An Identification the Sources of Risk in Hedge Funds

A research project submitted in partial fulfillment of the requirements for
the degree of Master of Finance

Saint Mary's University

Written for MFIN 6692.0 under direction of
Dr. Francis Boabang

Approved: Dr. Francis Boabang
Faculty Advisor

Approved: Dr. Francis Boabang
MFin Director

Date: August 28, 2013

Acknowledgements

I would like to thank my supervisor Dr. Francis Boabang and all instructors in Master of Finance Program for their guidance while studying in the program. I would like to thank my parents, and Zhimin Yao for their generous support and encouragement.

Abstract

An Identification the Sources of Risk in Hedge Funds

by

Taowei Li

August, 2013

This paper identifies several sources of risk in hedge funds. Historical data are collected from January 1st, 2004 to January 1st, 2013. We employ multivariate regression model to analyze the relationship between the overall hedge fund performance indices and the ten identified sources of risk. We construct model by fitting all the variables, and then improve it based on Akaike Information Criterion (AIC) by using a stepwise algorithm. Our results indicate that the sources of equity risk, interest rate risk, emerging market risk, and macroeconomics risk are critical risk sources in the hedge fund performance modeling.

Table of Contents

List of Table

List of Figure

Chapter 1. Introduction

In financial market, risk management is always a popular and complex topic that attracts the investors' attention. Risk management includes risk identification, potential effects assessment, and corresponding strategy development. The role of practice risk management is to rationally allocate resources to optimize gains and reduce losses (Connor and Woo, 2004). In hedge fund practice, risk management is always a challenge since hedge funds include investments in multiple markets with different strategies. Therefore, it is difficult to find and follow a common scheme to build a risk management strategy for hedge fund. In this paper, we aim to analyze various theoretical financial and statistical models, which are applied in hedge fund, to identify and group the different risk sources in hedge fund. The purpose of this paper is to investigate hedge fund risk sources to provide a different and compact view of the risk components to improve hedge fund risk management.

1.1 Background

1.1.1 Hedge Fund Definition

The term "hedge fund" and the first hedge fund structure were introduced by Alfred W. Jones, which was a financial journalist, in 1949 (Anson, 2006). Hedge fund aims to achieve a positive return on investment no matter the market is raising or falling. A typical hedge fund can be described as an actively managed investment portfolio, which its performance is measured by absolute portfolio return but not individual assert return (Anson, 2006). Hedge fund works is a type of investment vehicle, which is only open to only limited wealthy investors. The idea of “hedge” is to reduce the overall risk of the investment portfolio by employing an assert position, such as short position, which can offset an existing risk of this assert. For example, an investor holds a large amount of equities can hedge the portfolio by selling stock index futures (Connor and Woo, 2004). However, the tradeoff of reducing portfolio risk is that the total return of such portfolio might be deducted at the same time. Therefore, no matter which hedge strategy is applied, the portfolio risk will only be reduced but not be wiped completely. The challenge of hedge fund management is to eliminate the overall portfolio risks while gaining maximum return on assert (Connor and Woo, 2004).

1.1.2 Hedge Fund Structure and Investment Strategies

A hedge fund is an investment vehicle, which can employ various investment and trading activities. The goal of operating a hedge fund is to maximum investment return and minimize investment risks. Generally, a hedge fund is formed as a limited partnership between fund manager and investors (Hedge Fund Fundamentals, 2012). Therefore, the way for a hedge fund to be structured can be very flexible because the investment activities are usually very different from one industry to another industry. However, no matter how a hedge fund is structured, the core part would contain investors, portfolio managers, prime brokers and auditors (Hedge Fund Fundamentals, 2012). In the partnership, the investors share income, expense, investment gains and losses. The portfolio managers, or fund manager, take responsibilities to determine investment strategy, make investing decisions, and allocate asserts. Prime brokers provide leverage and short term financing solutions based on the collateral from hedge fund investors. Auditors work as regulators, which secure the fund and ensure the fund operations satisfying required laws and regulations.

The investment strategies of a hedge fund is established and deployed by the portfolio manager. Therefore, each hedge fund could have its unique investment strategies. Also, one hedge fund can pursue several strategies at the same time. The typical investment strategies the fund managers might use are long short, relative value, event driven, and tactical trading (Connor and Woo, 2004). The long short investment strategy focuses on stock and security selection to achieve absolute returns. In this strategy, deploying short or long positions can offset the market risk of stock and security. Relative value strategy uses relative security price discrepancies, which are caused by mispricing, to gain return. The event driven strategy makes uses of investment opportunities from particular events, such as merge, acquisitions, and recapitalization. Tactical trading strategy speculates the market trend by observing market environment changes, such as global macros and commodity trading advisers.

1.1.3 Hedge Fund Risk Measure

As partnership organization, hedge fund faces risks based on three categories, which are credit risk, market risk, operational risk, and other risks. Hedge fund risk factors are strongly dependent on the chosen investment strategy. Additionally, since the statistical risk measure techniques are broadly used, hedge funds are exposed on three risks, which are liquidity risk, nonlinear risk, and dynamic strategy risk (Alvarez and Levinson, 2007). For measuring liquidity risk exposure in hedge fund, the common technique is to examine the autocorrelation coefficients of the fund's periodical returns. The nonlinear risk in hedge fund can be modeled and measured by using value at risk (VaR) model. The dynamic strategy risk can be captured by using roll-over regression technique (Smedts and Smedts, 2006).

1.2 Purpose of the Study

During the 2008 financial crisis, hedge fund suffered a heavy loss, in which two-thirds of the hedge funds went bankrupt. According to the evaluation from Hedge Fund Research (HFR), the asset of hedge fund industry declined drastically in the second quarter of 2008 and the first quarter of 2009, and it decreased from 1.87 trillion (end of 2007) to 1.33 trillion (first quarter of 2009). This is a 28.88% large drop to hedge fund asset. From "Hedge fund and financial crises" (Maria, 2009, p.96), there are three main effects. Firstly, a broad decline for hedge fund. In addition, a broad decline in asset value. Moreover, there were some changes in regulations.

After this crisis, hedge fund managers and investors recognized the importance of the risk management. There are many reasons to do risk management. Risk management could provide the "insider knowledge", which can help managers achieve the effective risk management. Also, hedge fund could reduce the volatility of income through risk management. Meanwhile, financial security also can be improved.

Identifying the sources of risk in hedge funds is an important part to improve risk management. This paper will try to identify the different sources of risk in hedge funds.

Meanwhile, it will figure out which sources affect hedge fund more significantly to help managers to avoid risk as far as possible. Therefore, it is very necessary to identify the sources of risk.

1.3 Organization of Paper

This paper is broken down into six chapters. Chapter 1 of this paper is a brief introduction of the background, study motivation, and the study structure. Chapter 2 provides a review of the relative literature and the subsequent foundation on which this paper is built upon. Chapter 3 provides hedge fund risk modeling and risk source identifying. In chapter 4, the result will be given. It will describe different effects on hedge fund from different risk sources. Chapter 5 provides a conclusion of this paper. Finally, chapter 6 will give some recommendations and future work.

Chapter 2: Literature Review

A hedge fund is an investment vehicle, so there are numerous ways for hedge fund managers to make their investment decisions to use any combination of investment strategies and trading activities. In 2008, Hodges summarized and categorized the common used hedge fund strategies into three classes, which are relative value strategies, event-driven strategies, and directional strategies (Hodges, 2008). Relative value strategies make use of price inefficiency in the market to gain benefits. The typical strategies in relative value strategy class are convertible arbitrage, equity market neutral, and relative value arbitrage (Khanniche, 2009). Event-driven strategies take advantages from special events in companies, which could possibly cause fluctuation in stock prices. For example, distressed securities strategy, activist strategy and merger arbitrage strategy are in the event-driven strategy class (Khanniche, 2009). Directional strategies focus on the trend of the overall market to place investments, and this class includes equity hedge strategy and macro strategy (Khanniche, 2009).

2.1 Risk Factors in Relative Value Strategies

The common used hedge fund strategies in relative value strategy class are convertible arbitrage strategy, equity market neutral strategy, and relative value arbitrage strategy.

In 2004, Vikas Agarwal, William H. Fung, Yee Cheng Loon and Narayan Y. Naik have done research on risk in convertible arbitrage strategy (Agarwal, Fung, Loon, & Naik, 2004). According to their research, the majorly concerned risk sources in most arbitrage strategy models are equity risk, interest rate risk, and credit risk (Agarwal, Fung, Loon, & Naik, 2004). Equity market neutral strategy tries to use equity market inefficiency to gain benefit by being short or long in stocks. In 2006, Stephen Foerster argued that the equity market neutral strategy is exposed to equity risk and market risk. The relative value arbitrage strategies seek to gain advantages from the price differences between related financial instruments. According to Evan Gatev, William N. Goetzmann, and K. Geert Pouwenhorst, the ordinary risk factors in relative value arbitrage strategies are market risk, the difference between small and big stocks (SMB), and the difference between value and growth stocks (HML) (Goetzmann, Gatev, & Rouwenhorst, 1998).

2.2 Risk Factors in Event-driven Strategies

Event-driven strategies attempt to take advantages of events, which are not willing to occur in a normal company's life cycle, for instance, mergers and restructurings. The specific used strategies under this class are distressed securities strategy, activist strategy, and merger arbitrage strategy.

The research of Thomas Della Casa, Mark Rechsteiner and Ayako Lehmann in 2008 showed that the common risk factors in distressed securities strategy are the credit risk spreads, which include US Treasuries (UST), and spreads to worst (STW) (Casa, Rechsteiner, & Lehmann, 2008). Activist strategy attempts to invest troubled companies to take positions in the companies to gain benefits. The typical risks in activist hedge fund strategies are equity risk and credit risk, which were described by Dulari Pancholi in 2012 (Pancholi, 2012). The merger arbitrage strategy tries to take advantages from merger or acquisition activities. From AIMA Canada's report in 2008, investor who uses merger arbitrage strategy need to deal with market risk, interest rate risk, and credit risk.

2.3 Risk Factors in Directional Strategies

Directional strategies make use of the market trends instead of individual stock of security to gain benefits. The common used specific strategies under this class include equity hedge strategy and macro strategy.

Equity hedge strategy is exposed to the excess return of the market (RMRF), the spread between small cap and large cap stocks (SMB), and HML (Fung & Hsieh, 2011). Macro strategy uses a top-down approach to invest multi-national financial product based on global macro trend. According to Credit Suisse, the macro strategy is usually exposed to credit risk, market risk, macroeconomic risk and emerging market risk (Credit Suisse, 2009).

Overall, the main and common risk factors of three different hedge fund strategy classes are shown on Table 1.

Table 1: Risk Factors in Hedge Fund Strategy Classes

Relative Value Strategies	Event-driven Strategies	Directional Strategies
Equity risk Interest rate risk Credit risk Market risk SMB HML	Credit risk Equity risk Market risk Interest rate risk	RMRF SMB HML Credit risk Emerging market risk Macroeconomic risk

Chapter 3: Data Selection and Methodology

3.1 Data Selection

In this paper, we measure the overall hedge fund performance by using the Credit Suisse Hedge Fund Index, which is a monthly balanced assert-weighted hedge fund index (Credit Suisse Hedge Index LLC., 2013). The overall hedge fund performance data we used is the Credit Suisse Broad Hedge Fund Index sample data from January 1st, 2004 to January 1st, 2013, which can be obtained from the Credit Suisse Hedge Index LLC website (Credit Suisse Hedge Index LLC., 2013).

The Standard & Poor's 500 Index is one of the most commonly used tools to benchmark the U.S. stock market risks. The index is an aggregate representation of the leading companies in the leading industries of the U.S. economy. Therefore, the index is can help analyzers and decision makers to understand the fluctuation of the equity market. Therefore, we select this index to represent the equity risk factor in this paper. The sample data we selected is the monthly S&P 500 Stock Price Index (SP500) change rate from January 1st, 2004 to January 1st, 2013 (Federal Reserve Bank of St. Louis, 2013). The data is available on the St. Louis FRED database, which is a part of American's central bank (Federal Reserve Bank of St. Louis, 2013).

Interest rate risk is the risk of security's value changes due to the change in interest rates. There are two components of the interest rate risk, which are the long-term interest rate risk and short-term interest rate risk. In this paper, we measure the long-term interest rate risk by using the sample data of the 10-year treasury constant maturity rate from 2004 to 2013. Using the secondary market 3-month T-Bill rate captures the short-term interest rate. Furthermore, the Moody's Seasoned Aaa Corporate Bond Yield is also used as an supplement to capture interest rate risk. All the data we used are available on the St. Louis FRED database (Federal Reserve Bank of St. Louis, 2013).

The market risk is the risk of the losses due to the changes on the overall financial market. The CBOE Volatility Index (VIX) is designed to represents the volatility of market (CBOE, 2013). Therefore, we use VIX as the measurement of the market risk. We take the sample data from 2004 to 2013 from CBOE website.

The risk factors, SMB, HML and RMRF, are the three Fama/French Benchmark Factors, which forms a model to describe stock returns (French, 1993). The factor SMB represents the small market capitalization. HML is the book to market ratio factor. RMRF is the value-weighted premium return factor on the major stocks (French, 1993).

Emerging markets are the rapidly growing markets, which has more return and more risks. The MSCI Emerging Markets Index is a measurement of market performance in global emerging markets (MSCI Indices, 2013). Therefore, we use this index as the emerging market risk measurement in this paper. The data we used is available on MSCI database.

The Barclay Global Macro Index measures the macroeconomic risk, which is a reflection of the global market direction (Barclay Hedge, 2013). The data is available on the Barclay Hedge database.

3.2 Methodology

In this paper, we are trying to deploy the multivariate regression model to analysis the relationships between the overall hedge fund performance indices with the different risk factors we have indicated from various hedge fund strategies. The involved variables are shown on Table 2.

Table 2: Regression Model Variables

Model Factor	**Variables**
Hedge Fund Performance	CSHI
Equity Risk	SP500 Fama/French Benchmark Factors (SMB, HML, RMRF)
Interest Rate Risk	10YTCMR 3MTCMR AAACBY
Market Risk	VIX
Emerging Market Risk	MSCIIDX
Macroeconomics Risk	BGMI

The variable CSHI, which is the Credit Suisse Hedge Index, is present as the dependent variable in the regression model. The independent variables are S&P 500 index (SP500), 10-year treasury constant maturity rate (10YTCMR), secondary market 3-month T-Bill rate (3MTCMR), Moody's Seasoned Aaa Corporate Bond Yield (AAACBY), CBOE Volatility Index (VIX), Fama/French Benchmark Factors (SMB, HML, RMRF), MSCI Emerging Markets Index (MSCIIDX), and Barclay Global Macro Index (BGMI). Therefore, we form a multivariate regression model with 10 factors, which is the Multivariate Regression Formula.

$$\begin{aligned} CSHI = \alpha + \hat{\beta}_1 SP500 + \hat{\beta}_2 10YTCMR + \hat{\beta}_3 3MTCMR \\ + \hat{\beta}_4 AAACBY + \hat{\beta}_5 VIX + \hat{\beta}_6 SMB + \hat{\beta}_7 HML \\ + \hat{\beta}_8 RMRF + \hat{\beta}_9 MSCIIDX + \hat{\beta}_{10} BGMI + \epsilon \end{aligned}$$

(Formula 3. 2. 1)

Based on the model, we will do hypothesis testing and regression model analysis to verify the model. Moreover, we will try to identify the relative quality of each dependent variable in the model by using Akaike Information Criterion (AIC) through stepwise analysis.

In this paper, we use R, which is statistical computation software, to express all the analysis results (R Project, 2013). The data is stored in csv file format, which is appended on the Appendix A. The R source code is stored as Rscript format, which is appended on the Appendix B.

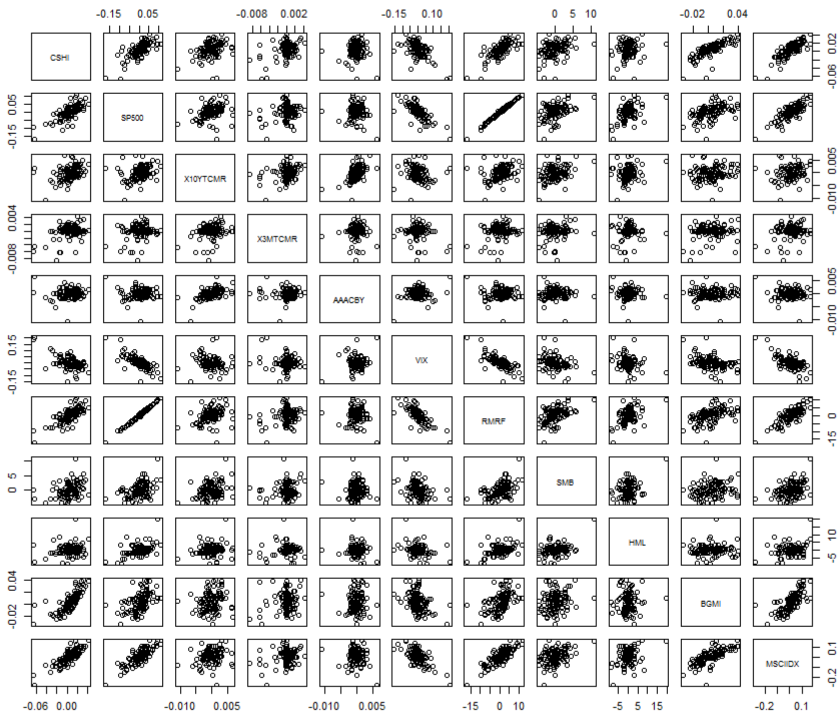
Chapter 4: Results and Analysis

In this chapter, we will firstly fit the ordinary formula (Formula 3.2.1) into a multi-variant regression model and do an analysis based on the model results. Moreover, we will try to improve the model by using stepwise algorithm. All the data used in the analysis in this chapter is attached on Appendix A. The analysis is done by using R, and all the procedures are shown on Appendix B.

Before using all the variables to fit our regression model, which is expressed on Formula 3.2.1, we want to explore the relationship between among the variables. The direct way to illustrate the relationship between two sample data sets is to construct a scatter plot between the data points. Therefore, since we have one dependent variable and ten free variables, we generate the scatter plots of all pair-wise combinations of these variables to have a first view of the sample data. The pair-wise graph is show on Figure 1.

From Figure 1, we observe that the dependent variable has significant linear relationship with variables SP500, X10YTCMR, RMRF, VIX, BGMI and MSCIDX. Also, the correlations between variable SP500 and RMRF are very strong, and the correlations between variable SP500 and VIX are significant. Based on the graphs, we can only tell there will be good chance for us to construct a multi-variant regression model from the sample data.

Figure 1: Pair-wise Scatter Plot of Model Variables



Before we go to the regression analysis step, we make a hypothesis of our multi-variant regression model as that, in the null hypothesis, we claim that there is no significant correlation at all in this model; while the alternative hypothesis states that at least one of the correlations is not zero. The direct explanation of such hypothesis is that, the null hypothesis assumes none of the independent variables belong in the model, but the alternative hypothesis says at least one of the variables fits the model. Our first step is to fit all the variables into the multi-variant regression model, in which the regression formula will be the same as Formula 3.2.1. After running through a linear analysis, the model results are shown on Table 2.

From Table 2, we have an overview of the linear model. As we can see that, the multivariate regression model has F-statistic 53.36 and an extremely low overall p-value. In this case, we can state that the null hypothesis has been rejected at 95% significance level. Therefore, among the ten independent variables, there is at least one which fits the model. The R-squared value for this model is exceeded 0.8, and it states that this model is fitted linearly. From the p-values on the table, we see that, the variables SP500, AAACBY, VIX, SMB, HML, and RMRF are not significant at level 95%.

Table 3: Regression Model Results for All Variables

<table>
<tr><td>Coefficients:</td><td>Estimate</td><td>Std. Error</td><td>t value</td><td>Pr(>|t|)</td></tr>
<tr><td>(Intercept)</td><td>0.0023769</td><td>0.000766</td><td>3.105</td><td>0.00249</td></tr>
<tr><td>SP500</td><td>-0.0912977</td><td>0.28371</td><td>-0.322</td><td>0.74829</td></tr>
<tr><td>S_10YTCMR</td><td>0.8466967</td><td>0.37472</td><td>2.26</td><td>0.02606</td></tr>
<tr><td>S_3MTCMR</td><td>1.6248343</td><td>0.383694</td><td>4.235</td><td>5.17E-05</td></tr>
<tr><td>AAACBY</td><td>-0.1733939</td><td>0.507108</td><td>-0.342</td><td>0.73314</td></tr>
<tr><td>VIX</td><td>0.0166821</td><td>0.024552</td><td>0.679</td><td>0.49844</td></tr>
<tr><td>SMB</td><td>-0.0005085</td><td>0.000547</td><td>-0.93</td><td>0.35463</td></tr>
<tr><td>HML</td><td>-0.0003943</td><td>0.000257</td><td>-1.532</td><td>0.12879</td></tr>
<tr><td>RMRF</td><td>0.002198</td><td>0.002895</td><td>0.759</td><td>0.44956</td></tr>
<tr><td>MSCIIDX</td><td>0.074723</td><td>0.023373</td><td>3.197</td><td>0.00187</td></tr>
<tr><td>BGMI</td><td>0.4236398</td><td>0.073489</td><td>5.765</td><td>9.50E-08</td></tr>
<tr><td colspan="5">Residual standard error: 0.007262 on 98 degrees of freedom</td></tr>
<tr><td>Multiple R-squared: 0.8449,</td><td colspan="3">Adjusted R-squared: 0.829</td><td></td></tr>
<tr><td colspan="5">F-statistic: 53.36 on 10 and 98 DF, p-value: < 2.2e-16</td></tr>
</table>

In order to gain more information about the linear model we fitted in, we then run thorough an Analysis of Variance (ANOVA) model on Formula 3.2.1 to retrieve information about residuals. The ANOVA results are shown on Table 3.

Table 4: ANOVA Results for All Variables

Analysis of Variance Table					
Response: CSHI					
	Df	Sum Sq	Mean Sq	F value	Pr(>F)
SP500	1	0.018093	0.018093	343.0713	< 2.2e-16
S_10YTCMR	1	0.000689	0.000689	13.064	0.000477
S_3MTCMR	1	0.001779	0.001779	33.7335	7.84E-08
AAACBY	1	4E-07	4E-07	0.0077	0.930357
VIX	1	5.27E-05	5.27E-05	0.9989	0.320027
SMB	1	2.6E-06	2.6E-06	0.0495	0.824395
HML	1	0.001051	0.001051	19.9356	2.15E-05
RMRF	1	0.000156	0.000156	2.9615	0.088423
MSCIIDX	1	0.004567	0.004567	86.5965	3.89E-15
BGMI	1	0.001753	0.001753	33.2312	9.50E-08
Residuals	98	0.005168	5.27E-05		

Table 3 shows that, at 95% significance level, adding variables AAACBY, VIX, SMB, and RMRF into the model do not significantly reduce the error of the entire model.

Based on the expressed result, the model showed reasonable accuracy. However, at this point, we cannot make an exactly conclusion that there are linear relationships between the dependent variables and the independent variables. One of the important assumption of the multi-variant regression model is that, the residuals of the model should be normal randomly distributed. Otherwise, we have a bias in our model. In order to verify the assumption, in Figure 2, we produce a scuttle plot of the model residuals to check if the error data follows normal distribution. In addition, in Figure 3 we generate a normal Quantile-Quantile (QQ) plots to check if the sampled residual data matches normal distribution.

Figure 2: Residual Scatter Plots

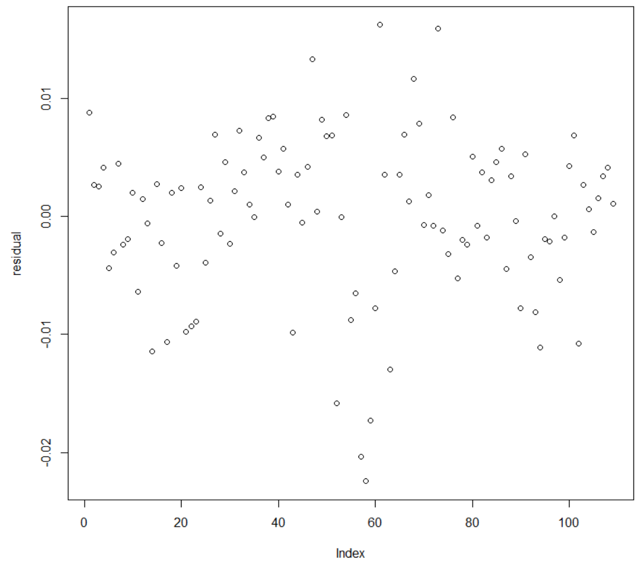
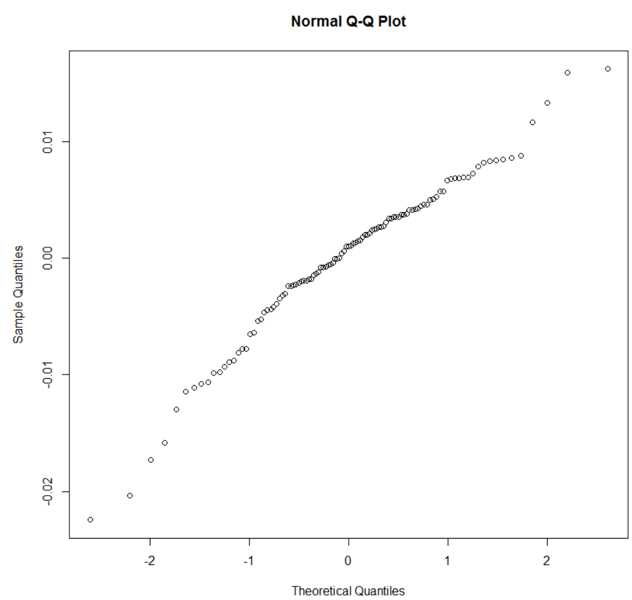


Figure 3: Residual QQ Plots



From Figure 2, we observe that most of the residual points are spread between -0.02 and 0.02, and there is no outlier occurs in the data. In Figure 3, we can see that the residual distribution follows normal distribution closely. Therefore, we can draw a conclusion that the residual assumption of the model is satisfied, and the fitted model is not biased. Therefore, the Formula 3.2.1 can be expressed as the function in Formula 4.1

$$
\begin{aligned}
CSHI \ = 0.0023769 - 0.0912977 * SP500 + 0.8466967 * 10YTCMR \\
+1.6248343 * 3MTCMR - 0.1733939 * AAACBY \\
+0.0166821 * VIX - 0.0005085 * SMB \\
-0.0003943 * HML + 0.0021980 * RMRF \\
+0.0747230 * MSCIIDX + 0.4236398 * BGMI
\end{aligned}
$$

(Formula 4.1)

The formula 4.1 is resulted from fitting all the variables into the regression model. Based on this function, we can do reasonable prediction of the overall hedge fund performance CSHI by fitting the risk variables. However, as we stated before, there are several variables did not show significance in the model. Therefore, we deploy the stepwise algorithm on the model to select variables based on Akaike Information Criterion (AIC), which is a representation of a stats model's quality. By using stepwise algorithm, we test the possible combinations of the independent variables by adding or dropping one variable in the model each time. In each time the model changes, the AIC value will be calculated to estimate the information losses. In general, a stats model has smaller AIC will have higher quality. The stepwise algorithm will run until a reduced model which has smallest AIC value is found. After going through the stepwise algorithm, we have an improved regression model which is shown on Formula 4.2

$$
\begin{aligned}
CSHI = \alpha + \ \hat{\beta}_1 10YTCMR + \hat{\beta}_2 3MTCMR + \hat{\beta}_3 HML \\
+ \ \hat{\beta}_4 RMRF + \hat{\beta}_5 MSCIIDX + \hat{\beta}_6 BGMI + \epsilon
\end{aligned}
$$

(Formula 4. 2)

From Formula 4.2, we observe that the variables SP500, VIX, AAACBY, and SMB are reduced from the model based on AIC, and the 10 factor model is reduced to be a 6 factor model. As we observed before, the variables VIX, SMB and AAACBY are not significant in the model. The reason the variable SP500 is dropped is because the high correlations between SP500 with other variables.

To examine the improved model, we fit the new formula with the regression model, and the results are shown on Table 4.

Table 5: Regression Model Results for Improved Formula

Coefficients:	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	0.00245	0.000722	3.394	0.000982
S_10YTCMR	0.733698	0.27976	2.623	0.010063
S_3MTCMR	1.666664	0.368267	4.526	1.63E-05
HML	-0.00041	0.000236	-1.759	0.081588
RMRF	0.001093	0.000297	3.679	0.000376
MSCIIDX	0.072547	0.021952	3.305	0.001312
BGMI	0.429114	0.070291	6.105	1.88E-08
Residual standard error: 0.007171 on 102 degrees of freedom				
Multiple R-squared: 0.8425,	Adjusted R-squared: 0.8333			
F-statistic: 90.95 on 6 and 102 DF, p-value: < 2.2e-16				

From Table 4, we can see that the overall F-statistic is 90.95, which is much higher than the original model's F-statistic 53.36. This indicates that the new model is better than the original one. Based on the p values, we can see that there only one variable, HML, does not show significance on the 95% level. Furthermore, we run ANOVA model on the improved formula to retrieve residual information about the new regression model. The ANOVA results are shown on Table 5.

Table 6: ANOVA Results for Improved Model

Analysis of Variance Table					
Response: CSHI					
	Df	Sum Sq	Mean Sq	F value	Pr(>F)
S_10YTCMR	1	0.004326	0.004326	84.109	5.55E-15
S_3MTCMR	1	0.00373	0.00373	72.5284	1.53E-13
HML	1	0.000391	0.000391	7.6076	0.006889
RMRF	1	0.013288	0.013288	258.3792	< 2.2e-16
MSCIIDX	1	0.004414	0.004414	85.8257	3.46E-15
BGMI	1	0.001917	0.001917	37.2693	1.88E-08
Residuals	102	0.005246	5.14E-05		

From the ANOVA table, we can see that every variable shows significance on the reducing model errors. Therefore, the final prediction function can be expressed as Formula 4.3.

$$\begin{aligned} CSHI = 0.0024504 + \ 0.7336976 * 10YTCMR + 1.6666637 * 3MTCMR \\ - 0.0004142 * HML + 0.0010930 * RMRF \\ + 0.0725469 * MSCIIDX + 0.4291143 * BGMI \end{aligned} \quad \textbf{(Formula 4. 3)}$$

Thus, the variables 10YTCMR, 3MTCMR, HML, RMRF, MSCIIDX, and BGMI are critical to form a prediction function to estimate the overall performance of hedge fund. Therefore, we can state that the equity risk, interest rate risk, emerging market risk, and macroeconomics risk are critical risk sources to have major influences in the hedge fund market.

Chapter 5: Conclusion

After financial crisis, hedge fund managers realized the importance of the risk management. This paper investigates the risk sources which have significant effects on the overall hedge fund performance. In this paper, we use the Credit Suisse Hedge Index to represent the overall hedge fund performance. The equity risk is represented by S&P500 index and the three Fama/French Benchmark Factors (SMB, HML, and RMRF). The 10-year treasury constant maturity rate, secondary market 3-month T-Bill rate, and Moody's Seasoned Aaa Corporate Bond Yield are used to represent the different components of the interest rate risk. Market risk is measured by using the CBOE Volatility Index. Emerging market risk is measured by the MSCI Emerging Markets Index. The macroeconomics risk is denoted by the Barclay Global Macro Index. We build and analysis a multi-variant regression model to help us to understand the importance of each risk factor which forms the hedge fund risk. The sample data we used are from January 1st 2004 to January 1st 2013, and the data is selected from the well-known public sources. After analysis and improve, a six factor multi-variant regression model has been constructed to explain the risk sources which can significantly affect the overall hedge fund performance. Based on the result, the equity risk, interest rate risk, emerging market risk, and macroeconomics risk are critical risk sources in the hedge fund performance modeling.

References

MSCI Indices. (2013). *MSCI Emerging Markets Indices*. Retrieved from MSCI Indicies: http://www.msci.com/

Anson, Mark J.P. (2006). *The Handbook of Alternative Assets.*John Wiley & Sons. p. 36. ISBN 0-471-98020-X.

Alvarez M. and Levinson M. (2007), Hedge Fund Risk Modeling.Avaliableat : http://www.barra.com/support/library/BarraOne_Hedge_Fund_Modeling.pdf

Agarwal, V., Fung, W. H., Loon, Y. C., & Naik, N. Y. (2004). *Risks in Hedge Fund Strategies: Case of Convertible Arbitrage.* Retrieved from http://www.lse.ac.uk/fmg/documents/events/conferences/2004/riskAndReturn/247_N_NaikIAM.pdf

AIMA Canada. (2008). *Merger (Risk) Arbitrage Strategy.* AIMA Canada.

Barclay Hedge. (2013). *Barclay Global Macro Index*. Retrieved from Barclat Hedge Alternative Investment Database: http://www.barclayhedge.com/research/indices/ghs/Global_Macro_Index.html

Casa, T. D., Rechsteiner, M., & Lehmann, A. (2008). *Hedge fund investing in distressed securities.* Man Investments.

CBOE. (2013). *CBOE*. Retrieved from Introduction to VIX Options and Futures: www.cboe.com/VIX

Connor, G., & Woo, M. (2004). *An Introduction to Hedge Funds*. Retrieved from LSE Research: http://eprints.lse.ac.uk/24675/1/dp477.pdf

Connor, G., & Lasarte, T. (2010, June 1). *An Overview of Hedge Fund Strategies.* Retrieved August 10, 2013, from aTrader: http://www.atrader.com/files/upl/pdf/nid/An-Overview-of-Hedge-Fund-Strategies.pdf

Connor, G. and Woo, M. (2004) *An Introduction to hedge funds.* Discussion paper, 477. Financial Markets Group, London School of Economics and Political Science, London, UK.

Credit Suisse. (2009). *Global Macro – A Bridge Over Troubled Water?* Credit Suisse.

Credit Suisse Hedge Index LLC. (2013). *Credit Suisse Hedge Fund Index*. Retrieved from http://www.hedgeindex.com/hedgeindex/secure/en/indexperformance.aspx?cy=USD&indexname=HEDG

Fung, W., & Hsieh, D. A. (2011). The Risk in Hedge Fund Strategies: Theory and Evidence from Long/Short Equity Hedge Funds. *Journal of Empirical Finance , 18*, 547-569.

Federal Reserve Bank of St. Louis. (2013). *Federal Reserve Bank of St. Louis*. Retrieved from Federal Reserve Economic Data: http://research.stlouisfed.org/fred2/

Foerster, S. (2006). *What Drives Equity Market Neutral Hedge Fund Returns?* Ivey Business School.

French, K. R. (1993). *Description of Fama/French Benchmark Factors*. Retrieved from http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library/f-f_bench_factor.html

Goetzmann, W., Gatev, E. g., & Rouwenhorst, K. (1998). *Pairs Trading: Performance of a Relative Value Arbitrage Rule.* Yale School of Management.

Hedge Fund Fundamentals (2012), *How Hedge Fund Are Structured.* Available at: http://www.hedgefundfundamentals.com/media_posts/how-hedge-funds-are structured/

Hodges, W. (2008). Three classic strategies demystified. *The Gateway* (9), 17.

Khanniche, S. (2009). *Evaluation of Hedge Fund Returns Value at Risk Using GARCH Models.* University of Paris West - Nanterre la Défense, EconomiX.

Maria, S. (2009), *Hedge funds and financial crises,*p. 96.Available at: http://www.riksbank.se/Upload/Dokument_riksbank/Kat_publicerat/PoV_sve/en/stromqvist2009_1_eng.pdf

Pancholi, D. (2012). *Investing in Activist Hedge Fund Strategies - An Opportune Time.* NEPC.

R Project. (2013). Retrieved from The R Project for Statistical Computing : http://www.r-project.org/

Smedts, K. and Smedts, J. (2006), *Dynamic Investment Strategies of Hedge Funds.* Available at SSRN: http://ssrn.com/abstract=958879

Appendix A:

Sample data from January 1st, 2004 to January 1st, 2013

CSHI	SP500	10YTCMR	3MTCMR	AAACBY	VIX	RMRF	SMB	HML	BGMI	MSCIIDX
0.017	0.01728	-0.0011	-0.0002	-0.0008	0	2.07	2.65	-0.63	0.0062	0.03255
0.014	0.01221	-0.0017	0.0005	-0.0004	-0.0208	1.33	-1.01	1.18	0.011	0.04493
0.0028	-0.0164	-0.0013	0.0001	-0.0017	0.0219	-1.29	1.73	1.69	0.0009	0.00906
-0.0058	-0.0168	0.0067	0	0.004	0.0045	-1.84	-2.14	1.63	-0.0212	-0.0846
-0.0023	0.01208	0.0013	0.0008	0.0031	-0.0169	1.24	-0.14	-1.54	-0.0059	-0.0227
0.0034	0.01799	-0.0004	0.0025	-0.0003	-0.0116	1.85	2.47	1.83	-0.0003	0.00217
-0.0031	-0.0343	-0.0012	0.0006	-0.0019	0.0098	-4.04	-3.72	3.19	-0.0088	-0.021
0.0014	0.00229	-0.0037	0.0015	-0.0017	-0.0003	0.06	-1.32	1.7	-0.0024	0.03924
0.0101	0.00936	0.0001	0.0017	-0.0019	-0.0195	1.62	2.95	-0.43	0.003	0.0555
0.0128	0.01401	-0.0009	0.0011	0.0001	0.0293	1.45	0.25	0.67	0.0089	0.0218
0.0265	0.03859	0.0031	0.0031	0.0005	-0.0303	4.56	4.08	1.57	0.0301	0.0921
0.0161	0.03246	-0.0012	0.0012	-0.0005	0.0005	3.39	0.33	0.42	0.0084	0.04677
-0.0034	-0.0253	-0.001	0.0014	-0.0011	-0.0047	-2.75	-1.55	0.37	-0.0086	0.0002
0.0143	0.0189	0.0022	0.0021	-0.0016	-0.0074	1.9	-0.66	0.97	0.0216	0.08556
-0.0015	-0.0191	0.0014	0.002	0.002	0.0194	-1.87	-1.31	1.83	-0.0084	-0.0679
-0.0104	-0.0201	-0.0029	0.0004	-0.0007	0.0129	-2.58	-4.21	-0.28	-0.0122	-0.0304
0.0015	0.02995	-0.0021	0.0006	-0.0018	-0.0202	3.63	2.93	-1.05	0.0098	0.03039
0.0131	-0.0001	-0.0006	0.0013	-0.0019	-0.0125	0.58	3.02	1.03	0.0126	0.03104
0.0192	0.03597	0.0034	0.0025	0.001	-0.0047	3.95	2.62	0.01	0.0125	0.06617
0.0088	-0.0112	-0.0026	0.0022	0.0003	0.0103	-1.21	-0.8	0.3	0.0081	0.00608
0.0163	0.00695	0.0032	-0.0002	0.0004	-0.0068	0.55	-0.65	0.48	0.033	0.09087
-0.0146	-0.0177	0.0023	0.0029	0.0022	0.034	-2.09	-1.53	0.55	-0.0169	-0.0664
0.0148	0.03519	-0.0008	0.0017	0.0007	-0.0326	3.57	0.59	-1.16	0.0213	0.08193
0.0161	-0.001	-0.001	0.0001	-0.0005	0.0001	-0.26	-0.29	0.29	0.0189	0.05762
0.0323	0.02547	0.0014	0.0035	-0.0008	0.0088	2.97	5.58	-0.89	0.0397	0.1094
0.0034	0.00045	0.0002	0.0019	0.0006	-0.0061	-0.28	-0.51	0.21	-0.0064	-0.0021
0.0182	0.01106	0.0031	0.0008	0.0018	-0.0095	1.42	3.06	-0.38	0.0099	0.00728
0.0222	0.01219	0.0021	0.0009	0.0031	0.002	0.77	-1.13	2.01	0.0308	0.06826
-0.013	-0.0309	0.0005	0.0012	0.0011	0.0485	-3.59	-2	2.79	-0.0231	-0.1076
-0.0011	8.7E-05	0.0003	0.0007	-0.0006	-0.0336	-0.33	-0.81	0.92	-0.0025	-0.0046
0.0029	0.00509	-0.0016	0.0016	-0.0004	0.0187	-0.72	-3.54	3.33	-0.0059	0.0111
0.0085	0.02127	-0.0025	0.0001	-0.0017	-0.0264	2.03	0.71	-0.51	-0.0073	0.02287
0.0013	0.02457	-0.001	-0.0015	-0.0017	-0.0033	1.86	-1.5	-0.22	-0.0117	0.00652
0.0177	0.03151	-0.0003	0.0011	0	-0.0088	3.16	2.05	0.14	0.0152	0.04662
0.0207	0.01647	-0.0015	0.0002	-0.0018	-0.0019	1.74	0.56	0.97	0.0281	0.07323

0.0183	0.01262	0.0025	-0.0009	-0.0001	0.0065	0.85	-0.94	1.65	0.0109	0.04412
0.0133	0.01406	0.0012	0.0013	0.0008	-0.0114	1.44	-0.36	-0.43	0.0042	-0.0122
0.0074	-0.0218	-0.0027	0.0005	-0.0001	0.05	-1.9	1.1	0.69	0.002	-0.0066
0.0124	0.00998	0.0009	-0.0009	-0.0009	-0.0078	0.67	-0.07	-0.64	-0.0033	0.03725
0.0202	0.04329	-0.0002	-0.0007	0.0017	-0.0042	3.54	-2.07	-0.71	0.0169	0.04516
0.0231	0.03255	0.0027	-0.0014	0	-0.0117	3.23	0.11	-0.04	0.0182	0.0451
0.0078	-0.0178	0.0013	-0.0012	0.0032	0.0318	-1.96	0.76	-1.53	0.0105	0.04426
0	-0.032	-0.0025	0.0021	-0.0006	0.0729	-3.75	-2.62	-4.39	0.0079	0.05009
-0.0153	0.01286	-0.0024	-0.0062	0.0006	-0.0014	0.82	-0.16	-1.59	-0.0203	-0.0232
0.0271	0.03579	0.0005	-0.0031	-0.0005	-0.0538	3.17	-2.24	-3.29	0.0387	0.10849
0.0316	0.01482	-0.0011	0.0001	-0.0008	0.0053	1.73	0.41	-4.71	0.0313	0.11015
-0.0121	-0.044	-0.0051	-0.0063	-0.0022	0.0434	-4.92	-2.47	-1.77	-0.0099	-0.0715
0.0047	-0.0086	0.0007	-0.0027	0.0005	-0.0037	-0.84	0.61	-3.13	0.0137	0.00286
-0.0148	-0.0612	-0.0037	-0.0025	-0.0016	0.037	-6.33	-1.29	8.18	0.0029	-0.1259
0.0161	-0.0348	-0.0014	-0.0063	0.002	0.0034	-3.16	0.07	-4.27	0.0362	0.07251
-0.0211	-0.006	-0.0008	-0.0086	-0.0002	-0.0093	-0.91	0.75	-1.12	-0.0239	-0.054
0.0057	0.04755	0.0032	0.0003	0.0004	-0.0482	4.64	-2.45	-0.36	0.0088	0.07871
0.02	0.01067	0.0029	0.0044	0.0002	-0.0296	1.88	3.23	-4.25	0.01	0.01553
0	-0.086	-0.0007	0.0013	0.0011	0.0612	-8.38	-0.09	-8.75	0.0032	-0.1015
-0.0261	-0.0099	0	-0.0023	-0.0001	-0.0101	-0.72	2.49	6.19	-0.0196	-0.0416
-0.0147	0.01219	-0.0016	0.0009	-0.0003	-0.0229	1.53	3.29	2.28	-0.0091	-0.0822
-0.0655	-0.0908	0.0002	-0.0059	0.0001	0.1874	-9.57	0.2	3.26	-0.0327	-0.1771
-0.063	-0.1694	0.0016	-0.0046	0.0063	0.205	-17.15	-2.87	-7.53	-0.0019	-0.275
-0.0415	-0.0748	-0.0108	-0.0048	-0.0016	-0.0461	-7.77	-4.27	-5.73	0.0055	-0.0763
-0.0003	0.00782	-0.0068	-0.0016	-0.0107	-0.1528	1.75	2.88	-0.06	0.016	0.07604
0.0109	-0.0857	0.0062	0.001	0	0.0484	-7.93	0.91	-5.43	-0.0059	-0.0662
-0.0088	-0.1099	0.0015	0.0017	0.0022	0.0151	-9.93	-0.83	-8.27	-0.0147	-0.0571
0.0065	0.0854	-0.0031	-0.0009	0.0023	-0.0221	8.83	0.92	5.07	0.0053	0.14152
0.0168	0.09393	0.0045	-0.0005	-0.0011	-0.0764	10.17	10.64	19.72	0.0104	0.16275
0.0406	0.05308	0.0031	0.0002	0.0015	-0.0758	5.33	-1.53	7.27	0.0378	0.16657
0.0043	0.0002	0.0006	0	0.0007	-0.0257	0.44	2.04	-4.75	-0.0133	-0.0153
0.0254	0.07414	-0.0001	0	-0.002	-0.0043	7.76	2.43	3.44	0.0135	0.10867
0.0153	0.03356	-0.0012	-0.0001	-0.0015	0.0009	3.23	-1.1	7.34	0.002	-0.0054
0.0304	0.03572	-0.0009	-0.0005	-0.0013	-0.004	4.15	2.86	0.58	0.0254	0.08885
0.0013	-0.0198	0.001	-0.0005	0.0002	0.0508	-2.49	-4.14	-1.7	-0.0007	0.00023
0.0211	0.05736	-0.002	-0.0002	0.0004	-0.0618	5.64	-3.12	-0.1	0.019	0.04251
0.0088	0.01777	0.0064	0	0.0007	-0.0283	2.8	5.7	-0.16	-0.0051	0.03813
0.0017	-0.037	-0.0022	0.0001	0	0.0294	-3.51	0.43	3.51	-0.0123	-0.0565
0.0068	0.02851	-0.0002	0.0005	0.0009	-0.0512	3.39	1.15	0.56	0.0041	0.00251

0.0222	0.0588	0.0023	0.0004	-0.0008	-0.0191	6.3	1.84	1.56	0.0182	0.0795
0.0124	0.01476	-0.0015	0.0001	0.0002	0.0446	2.13	4.36	2.58	0.0028	0.0096
-0.0276	-0.082	-0.0038	0	-0.0033	0.1002	-7.86	0.32	-1.79	-0.0181	-0.0918
-0.0084	-0.0539	-0.0034	-0.0004	-0.0008	0.0247	-5.67	-1.9	-1.69	0.0018	-0.0091
0.0159	0.06878	-0.0003	0.0004	-0.0016	-0.1104	7.27	-0.45	1.04	0.0037	0.07998
0.0023	-0.0474	-0.0047	0	-0.0023	0.0255	-4.81	-2.75	-1.66	0.009	-0.0215
0.0343	0.08755	0.0006	-0.0001	0.0004	-0.0235	9.56	3.57	-2.65	0.0294	0.10874
0.0192	0.03686	0.001	-0.0002	0.0015	-0.025	4.02	0.41	-1.46	0.0125	0.0281
-0.0018	-0.0023	0.0018	0.0001	0.0019	0.0234	0.63	3.45	-0.54	-0.0052	-0.027
0.029	0.0653	0.0049	0	0.0015	-0.0579	6.77	0.82	4.7	0.0206	0.07021
0.0069	0.02265	0.0012	0.0001	0.0002	0.0178	2.05	-2.05	0.62	-0.0063	-0.0281
0.0138	0.03196	0	-0.0002	0.0018	-0.0118	3.49	1.64	0	0.0079	-0.0101
0.0012	-0.001	0.0005	-0.0003	-0.0009	-0.0061	0.57	2.05	-1.61	-0.0046	0.05696
0.018	0.0285	-0.0015	-0.0004	0.0003	-0.0299	2.95	-0.79	-1.7	0.018	0.02832
-0.0096	-0.0135	-0.0027	-0.0002	-0.002	0.007	-1.28	-0.59	-0.69	-0.0147	-0.0299
-0.0136	-0.0183	0.0013	0	0.0003	0.0107	-1.68	-0.56	-1.01	-0.0158	-0.0186
0.0069	-0.0215	-0.0036	0	-0.0006	0.0873	-2.3	-1.17	-1.16	0.0079	-0.0074
-0.023	-0.0568	-0.0059	-0.0002	-0.0056	0.0637	-5.95	-2.76	-2.27	-0.0146	-0.0919
-0.032	-0.0718	-0.0031	-0.0001	-0.0028	0.1134	-7.53	-2.86	-2.04	-0.0167	-0.1478
0.0173	0.10772	0.0025	0.0001	-0.0011	-0.13	11.34	3.55	3.23	0.0093	0.13076
-0.0079	-0.0051	-0.0009	-0.0001	-0.0011	-0.0216	-0.29	0.17	-1.75	-0.0063	-0.0675
-0.0022	0.00853	-0.0019	0	0.0006	-0.044	0.86	-0.8	0.9	-0.0005	-0.0129
0.0234	0.04358	-0.0006	0.0002	-0.0008	-0.0396	5.03	2.8	1.45	0.0194	0.11241
0.0161	0.04059	0.0015	0.0006	0	-0.0101	4.46	-1.89	1.12	0.0141	0.05891
0.0005	0.03133	0.0025	-0.0001	0.0014	-0.0293	2.96	-0.5	0.2	-0.0059	-0.0352
-0.0004	-0.0075	-0.0028	0	-0.0003	0.0165	-0.78	-0.31	-2.18	-0.0092	-0.0148
-0.0133	-0.0627	-0.0036	0.0001	-0.0016	0.0691	-6.27	-0.25	-1.91	-0.0122	-0.1167
-0.004	0.03955	0.0008	0	-0.0016	-0.0698	3.85	0.72	0.8	-0.0051	0.03427
0.0142	0.0126	-0.0016	0.0001	-0.0024	0.0185	0.86	-2.52	-0.17	0.0149	0.01615
0.0084	0.01976	0.0006	0	0.0008	-0.0146	2.58	0.5	0.79	0.0056	-0.0054
0.0104	0.02424	0.0008	0.0001	0.0001	-0.0174	2.69	0.72	1.36	0.0039	0.0584
-0.0018	-0.0198	0.0007	-0.0001	-0.0002	0.0287	-1.69	-1.31	3.43	-0.0083	-0.0073
0.0064	0.00285	-0.001	-0.0001	0.0003	-0.0273	0.71	0.55	-1.4	-0.0007	0.01175
0.0148	0.00707	0.0016	-0.0002	0.0015	0.0215	1.09	1.53	3.56	0.0095	0.04784
0.0207	0.05043	0.0024	0	0.0015	-0.0374	5.65	0.57	0.68	0.0186	0.01309

Appendix B:

R Code Analysis Results:

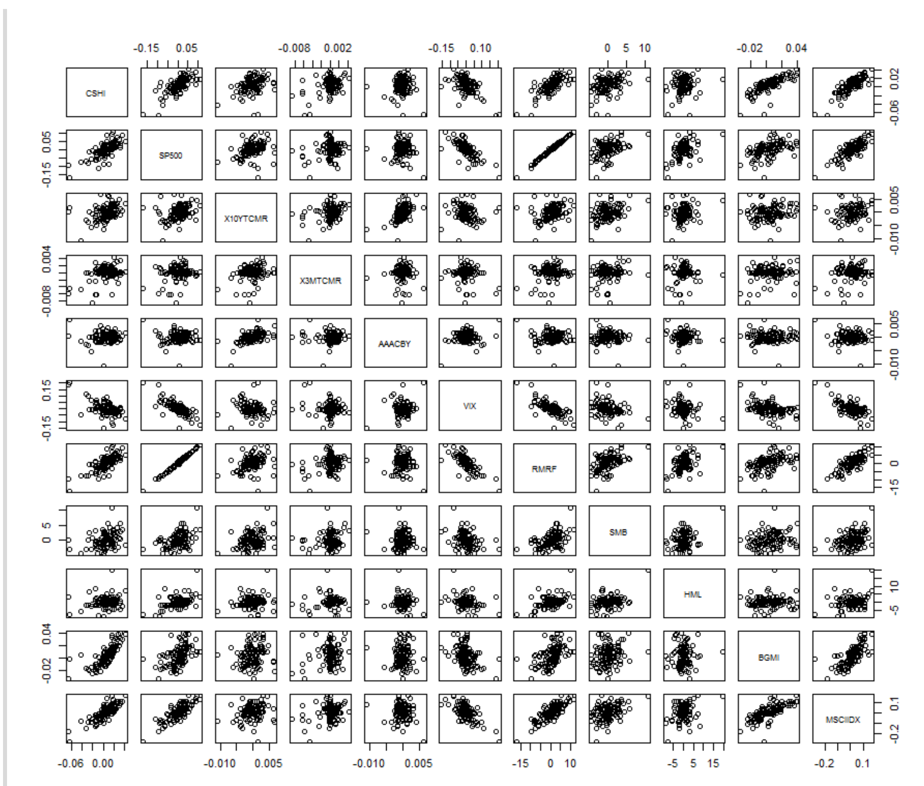
R version 2.14.2 (2012-02-29)
Copyright (C) 2012 The R Foundation for Statistical Computing
ISBN 3-900051-07-0
Platform: x86_64-pc-mingw32/x64 (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

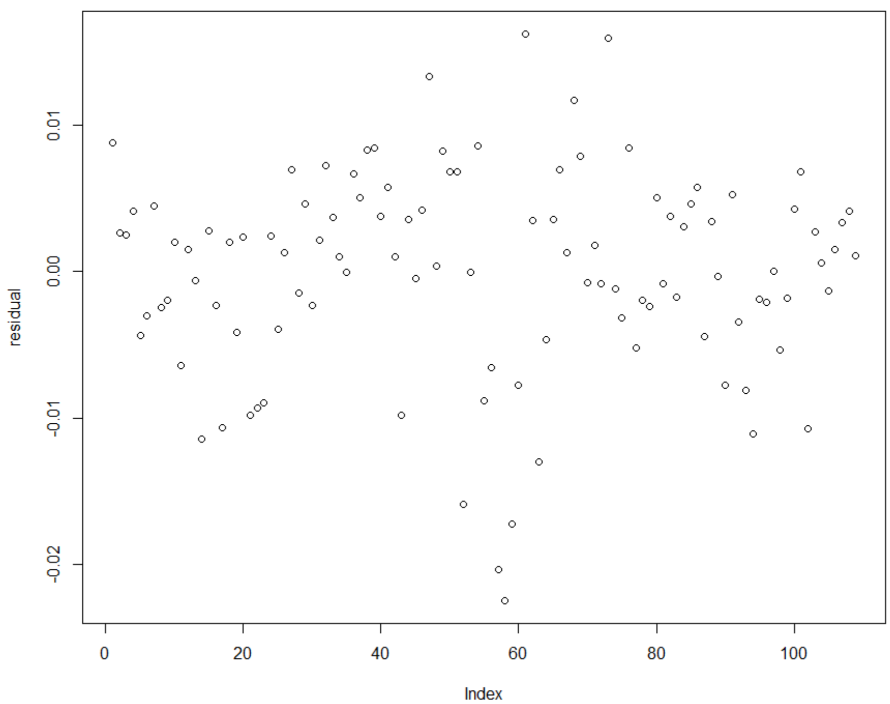
Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

```
> setwd("J:/")
> ##load data
> data = read.table("Appendix A FINALDATA.csv",header=T,sep= ",")
> attach(data)
> #plot data
> plot(data)
```

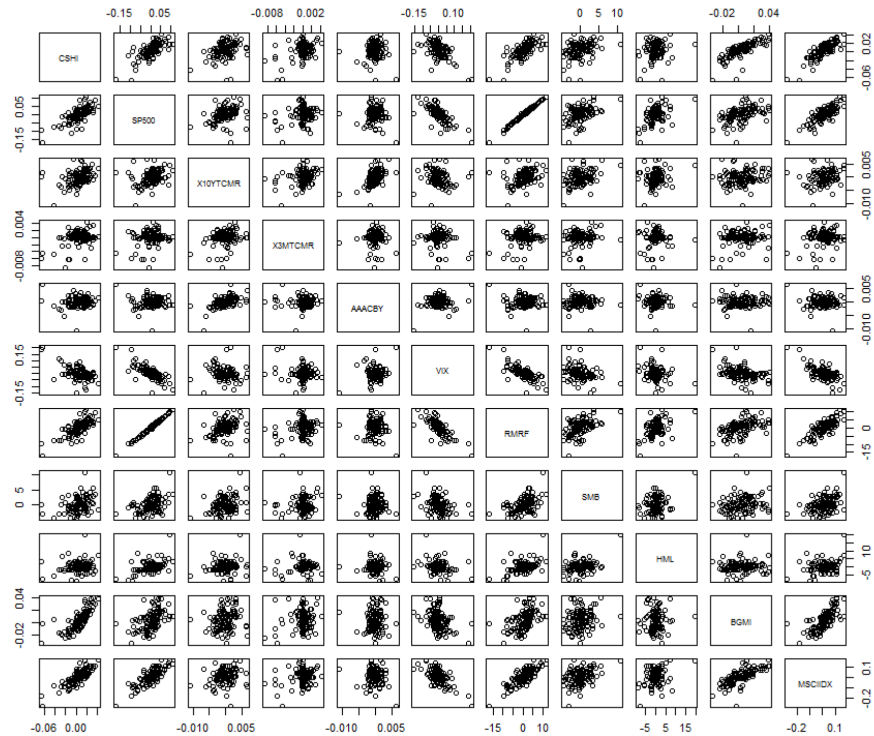


```
> #assign variables
> CSHI = data$CSHI
> SP500 = data$SP500
> S_10YTCMR = data$X10YTCMR
> S_3MTCMR = data$X3MTCMR
> AAACBY = data$AAACBY
> VIX = data$VIX
> SMB = data$SMB
> HML = data$HML
> RMRF = data$RMRF
> MSCIIDX = data$MSCIIDX
> BGMI = data$BGMI
> #Linear regression model analysis
> model.lm =
lm(CSHI~SP500+S_10YTCMR+S_3MTCMR+AAACBY+VIX+SMB+HML+RMRF+MSCIIDX+BGMI)
> summary(model.lm)

Call:
lm(formula = CSHI ~ SP500 + S_10YTCMR + S_3MTCMR + AAACBY + VIX +
    SMB + HML + RMRF + MSCIIDX + BGMI)

Residuals:
      Min        1Q    Median        3Q       Max
-0.022432  -0.003174   0.001042   0.004176   0.016215

Coefficients:
              Estimate   Std. Error   t value   Pr(>|t|)
(Intercept)  0.0023769    0.0007655     3.105    0.00249 **
SP500       -0.0912977    0.2837101    -0.322    0.74829
S_10YTCMR    0.8466967    0.3747196     2.260    0.02606 *
S_3MTCMR     1.6248343    0.3836941     4.235    5.17e-05 ***
AAACBY      -0.1733939    0.5071079    -0.342    0.73314
VIX          0.0166821    0.0245515     0.679    0.49844
SMB         -0.0005085    0.0005467    -0.930    0.35463
HML         -0.0003943    0.0002574    -1.532    0.12879
RMRF         0.0021980    0.0028952     0.759    0.44956
MSCIIDX      0.0747230    0.0233729     3.197    0.00187 **
BGMI         0.4236398    0.0734893     5.765    9.50e-08 ***
---
Signif. codes:  0 ?**?0.001 ?*?0.01 ??0.05 ??0.1 ??1

Residual standard error: 0.007262 on 98 degrees of freedom
Multiple R-squared: 0.8449,	Adjusted R-squared: 0.829
F-statistic: 53.36 on 10 and 98 DF,  p-value: < 2.2e-16

> anova(model.lm)
Analysis of Variance Table

Response: CSHI
            Df     Sum Sq    Mean Sq    F value      Pr(>F)
SP500        1  0.0180929  0.0180929   343.0713   < 2.2e-16 ***
S_10YTCMR    1  0.0006890  0.0006890    13.0640   0.0004774 ***
S_3MTCMR     1  0.0017790  0.0017790    33.7335   7.837e-08 ***
AAACBY       1  0.0000004  0.0000004     0.0077   0.9303569
VIX          1  0.0000527  0.0000527     0.9989   0.3200266
SMB          1  0.0000026  0.0000026     0.0495   0.8243948
```

```
HML          1   0.0010514   0.0010514    19.9356   2.145e-05 ***
RMRF         1   0.0001562   0.0001562     2.9615   0.0884234 .
MSCIIDX      1   0.0045669   0.0045669    86.5965   3.890e-15 ***
BGMI         1   0.0017525   0.0017525    33.2312   9.500e-08 ***
Residuals   98   0.0051683   0.0000527
---
Signif. codes:  0 ?**?0.001 ?*?0.01 ??0.05 ??0.1 ??1
> #residual data
> residual = residuals(model.lm)
> plot(residual)
```




```
> qqnorm(residual)
```




```
> #Stepwise Analysis
> step(model.lm,direction="both")
Start:  AIC=-1063.26
CSHI ~ SP500 + S_10YTCMR + S_3MTCMR + AAACBY + VIX + SMB + HML +
    RMRF + MSCIIDX + BGMI

            Df   Sum of Sq        RSS      AIC
- SP500      1   0.00000546   0.0051738  -1065.2
- AAACBY     1   0.00000617   0.0051745  -1065.1
- VIX        1   0.00002435   0.0051927  -1064.8
- RMRF       1   0.00003040   0.0051987  -1064.6
- SMB        1   0.00004562   0.0052139  -1064.3
<none>                        0.0051683  -1063.3
- HML        1   0.00012375   0.0052921  -1062.7
- S_10YTCMR  1   0.00026926   0.0054376  -1059.7
- MSCIIDX    1   0.00053902   0.0057073  -1054.5
- S_3MTCMR   1   0.00094574   0.0061141  -1047.0
- BGMI       1   0.00175254   0.0069209  -1033.4

Step:  AIC=-1065.15
CSHI ~ S_10YTCMR + S_3MTCMR + AAACBY + VIX + SMB + HML + RMRF +
    MSCIIDX + BGMI

          Df   Sum of Sq       RSS      AIC
- AAACBY   1   0.00000646   0.0051802  -1067.0
- VIX      1   0.00001987   0.0051936  -1066.7
- SMB      1   0.00005791   0.0052317  -1065.9
<none>                      0.0051738  -1065.2
- HML      1   0.00015507   0.0053288  -1063.9
```

```
+ SP500      1   0.00000546   0.0051683   -1063.3
- S_10YTCMR  1   0.00027288   0.0054467   -1061.5
- MSCIIDX    1   0.00053360   0.0057074   -1056.5
- RMRF       1   0.00065588   0.0058297   -1054.1
- S_3MTCMR   1   0.00101134   0.0061851   -1047.7
- BGMI       1   0.00180319   0.0069770   -1034.6

Step:  AIC=-1067.01
CSHI ~ S_10YTCMR + S_3MTCMR + VIX + SMB + HML + RMRF + MSCIIDX +
    BGMI

            Df    Sum of Sq         RSS       AIC
- VIX        1   0.00001586   0.0051961   -1068.7
- SMB        1   0.00005236   0.0052326   -1067.9
<none>                        0.0051802   -1067.0
- HML        1   0.00014922   0.0053295   -1065.9
+ AAACBY     1   0.00000646   0.0051738   -1065.2
+ SP500      1   0.00000575   0.0051745   -1065.1
- S_10YTCMR  1   0.00036666   0.0055469   -1061.6
- MSCIIDX    1   0.00058848   0.0057687   -1057.3
- RMRF       1   0.00065785   0.0058381   -1056.0
- S_3MTCMR   1   0.00105025   0.0062305   -1048.9
- BGMI       1   0.00182010   0.0070003   -1036.2

Step:  AIC=-1068.68
CSHI ~ S_10YTCMR + S_3MTCMR + SMB + HML + RMRF + MSCIIDX + BGMI

            Df    Sum of Sq         RSS       AIC
- SMB        1   0.00004971   0.0052458   -1069.6
<none>                        0.0051961   -1068.7
- HML        1   0.00013852   0.0053346   -1067.8
+ VIX        1   0.00001586   0.0051802   -1067.0
+ AAACBY     1   0.00000245   0.0051936   -1066.7
+ SP500      1   0.00000127   0.0051948   -1066.7
- S_10YTCMR  1   0.00039392   0.0055900   -1062.7
- MSCIIDX    1   0.00057305   0.0057691   -1059.3
- RMRF       1   0.00074282   0.0059389   -1056.1
- S_3MTCMR   1   0.00106204   0.0062581   -1050.4
- BGMI       1   0.00190070   0.0070968   -1036.7

Step:  AIC=-1069.64
CSHI ~ S_10YTCMR + S_3MTCMR + HML + RMRF + MSCIIDX + BGMI

            Df    Sum of Sq         RSS       AIC
<none>                        0.0052458   -1069.6
+ SMB        1   0.00004971   0.0051961   -1068.7
- HML        1   0.00015911   0.0054049   -1068.4
+ SP500      1   0.00002028   0.0052255   -1068.1
+ VIX        1   0.00001322   0.0052326   -1067.9
+ AAACBY     1   0.00000002   0.0052458   -1067.6
- S_10YTCMR  1   0.00035373   0.0055995   -1064.5
- MSCIIDX    1   0.00056168   0.0058075   -1060.5
- RMRF       1   0.00069622   0.0059420   -1058.1
- S_3MTCMR   1   0.00105337   0.0062992   -1051.7
- BGMI       1   0.00191674   0.0071626   -1037.7
```

```
Call:
lm(formula = CSHI ~ S_10YTCMR + S_3MTCMR + HML + RMRF + MSCIIDX +
    BGMI)

Coefficients:
(Intercept)    S_10YTCMR     S_3MTCMR          HML         RMRF      MSCIIDX         BGMI
  0.0024504    0.7336976    1.6666637   -0.0004142    0.0010930    0.0725469    0.4291143

> model.fixed.lm = lm(CSHI~S_10YTCMR+S_3MTCMR+HML+RMRF+MSCIIDX+BGMI)
> summary(model.fixed.lm)

Call:
lm(formula = CSHI ~ S_10YTCMR + S_3MTCMR + HML + RMRF + MSCIIDX +
    BGMI)

Residuals:
      Min         1Q     Median         3Q        Max
-0.022566  -0.002789   0.001007   0.004525   0.015983

Coefficients:
              Estimate  Std. Error  t value  Pr(>|t|)
(Intercept)  0.0024504   0.0007220    3.394  0.000982 ***
S_10YTCMR    0.7336976   0.2797601    2.623  0.010063 *
S_3MTCMR     1.6666637   0.3682673    4.526  1.63e-05 ***
HML         -0.0004142   0.0002355   -1.759  0.081588 .
RMRF         0.0010930   0.0002971    3.679  0.000376 ***
MSCIIDX      0.0725469   0.0219523    3.305  0.001312 **
BGMI         0.4291143   0.0702906    6.105  1.88e-08 ***
---
Signif. codes:  0 ?**?0.001 ?*?0.01 ??0.05 ??0.1 ??1

Residual standard error: 0.007171 on 102 degrees of freedom
Multiple R-squared: 0.8425,     Adjusted R-squared: 0.8333
F-statistic: 90.95 on 6 and 102 DF,  p-value: < 2.2e-16


> anova(model.fixed.lm)
Analysis of Variance Table

Response: CSHI
            Df     Sum Sq    Mean Sq   F value     Pr(>F)
S_10YTCMR    1  0.0043257  0.0043257   84.1090  5.554e-15 ***
S_3MTCMR     1  0.0037301  0.0037301   72.5284  1.531e-13 ***
HML          1  0.0003913  0.0003913    7.6076   0.006889 **
RMRF         1  0.0132883  0.0132883  258.3792  < 2.2e-16 ***
MSCIIDX      1  0.0044140  0.0044140   85.8257  3.459e-15 ***
BGMI         1  0.0019167  0.0019167   37.2693  1.879e-08 ***
Residuals  102  0.0052458  0.0000514
---
Signif. codes:  0 ?**?0.001 ?*?0.01 ??0.05 ??0.1 ??1
```