,716		X						X	X
4	31,0	29,9	24,6	6,7	0,61313	462,886	483,541		X		X				X	X
4	30,8	29,6	25,4	7,5	0,61417	463,717	484,372	X						X	X	X
5	31,9	30,5	24,8	5,6	0,61046	461,845	485,881	X			X			X	X	X
5	31,5	30,1	23,3	6,9	0,61206	463,123	487,159		X	X	X				X	X
6	32,8	31,1	24,8	4,3	0,60747	460,545	487,945	X	X		X			X	X	X
6	32,0	30,3	23,6	7,1	0,61114	463,495	490,894	X			X	X		X	X	X
7	32,9	30,9	23,6	6,1	0,60845	462,461	493,206	X	X		X	X		X	X	X
7	32,9	30,9	21,6	6,2	0,60869	462,654	493,399	X	X		X		X	X	X	X
8	32,9	30,6	20,2	8,0	0,60967	464,583	498,656	X	X		X	X	X	X	X	X
8	32,9	30,6	22,0	8,0	0,60971	464,612	498,684	X	X	X	X	X		X	X	X
9	32,9	30,4	19,2	10,0	0,61096	466,770	504,151	X	X	X	X	X	X	X	X	X

Applying the backward elimination technique (Table 5.2.13) get the following optimal model (Table 5.2.14):

Table 5.2.13

Backward Elimination of Terms

Candidate terms: t2_MktRF; t2_SMB; t2_HML; t2_RMW; t2_CMA; t2_MOM; t2_IND; bear/bull; crisis_2008

	------Step 1------		------Step 2------		------Step 3------	
	Coef	P	Coef	P	Coef	P
Constant	2,7985		2,7984		2,7986	
t2_MktRF	0,0284	0,038	0,0289	0,017	0,0290	0,016
t2_SMB	-0,01534	0,083	-0,01525	0,082	-0,01532	0,079
t2_HML	0,0009	0,940				
t2_RMW	-0,0354	0,014	-0,0351	0,012	-0,0352	0,012
t2_CMA	-0,0077	0,637	-0,0072	0,628	-0,0072	0,630
t2_MOM	-0,00097	0,856	-0,00111	0,824		
t2_IND	-0,0224	0,034	-0,02270	0,016	-0,02245	0,016
bear/bull	-0,261	0,025	-0,261	0,024	-0,262	0,024
crisis_2008	-0,6852	0,000	-0,6853	0,000	-0,6848	0,000
S		0,610962		0,609674		0,608450
R-sq		32,92%		32,92%		32,91%
R-sq(adj)		30,35%		30,65%		30,92%
Mallows' Cp		10,00		8,01		6,06
AICc		466,77		464,58		462,46
BIC		504,15		498,66		493,21

	------Step 4------	
	Coef	P
Constant	2,7977	
t2_MktRF	0,0272	0,017
t2_SMB	-0,01581	0,068
t2_HML		
t2_RMW	-0,0344	0,013
t2_CMA		
t2_MOM		
t2_IND	-0,02033	0,013
bear/bull	-0,261	0,024
crisis_2008	-0,6849	0,000
S		0,607468
R-sq		32,84%
R-sq(adj)		31,15%
Mallows' Cp		4,29
AICc		460,54
BIC		487,94

α to remove = 0,1

Table 5.2.14

Regression Equation

t2_volatility = 2,7977 + 0,0272 t2_MktRF - 0,01581 t2_SMB - 0,0344 t2_RMW - 0,02033 t2_IND
+ 0,0 bear/bull_0 - 0,261 bear/bull_1 + 0,0 crisis_2008_0
- 0,6849 crisis_2008_1

As we can see from the tables below (Table 5.2.15), almost all six variables MktRF-SMB-RMW-IND-bear/bull-crisis_2008 are statistically significant (p-value<0.05). In addition, almost for all six variables we have VIF<5, as a result there is no multicollinearity. Finally, the values of the Cp-Mallows and AIC criteria are among the lowest possible (4.3 and 460.54 respectively).

Table 5.2.15

Coefficients

Term	Coef	SE Coef	95% CI	T-Value	P-Value	VIF
Constant	2,7977	0,0879	(2,6245; 2,9709)	31,82	0,000	
t2_MktRF	0,0272	0,0114	(0,0048; 0,0495)	2,39	0,017	4,17
t2_SMB	-0,01581	0,00862	(-0,03280; 0,00117)	-1,83	0,068	1,23
t2_RMW	-0,0344	0,0137	(-0,0614; -0,0073)	-2,50	0,013	1,88
t2_IND	-0,02033	0,00817	(-0,03641; -0,00424)	-2,49	0,013	5,31
bear/bull						
1	-0,261	0,115	(-0,487; -0,035)	-2,27	0,024	1,38
crisis_2008						
1	-0,6849	0,0917	(-0,8655; -0,5044)	-7,47	0,000	1,37

Table 5.2.16

Model Summary

S	R-sq	R-sq(adj)	PRESS	R-sq(pred)	AICc	BIC
0,607468	32,84%	31,15%	98,3510	24,79%	460,54	487,94

Table 5.2.17

Analysis of Variance

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Regression	6	42,947	32,84%	42,947	7,1578	19,40	0,000
t2_MktRF	1	0,060	0,05%	2,113	2,1133	5,73	0,017
t2_SMB	1	0,256	0,20%	1,241	1,2410	3,36	0,068
t2_RMW	1	0,754	0,58%	2,309	2,3091	6,26	0,013
t2_IND	1	2,119	1,62%	2,286	2,2861	6,20	0,013
bear/bull	1	19,154	14,65%	1,908	1,9080	5,17	0,024
crisis_2008	1	20,603	15,75%	20,603	20,6031	55,83	0,000
Error	238	87,826	67,16%	87,826	0,3690		
Total	244	130,773	100,00%				

Regarding the residuals, we conclude from the following graph that the residuals follow the normal distribution (Figure 5.2.4). The Cochrane-Orcutt method solved the autocorrelation problem and the problem of the non constant variation of errors. The second graph we conclude that there is a constant variation of the errors (Figure 5.2.5), as it seems that the errors are randomly distributed around zero. In addition, there does not seem to be any autocorrelation problem, as the errors do not follow a pattern in time, they are randomly distributed around zero (Figure 5.2.6) and the Durbin Watson Statistic is D=1.97≅2 (Table 5.2.18). Therefore, the conditions of our model are met.

Figure 5.2.4

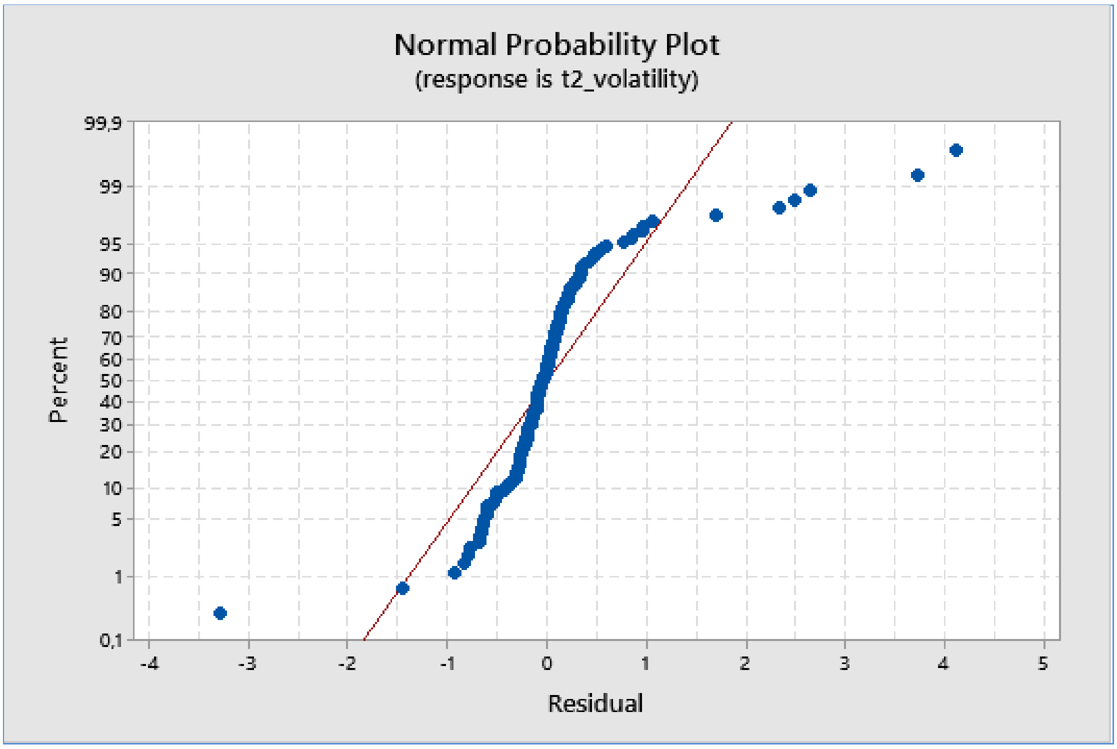


Figure 5.2.5

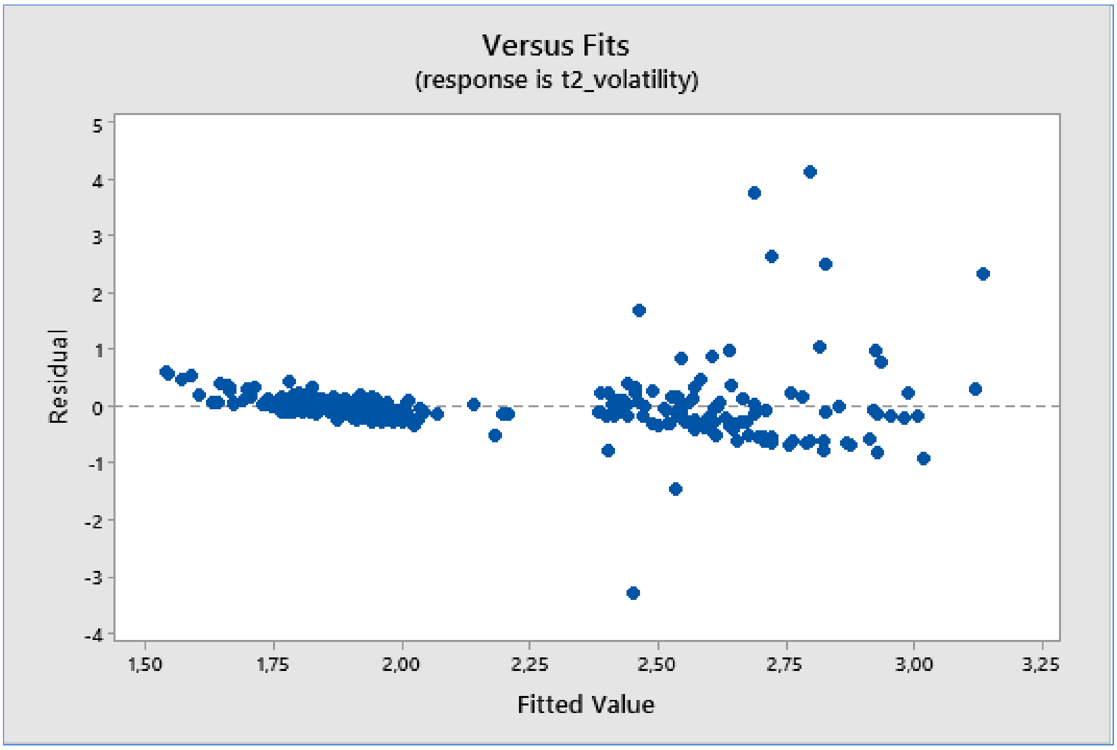


Figure 5.2.6

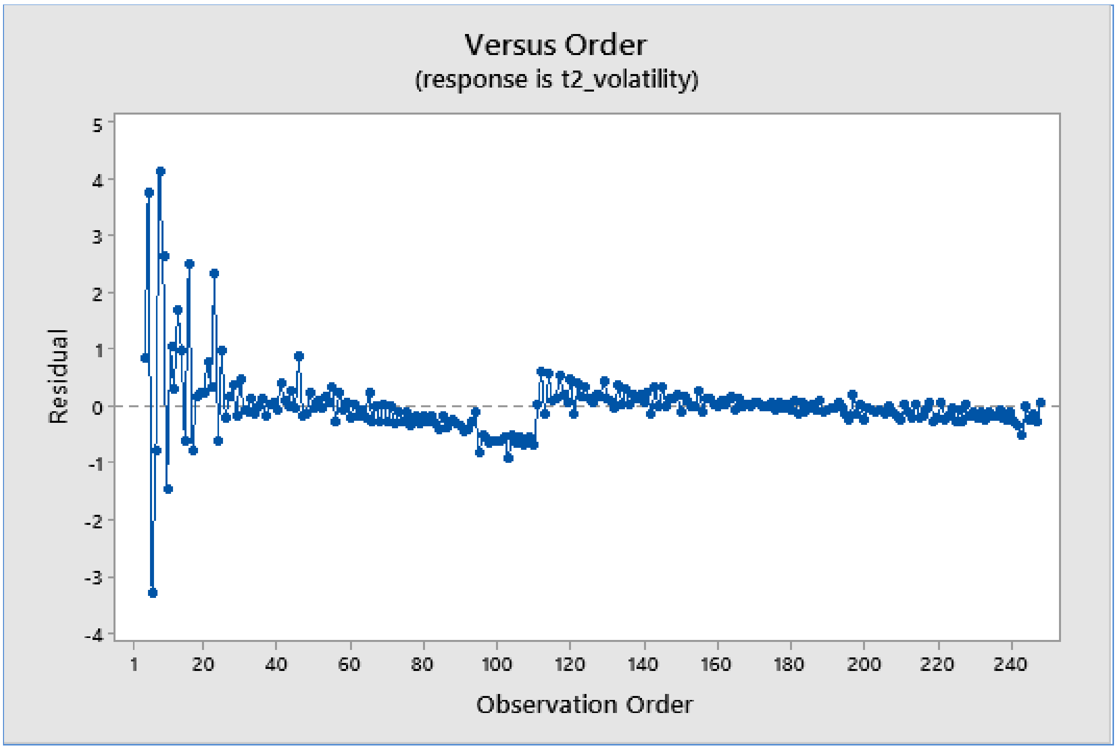


Table 5.2.18

Durbin-Watson Statistic

Durbin-Watson Statistic = 1,97189

Finally, check for points of influence from HI diagram (Figure 5.2.7) and Cook's distance diagram (Figure 5.2.8) in relation to the sequence of observations. If $HI > \frac{2p}{n}$, where $p = k + 1$ is the number of parameters to be estimated, k is the number of explanatory variables in the model and n is the sample size, then this observation is highly influential. From the HI diagram we have large values in observations 2000:04, 2000:07, 2001:02, 2001:10, 2002:10, 2002:12, 2020:04. We observe that the points of influence arise in times of financial crisis, with the result that there is great turmoil in the market. If $D_i > 1$, then this observation is highly influential. From Cook's diagram (Figure 5.5.8), observe that there aren't observations that beyond the one.

Figure 5.2.7

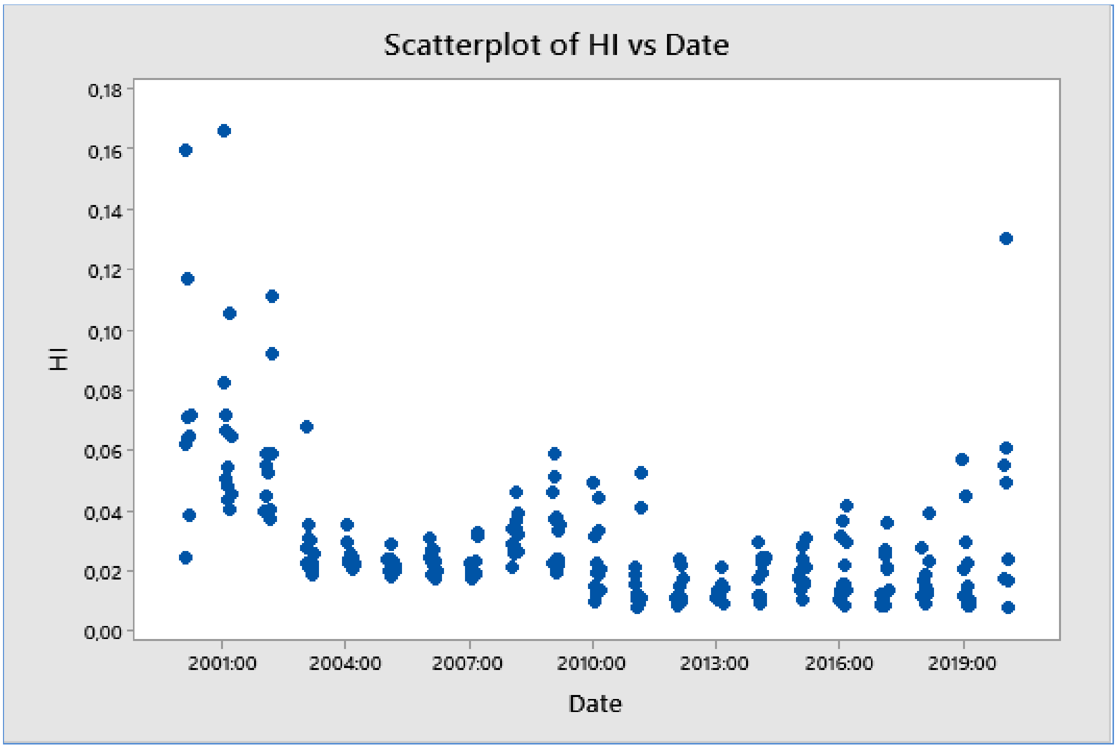
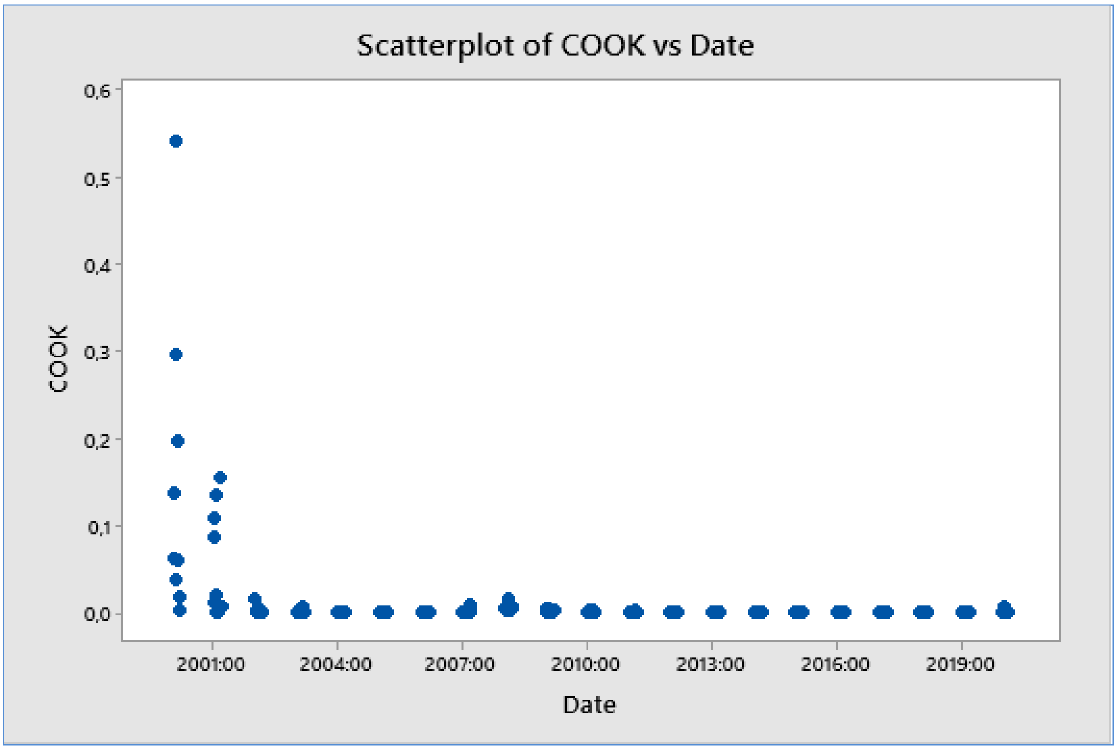


Figure 5.2.8



Finally, returning from the transformation to our original variables we have the following optimal model:

Regression Equation

$$t2\_volatility = 2,7977 + 0,0272\ t2\_MktRF - 0,01581\ t2\_SMB - 0,0344\ t2\_RMW - 0,02033\ t2\_IND + 0,0\ bear/bull\_0 - 0,261\ bear/bull\_1 + 0,0\ crisis\_2008\_0 - 0,6849\ crisis\_2008\_1$$

$$\Leftrightarrow\ volatility = \frac{2,7977}{(1-\rho_1)(1-\rho_2)} + 0,0272\ MktRF - 0,01581\ SMB - 0,0344\ RMW - 0,02033\ IND + \frac{0,0}{(1-\rho_1)(1-\rho_2)}\ bear/bull\_0 - \frac{0,261}{(1-\rho_1)(1-\rho_2)}\ bear/bull\_1 + \frac{0,0}{(1-\rho_1)(1-\rho_2)}\ crisis\_2008\_0 - \frac{0,6849}{(1-\rho_1)(1-\rho_2)}\ crisis\_2008\_1$$

$$\Leftrightarrow\ volatility = 27,2680 + 0,0272\ MktRF - 0,01581\ SMB - 0,0344\ RMW - 0,02033\ IND + 0,0\ bear/bull\_0 - 2,5438\ bear/bull\_1 + 0,0\ crisis\_2008\_0 - 6,6754\ crisis\_2008\_1$$

6. Conclusion

This paper examines the risk factors that explain optimally the returns and volatility of a portfolio consisting of shares of technology industry leaders. From our analysis we come to two optimal models, one for the returns and one for the volatility, respectively.

The optimal model for the portfolio returns of technology industry leaders is:

$$\widehat{Returns} = -5,57 - 0,739\,CMA + 1,0725\,IND + 0,3578\,volatility$$

From this model we conclude that the factors that explain the portfolio returns of technology industry leaders are the investment factor (CMA), the industry factor (IND) and the volatility of the technology industry leaders' portfolio. We observe that volatility plays the role of proxy for the interpretation of returns. In addition, the model informs us that if the investment factor (CMA) increases by one unit then the returns of the portfolio will decrease by 0.739 units on average. If the industry factor (IND) increases by one unit then the portfolio returns will increase by 1.0725 units on average. If the volatility of the technology industry leaders increases by one unit then the portfolio returns will increase by 0.2578 units on average. Finally, the percentage of variance of the variable Returns which is explained by the variables CMA, IND and volatility is 61.64% (Table 5.1.11 – R-sq=61,64%).

The optimal model for the volatility of the portfolio of technology industry leaders is:

$$\begin{aligned}\widehat{volatility} = {} & 27,2680 + 0,0272\,MktRF - 0,01581\,SMB - 0,0344\,RMW \\ & - 0,02033\,IND + 0,0\,bear/bull\_0 - 2,5438\,bear/bull\_1 \\ & + 0,0\,crisis\_2008\_0 - 6,6754\,crisis\_2008\_1\end{aligned}$$

From this model we conclude that the factors that explain the volatility of the portfolio of the leaders in the technology industry are the market factor (MktRF), the size factor (SMB), the profit factor (RMW) and the situation of market factor (bear/bull). The model informs us that if the market factor (MktRF) increases by one unit then the portfolio volatility will increase by 0.0272 units on average. If the size factor (SMB) increases by one unit then the portfolio volatility will decrease by 0.01581 units on average. If the profit factor (RMW) increases by one unit then the portfolio volatility will decrease by 0.0344 units on average. If the industry factor (IND) increases by one unit then the portfolio volatility will decrease by 0.02033 units on average. If the financial market is in a bull situation then the portfolio volatility will increase by 2.5438 units on average. In addition, the model informs us that after the stock market crisis of 2008, the portfolio volatility has increased by 6.6754 units on average. Finally, the percentage of variance of the variable volatility which is explained by the variables MktRF, SMB, RMW, IND, bear/bull and crisis_2008 is 32.84% (Table 5.2.16 – R-sq=32,84%).

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