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The Application of Fama-French Capital Asset Pricing Model and Quantile Regression on Chinese Stock Market

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The Application of Fama-French Capital Asset Pricing Model and Quantile Regression on Chinese Stock Market

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Abstract

Fama-French three factors asset pricing model has been well documented for the stock market cross the world. This research will apply Fama-French model to Chinese stock market using the quantile regression approach. All the portfolios are sorted by size and book-to-market ratio to mimic the market size factor and market value factor. The regression reveal that portfolios returns are positively related with market risk and investors will make more profit by holding stocks with smaller company size and higher book-to-market ratio. With the assumption that the returns are normally distributed and expected returns are linearly dependent on three factors, existing studies on Chinese stock market have used ordinary least square (OLS) method to test asset pricing models. These assumptions are not valid in most of the markets. Thus, the present study tests the three risk factors model using quantile regression with the same data set. The results of the study reveal that the when it comes to extreme values in a distribution, the OLS method becomes inefficient. Quantile regression is a better way for investors to examine the extreme values in the distribution tails.

JEL classification: C31; G12; G51

Keywords: Asset Pricing; Fama-French Three Factors Model; Quantile Regression

Table of Contents

Page

Chapter

List of Tables

Table Page

List of Figures

Figure Page

Chapter 1. Introduction

The basic principle of investment is the return and risk of the financial assets should match. The return of stocks has been a core topic of the investment industry and received attention as an important topic of financial economics. But how to measure the expected returns and risk in the uncertain investment environment is always challenging for all investors. A variety of asset pricing models are trying to address the factors that decide the asset price to guide the investors on investment decision.

Markowitz (1952) published portfolio selection theory based on Efficient Market Hypothesis, creating the modern investment theory. Sharp (1964), Linter (1965) and Moisson (1996) respectively put forward the Capital Asset Pricing model (refer as CAPM below), which describes the relationship between systematic risk and expected return of assets, particularly stocks, under the Efficient Market Hypothesis. The strict assumptions coming from efficient market hypothesis put the capital asset pricing model in face of the challenge from empirical tests on US stock market. To improve the model, Fama and French (1992) first attributed the return of asset to market factor, size factor and value factor, of which the first represented the systematic risk of the market and the other two referred as characteristic risks included in the certain asset. The Fama-French three factors model including size and value factor make CAPM less persuasive in explaining the performance of asset and then successfully explain the difference in the returns on various assets. Fama-French model also acquired the support from empirical tests on the stock market over the world. Many researches on Shanghai stock market argue that Fama-French model could well explain the factors that affect the stock return,

especially market premium factor and size factor, although the explanatory power of book-to-market ratio factor is relatively weak.

Although the three factors model explains a big part of the stock return, its predictive ability is still limited. This model has been challenged by many researchers. Traditionally regression models assume that the expected return is linearly dependent on those factors and hence Ordinary Least Square (OLS) is widely used to measure the coefficient of the factors. But OLS use the mean of variables to get the results and ignore the distributions of the variables. When it comes to risk analysis, the parts of the return distributions in which the investors are often interested, such as extreme values in the tails are not well analyzed by OLS method with variables mean.

A more comprehensive picture of the effect of independent variables on the dependent variable can be obtained by using Quantile regression. The quantile regression had been proved to be more effective way to obtain the effect of the independent variables on the dependent variable in the US stock market. In order to extend prior Chinese CAPM study field, this article will test whether Fama-French model would apply to Shanghai A-share stock market by using both OLS linear regression and quantile regression by reference to its monthly data over the last decade. The purpose of this search is to examine whether OLS is able to capture the extreme tail distributions and explore whether the two techniques provided different insights by comparing both coefficients obtained from OLS and quantile regression.

The literature review includes the development of asset pricing model and the formation of the Fama-French three factors model. The empirical test on Shanghai A-share

stock market includes the data description, the formation of the portfolios, the calculation of the independent variables and dependent variable and the empirical test results. The regression results will be analyzed from different aspect to verify the hypotheses regarding how three factors affect stock return. The quantile regression will be run on both 0.05 and 0.95 quantile of the portfolios return. The comparisons of liner regression and quantile regression draw the conclusion of the empirical test.

Chapter 2. Literature Review

Early theories suggested that the risk of an individual security is the standard deviation of its returns – a measure of return volatility. Thus, the larger the standard deviation of security returns the greater the risk. Markowitz (1952) pioneered Modern portfolio theory in his paper "portfolio selection", which is a theory on how risk-averse investors can construct portfolios to optimize or maximize expected return based on a given level of market risk. Markowitz observed that when a portfolio of risky assets is formed, the standard deviation of the portfolio is less than the sum of standard deviation of every single security. Markowitz was the first to develop a specific measure of portfolio risk and to derive the expected return of portfolio. The model assumes that all investors are risk averse and only mean and variance of one-period investment return are considered by investors. According to the theory, it's possible to construct optimal portfolios offering the maximum expected return for any given level of risk and minimal risk for any given level of return.

Sharpe (1964), Lintner (1965) and Moisson (1996) independently, proposed Capital Asset Pricing Theory (CAPM), also known as the single index model, to quantify the relationship between market risk, which is beta, of an asset and its corresponding return[1]. According to the efficient market hypothesis[2], which views the price as a proxy for all the information available

[1] Harry Markowitz, Merton Miller and William Sharpe was awarded the Nobel Prize in Economic Sciences in 1990 for their pioneering work in the theory of financial economics and asset pricing, Capital asset pricing model (CAPM).

[2] CAPM built on some strict assumptions: 1. Security markets are perfectly competitive. 2. There are no taxes or transaction costs. 3. All investors are rational mean-variance optimizers which means everyone uses the Markowitz portfolio selection method. 4. Perfect Information. 5. All investors have only one and the same holding

in the market, the return difference among portfolios is attributed to various risk factors underlying different capital assets[3]. Higher risk comes with higher return for most of stocks.

The CAPM equation (Sharpe, 1964) which describes individual stock return is:

Equation 1: CAPM

$$E(R) = R_f + \beta\big(E(R_m) - R_f\big)$$

Where E(R) is the expected return on the capital asset, R_f is the risk-free rate of interest such as interest arising from government bonds, R_m is the expected return of the overall market, E $(R_m) - R_f$ is known as the market premium (the difference between the expected market return rate and the risk-free rate). β is the sensitivity of the expected excess returns to the expected excess returns rate of market, or $\beta = cov(R, R_m)/\delta^2(R_m)$. The beta of an asset, such as a stock, measures the market risk of that particular asset as compared to the rest of the market.

Starting from the 1990s, the Chinese scholars used a series of empirical test to explain if the capital asset pricing model is applicable in the Chinese securities market. However, the application of the CAPM in Chinese capital market is limited due to the strict assumptions of the CAPM. The efficient market assumption behind CAPM is less likely to be valid in Chinese stock market since the Chinese stock market is not well developed. Tao and Lin (2000) selected 40

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period. 6. Investments are limited to publicly traded assets with unlimited borrowing and lending at the risk-free rate.

[3] Investors face two kinds of risks, namely, diversifiable risk (unsystematic) and non-diversifiable risk (systematic). Unsystematic risk is the component of the portfolio risk that can be eliminated by increasing the portfolio size, which means individual security risk such as business or financial risk can be eliminated by constructing a well-diversified portfolio. Systematic risk is associated with overall movements of market or economy and therefore is often referred to as the market risk. The market risk is the component of the total risk that cannot be eliminated through portfolio diversification.

stocks in Shanghai stock market from 1996 to 1998 to test the CAPM. The coefficient of market risk, beta, is not significant according to the empirical test results. So there are other factors affect stock return besides systemic risk factor. The stock return is not simply linear correlate with market risk. The CAPM is not applicable in Chinese stock market.

The CAPM model started losing its grounds due to asset pricing anomalies which emerged from many empirical works are founded in various stock markets across the world. Asset pricing anomalies include company characteristics such as company size effect, value effect and price to earnings ratio effect. Further, there are substantial published literatures that prove the companies with small size and high book-to-market ratio have higher return rate. Chan, Hamao, and Lakonishok (1991) conducted their CAPM study with four factors, which is earnings yield, size, book-to-market ratio and cash flow yield, by using monthly data set over a period of January 1971 to December 1988 of the Tokyo Stock Exchange. Their study revealed a significant relationship among four independent variables and expected returns in Japanese market. Book-to-market ratio and cash flow yield have the most significant positive impact on expected returns among four variables considered. Banz (1981) documented that excess returns would have been earned by holding small size firms and smaller size firms have had higher risk returns, on average, than larger size firms by examining the NYSE stock market over a period of 1936 -1977. The size effect appeared to be important in terms of statistical significance in explaining returns, as did beta. The real payoff from holding small size stocks came from holding the smallest 20 percent of the firms in the sample.

Fama and French (1992) examined market size and book-to-market ratio and concluded that expected returns could be explained by those two factors. So the basic capital asset pricing model got extended to include size (measured by market capitalization) and value (measured by Book value to Market value) as explanatory factors in explaining the stock returns. SMB, which stands for Small minus Big, is designed to measure the additional return investors have historically received from investing in stocks of companies with relatively small market capitalization. This additional return is often referred to as the "size premium." HML, which is short for High minus Low, has been constructed to measure the "value premium" provided to investors for investing in companies with high book-to-market values[4]. The expanded model captures much of the cross-section average returns among US stock markets. This is confirmed by several international markets as well[5]. Fama and French extend the three factors model by adding operating profitability, investment, dividend yield, prior returns, new share issue, earning to price ratio and cash flow to price ratio to further study the factors that affect the stock return[6].

While the application of the Fama-French three factors asset pricing model has been well documented by using US stock market data, researchers from all over the world tested Fama French model with non-US stock market data. Gaunt (2004) used Australian stock market

[4] The book-to-market ratio is a ratio used to find the value of a company by comparing the book value of a firm to its market value, commonly expressed as B/M.

[5] The evidence from international stock market are Australian stock market (Gaunt, 2004), New Zealand stock market (Djajadikerta & Nartea, 2005), India stock market (Connor & Sehgal, 2001)

[6] Fama and French's further study on CAPM, (Fama & French, 1993), (Fama & French, 1995), (Fama & French, 1996), (Fama & French, 2004), (Fama & French, 2014). Kenneth R. French's Data Library has the updated three factors and five factors value. All the research data can be found in the Data Library. Data Library: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

data from 1981-2000 to investigate size and book-to-market ratio as determinants of asset returns. Their study revealed that the three factor model provides significantly improved explanatory power compared to the CAPM. However, contrary to US evidence, the explanatory power comes from just one of the two additional factors, namely size. Their study extended CAPM literature by evaluating the ability of the three factors model to capture underlying business risk, which is measured by the return on assets of the firm. That is, for each of the 25 portfolios formed at the end of each year, stocks are ranked from highest to lowest return on assets (ROA) with the highest 50 percent of stocks partitioned into one subgroup and the lowest 50 percent into another subgroup. Low ROA group are expected to be fundamentally riskier than the high ROA group. The CAPM three factors model would predict higher return rate for the low ROA (high risk) subgroup, which is constant with the positive relation between risk and return.

Three factors model has been proved to be valid in Chinese stock market. Gao (2018) applied Fama-French three factor model to Shanghai A-share stock market by reference to the monthly data of all the stocks over a period of 2004-2014. The result turned out to be positive as the model could well explain the stock return, especially market premium factor and size factor, though comparing to which the explanatory power of book-to-market ratio factor is relatively weak. However the predictive ability of the model is limited. Notwithstanding the explanation power of the three factors is well improved compared to the one factor CAPM model, Fama-French three factor model could still be improved. The article attempted to improve the model by adding liquidity index - turnover rate as one of the independent variables

since speculations make the turnover rate as a considerable factor in Chinese stock market. The turnover rate has a significant effect on stock return rate meanwhile the significance level of the regression coefficient is improved as well. Wang (2012) examined whether the effect of size and book-to-market ratio existed in the growth enterprises market board and added pricing to earnings ratio to the model to test if the P/E ratio affect stock return[7]. The article tested the extended four factors model with growth enterprise market data from 2011 to 2013. In general, the three factors model still has the adequate power to explain the stock returns in the Chinese market. What's more, the P/E factor also contribute to the model's explanation power.

Quantile regression has been used widely in the past decade in many areas of applied econometrics. Allen, Singh and Powell (2009) applied quantile regression to CAPM study. They empirically examined the effect of the three risk factors on stock returns, beyond the mean of the distribution of the stock return, by using quantile regressions and US stock market data set. Their study examined whether OLS is able to capture the extreme tail distributions and to explore whether the two techniques provided different insights by using both coefficients as obtained from OLS and quantile regressions. Their study used daily price of the 30 Dow Jones Industrial Average Stocks from January 2002 to May 2009. While regular CAPM study calculated the coefficients along the median (0.50) of the dependent variable, their quantile regression study calculated coefficients on 0.05 quantile and 0.95 quantiles of the dependent variable, at 95 percentile confidence levels. Their study indicates that when it comes to boundary values in a distribution the OLS method becomes inefficient. Also the return of a security is not linearly

[7] China's growth enterprise market officially opened in 2009 October and has become an important capital market after 5 years of development.

dependent on these factors around the whole distribution. For example, the market factor beta is 1.29 under OLS method. However, it is 1.18 in 0.05 quantile and 0.65 in 0.95 quantile, which means market risk has less effect on the stock return when it comes to the tail distributions of return. The stock either get overvalued or undervalued by other reasons. Similarly, the coefficient of the size factor is insignificant and constant in the lower quantiles but then becomes significant and positive in the higher quantiles.

Maria and Francisco (2018) conducted their research by comparing twelve different factor models in explaining variations of US stock market returns between 1989 and 2014 using the quantile regression. Specifically, these models are based on Fama-French three factors model (Fama & French, 1993) and five factor models (Fama & French, 2014), adding other explanatory factors such as real interest, expected inflation rates, the Carhart (1997) risk factor for momentum and for momentum reversal, the Lubos and Robert (2003) traded liquidity factor. The results regarding market risk, size and value factors are the same as the research on Chinese stock market. US stock market indicates positive and statistically significant coefficients to changes in the profitability factor for all the models based on the Fama and French five factor model. US stock market exhibits positive coefficients to movements in the investment factor. Finally, US stock market indicates negative and statistically significant coefficients to variations in the momentum factor in all the models, but momentum reversal and traded liquidity change their sign from negative to positive. Their research points out that the extreme quantile 0.1 of the return distribution (associated with recession periods) shows the best results in all the factor models.

Chapter 3. The Test of Fama-French Model on Shanghai Stock Market

Introduce of Chinese Stock Market

Chinese stock markets are described as speculative. Stock markets in highly developed economies have speculation as well, but prices are disciplined in the long run by the ability of shareholders to extract value from the companies. In the long term share price reflect the underlying firm value and firm's net assets will be the biggest determinant of future share price. When shares fail to represent a true ownership stake, then their price will be determined by other factors. In China's case, this translates into speculation, especially about government policy. The very strong bear markets are heavily driven by the supportive government. Chinese speculators are experts at reading such signs indicating the supportive government actions. Once speculators began to pull back, prices fell quickly and strongly and the official sector put a floor under stock prices and ban on short selling.

In the mature stock markets of developed countries, institutional investors occupy a large proportion of market transactions[8]. Institutions own about 78% of the market value of the U.S. broad-market Russell 3000 index, and 80% of the large-cap S&P 500 index[9]. Unlike many of the world's stock markets, most trades on the Chinese stock market are made by individual retail investors, rather than institutional investors. Individual investors make up 80 percent of

[8] The main institutional investors in the US stock market are mutual funds, investment bank and insurance companies.

[9] In dollars, that is about $21.7 trillion and $18 trillion, respectively. Of the 10 largest U.S. companies, institutions own between 70% and 85.8%. Investment advisers are the largest institutional owner of equities through mutual funds and other investment vehicles. Apple, the largest company by market cap, is the most widely held company by institutions, with Vanguard, BlackRock (BLK) and State Street the largest holders. (Mcgrath, 2017) http://www.pionline.com/article/20170425/INTERACTIVE/170429926/80-of-equity-market-cap-held-by-institutions

the trading volume in China's $7.6 trillion stock market (Bloomberg Business, 2017)[10]. About 85 percent of trades are retail, according to Reuters. China's approximately 200 million retail investors trade more often than any other investors on Earth—81 percent said they trade at least once a month, compared with 53 percent in the U.S, according to a recent survey by State Street. Another survey found more than two-thirds of the most recent new investors didn't even graduate from high school and many seem to be investing with borrowed money based on faith in the central government. Individual investors lead to high turnover rate, frequently price fluctuate and speculation (Fahey & Chemi, 2015)[11].

In addition, the information disclosure of listed companies is not accurate and comprehensive, which leads to information asymmetry between listed companies and investors. So investors cannot judge the true profitability of the company and lose confidence in long-term investment. Due to the stock market's short and rapid development as an emerging market, market regulation cannot keep up with market violation, which leads to price manipulation. Some institutional investors use capital and information advantages to intentionally raise or lower the stock price to generate profits. Market price manipulation distort market prices, reduce market efficiency and hinder the long-term stable development of the market (Zhang & Yao, 2016). The understanding of Chinese stock market helps us analyze the empirical test results.

[10] Data from Bloomberg Businessweek, (Bloomberg Business, 2017)

[11] The article also argue that China's market is insulated from world markets. Chinese IPOs are often hugely underpriced. According to one study, they average first-day returns of 137 percent, compared with around 17 percent for U.S.

Fama-French Three Factors Model and Hypotheses

Many researches on Shanghai stock market prove that Fama-French model could well explain the factors that affect the stock return. The Fama-French three factors model is written as[12] (Fama & French, 1992).

Equation 2: Fama-French three factors model

$$\mathbf{R} - \boldsymbol{R_f} = \mathbf{a} + \beta\left(R_m - R_f\right) + s(SMB) + h(HML) + e$$

This test attempts to verify whether Fama and French three factors model is applicable in Shanghai A-share stock market and can well explain the factors that affect the stock return rate. This study has the following hypotheses. Stock with higher book-to-market ratio is undervalued, which indicating that the stock price will increase in the future. The investor will make more profits by holding stocks with higher book-to-market ratio. As of size effect, small size company has higher risk and the investors will have higher return rate expectation. Market premium factor and size factor have strong explanatory power but book-to-market ratio factor has relatively weak explanatory power. OLS is unable to capture the distribution of historical returns for tail distributions. Quantile regression is a better way for investors to exam the extreme values in the distribution tails when it comes to risk analysis.

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[12] R is the return of the portfolios, R_f is risk-free rate and R_m is the return of overall market.
R - R_f is the excess return rate of portfolios.
β is the coefficient of market factor.
$R_m - R_f$ is the excess return rate of market risk factor.
S is the coefficient of size factor, SMB is the excess return rate of size factor.
H is the coefficient of value factor, HML is the excess return rate of value factor
a is the intercept and e is the standard error.

Description of Data

There are two stock exchanges in mainland China, Shanghai Stock Exchange (SSE) and Shenzhen Stock Exchange (SZSE). A majority of the stocks in Shanghai stock exchange are A-share, which means RMB local share. The empirical test chose Shanghai A-share stock market data from 2001 to 2011 as the research sample[13]. All the data are from RESSET finance database[14]. In particular, the stock market indexes this study focus on include two parts, one is the individual stock index include market value, book-to-market ratio and monthly return rate, the other part is the overall market index include risk free rate and Shanghai A-share market return rate.

The reason this study chooses Shanghai stock market instead of Shenzhen stock market is companies listed on SSE are usually sizeable enterprises, many of which are state-owned. Financial services, real estate, resources and energy, as well as infrastructures are the main industries of Shanghai stocks. The SZSE is made up of a bigger portion of small and medium-sized enterprises and private companies, many of which are from high technology industry (The Chin Family, 2016). Also Shanghai stock market value distribution is extensive, including market value from under 1 billion CNY (CNY: Chinese Yuan) to more than 10 billion CNY, to facilitate analysis of market value factor. Financial stocks and ST and ST* stocks should be excluded from the stock sample. The assets and liabilities structure and risk management of financial company

[13] The stock market data before 2001 are not chosen because the stock market was underdeveloped before 2001 and the assumption behind the model was not valid.

[14] RESSET Financial Research Database (RESSET/DB) is mainly for colleges and universities, financial research institutions, research departments of financial enterprises, providing support for empirical research and model test. http://www.resset.cn:8080/en/product/db.jsp

are different from ordinary company. A stock will be identified as ST or ST* stock if the company facing operating or financial issues in Chinese stock market. The price fluctuation of ST and ST* stocks is limited within 5%, but the price fluctuation of the rest of common stocks are limited within 10%. US stock markets do not have a floor for price fluctuation of individual stocks. According to the pervious analysis of Chinese stock market, prevailing speculation is caused by the immature stock market and is the main reason why the government set limitation on price fluctuation. ST and ST* stocks need to be excluded from the sample because the trading mechanism and risk are different from common stock. Any stocks with missing data like return rate, market value and book-to-market ratio should not be included in the sample.

Manipulation of Dependent Variables and Independent Variables Data

Dependent variables. The sample stocks are ranked by market size by the end of each year in ascending order and divided into 5 groups according to the market value. Then each of these five groups is divided into 5 subgroups according to the book-to-market ratio of each stock at the end of each year in ascending order. 25 combination portfolios are formed by the above grouping method. Stock samples need to be regrouped once a year by the market value and book-to-market ratio at the end of each year. For example, all the stocks can be divided into 5 groups according to the market value of each stock on December 31, 2001. Each of these 5 groups can be further divided into 5 subgroups according to the book-to-market ratio of each stock on December 31, 2001 in that group. 25 stock groups are formed and stay the same for the entire year of 2001. 25 groups are formed with the market value and book-to-market ratio of next year and stay the same in the next year with the same method. The portfolios monthly

return rate is calculated with the weighted average monthly return rate of all the stocks in that portfolio according to the market value of corresponding month as the weight.

The risk-free rate of return is the theoretical rate of return of an investment with zero risk. The risk-free rate represents the interest an investor would expect from an absolutely risk-free investment over a specified period of time. In US the interest rate on a three-month U.S. Treasury bill is often used as the risk-free rate for U.S.-based investors. Since this study is about Chinese stock market, one-year bank closed deposit interest rate is used as the risk free rate R_f[15]. Bank deposit interest rate usually stated as annual rate, the annual interest rate need to be converted into monthly interest rate in the same period corresponding to the return rate of 25 portfolios. If the central bank adjusted interest rate during a certain month, the interest rate of that month can be calculated by weighted average based on number of days before and after the interest rate changed. By subtracting the risk free rate from the portfolios monthly return rate, $R - R_f$ is the excess return rate of 25 portfolios of entire period, which is the dependent variables of the regression model.

Table 1 is the statistics summary of all the portfolios, including average market value and average book-to-market ratio of 25 groups. Table 2 is the average excess return rate of 25 groups, including standard deviation and T value. (Trading Economics, 2018)

[15] Current Deposit Interest Rate is 0.35%. The average deposit interest rate from 2001 to 2010 is about 0.75% **(Trading Economics, 2018)** https://tradingeconomics.com/china/deposit-interest-rate

Table 1: Summary Statistics of 25 Groups from 2001-2011

Table 1a: average market value of 25 groups (measured in CNY)					
	based on book-to-market ratio				
market value	A(low)	B	C	D	E(high)
1(small)	1375730	1443499	1575180	1546160	1502194
2	2359771	2299069	2285880	2324094	2343194
3	3241760	3303682	3292647	3200824	3239630
4	5106780	5077783	5040488	5085066	5197379
5(big)	15801200	15432550	15494442	14584653	19328079
Table 1b: average book-to-market ratio of 25 groups					
	based on book-to-market ratio				
market value	A(low)	B	C	D	E(high)
1(small)	0.378	0.520	0.794	1.027	1.538
2	0.449	0.557	0.913	1.039	1.707
3	0.422	0.638	0.853	1.083	1.706
4	0.437	0.561	0.895	1.051	1.845
5(big)	0.431	0.645	0.852	1.093	1.830

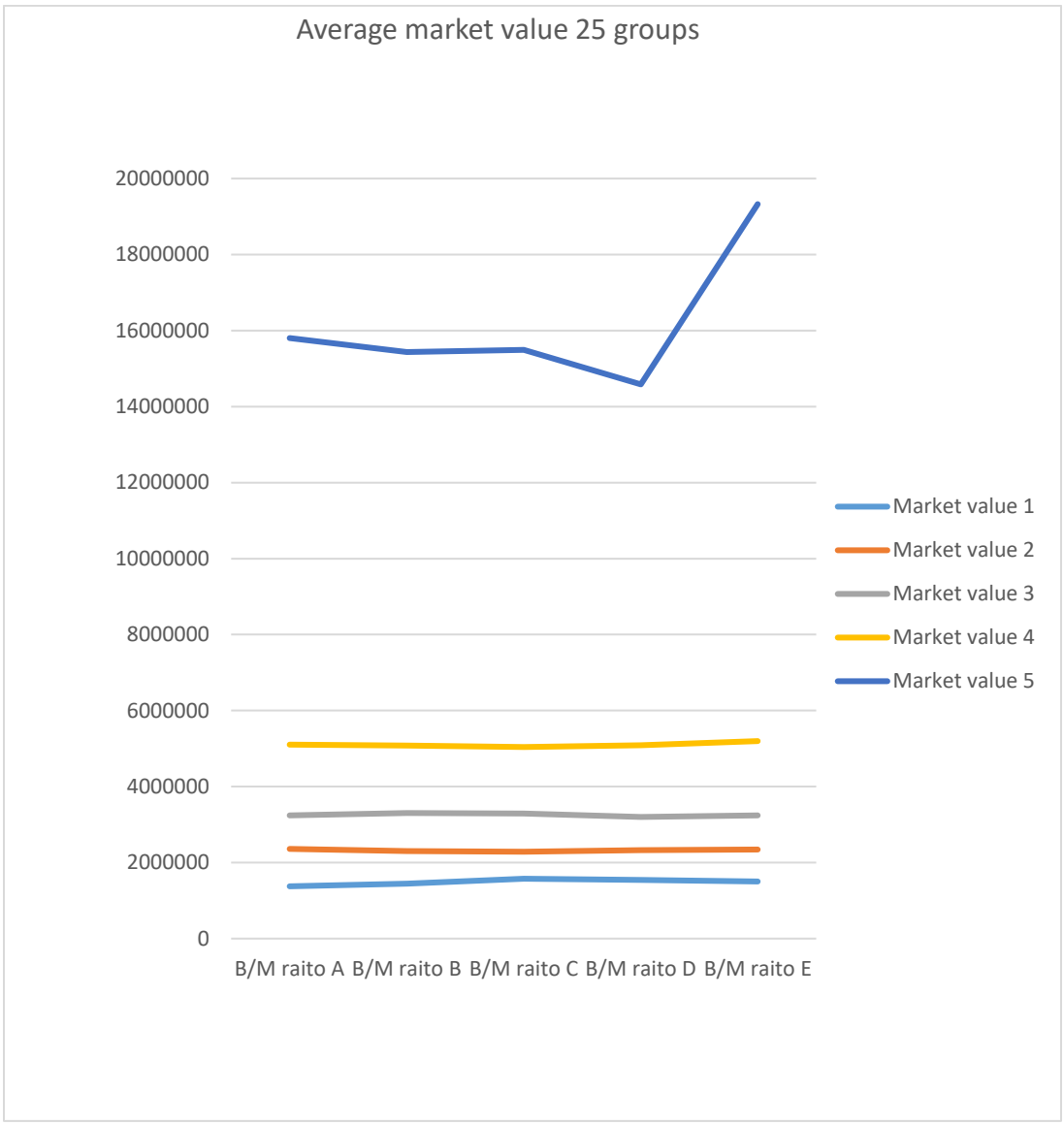

Figure 1: Average Market Value 25 Groups (Measured in CNY)

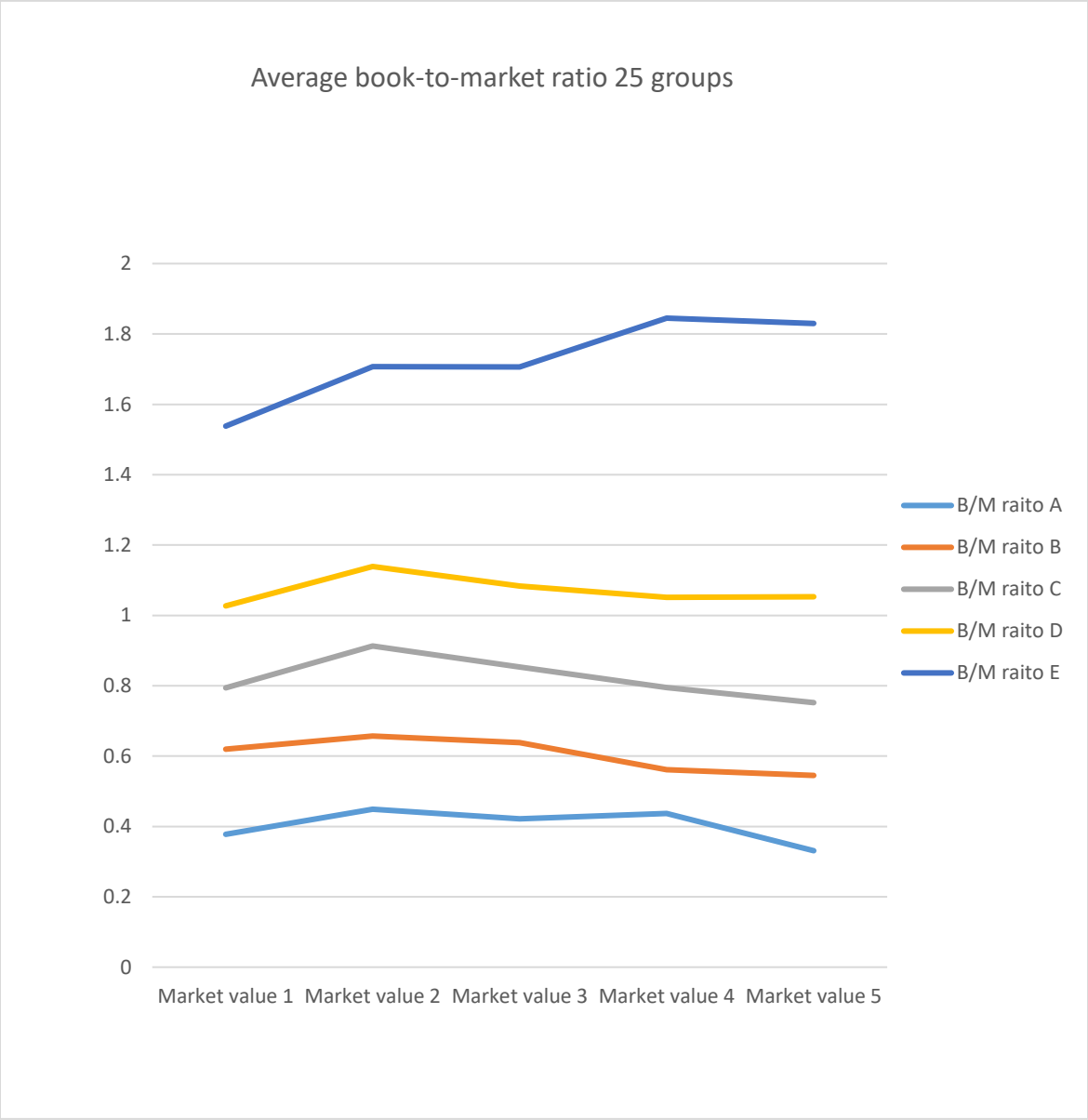

Figure 2: Average Book-to-Market Ratio 25 groups

Table 1a is the average market value of 25 groups. Figure 1 does not indicate any positive or negative relation between market value and book-to-market ratio when the same market value group is held. Table 1b is the average book-to-market ratio of 25 groups which has a consistent trend compared to market value of 25 groups. Figure 2 indicates that average book-to-market ratio increase when the market value goes up if the same book-to-market ratio group is held. Big companies have higher book-to-market ratio than small companies and small companies' market value is high compared to their own book value. The investors are more interested in small companies in Chinese stock market and drive the stock price up above company's book value. Individual investors seek for short term profit from stock market and use short-term speculative as investment strategy (Yu, Sutthisit, & Wu, 2012). Also small companies offer small amount of share and stock price is lower than big companies. The high demand for small company stocks push the stock price in a high point. This makes the market value of small companies always higher than their book value and the book-to-market ratio is lower than big companies.

Table 2: Statistics Summary Excess Return Rate of 25 Groups

Table 2a: average excess return rate of 25 groups					
	based on book-to-market ratio				
market value	A(low)	B	C	D	E(high)
1(small)	0.008	0.014	0.012	0.015	0.014
2	0.006	0.010	0.010	0.012	0.011
3	0.002	0.005	0.009	0.009	0.008
4	0.005	0.006	0.006	0.007	0.008
5(big)	-0.001	0.003	-0.001	0.007	0.009
Table 2b: std dev of excess return rate of 25 groups					
	based on book-to-market ratio				
market value	A(low)	B	C	D	E(high)
1(small)	0.111	0.110	0.111	0.113	0.109
2	0.121	0.104	0.105	0.108	0.108
3	0.095	0.100	0.106	0.105	0.106
4	0.094	0.100	0.102	0.103	0.108
5(big)	0.088	0.094	0.095	0.099	0.094

Table 2a presents that the distribution of average excess return rate of 25 groups is wide, up to 1.45% and down to -0.11%. In general, excess return rate is negatively related with market size if book-to-market ratio stay the same, which means the bigger of the company market size, the lower of the excess return rate. However, the negative relation is not held for

Group E with highest book-to-market ratio in the last column of the table. The average excess return rate of the group E5 (highest book-to-market ratio and biggest market size) is 0.87%, which is fairly high. The relation between book-to-market ratio and average excess return rate is not distinct comparing to the relation between market size and average excess return rate. But the table still presents an overall positive relation between book-to-market ratio and average return. The average return rate of the high book-to-market ratio group E is higher than the low book-to-market ratio group A. In general, the groups with small size and high book-to-market ratio have relatively high excess return rate and the groups with big size and low book-to-market ratio have relatively low excess return rate (Fama & French, 1992).

Standard deviation of average excess return increases along with the decrease of market value size if book-to-market ratio is held in the same group. Standard deviation of the stock return represents the stock risk, so the investment to small companies has a higher risk. Book-to-market ratios are positively related with the standard deviation of average excess return rate if market value is held in the same group. Book-to-market ratio can reflect the stock portfolio risk, higher book-to-market ratio is associated with higher investment risk. Because the companies might have operation issue and perform low profitability if the market value is low compared to book value. Higher risk is involved in the investment of those companies. This is consistent with the positive relation between book-to-market ratio and excess return rate. The investors expect higher return rate with the investment to high risk stocks. According to Table 2, although some individual data does not conform to the previous results, but in general

the standard deviation has negative relation with size factor and positive relation with book-to-market ratio factor.

Independent variables. The empirical test needs three independent variables sequences, market risk factor ($R_m - R_f$), size factor (SMB), value factor (HML). The additional return an investor receives for holding a risky market portfolio instead of risk-free assets is termed as a market risk premium. Market risk premium ($R_m - R_f$), is the return of the market in excess of the risk-free rate, which means the amount the investor will be compensated for taking the market risk. Stock market indexes can represent the market return rate. Researchers usually use S&P 500 as the US stock market return rate[16]. The SSE Composite, which is short for the Shanghai Stock Exchange Composite Index, is a market composite index made up of all the A-shares and B-shares that trade on the Shanghai Stock Exchange. The SSE Composite is a good way to get a broad overview of the performance of companies listed on the Shanghai exchange. SEE Composite index will be used as market return rate. The monthly market excess return rate ($R_m - R_f$) from May 2001 to April 2011 is calculated by subtracting monthly risk free rate data from monthly market return rate data.

The Fama-French three factors model create small minus big (SMB) portfolios and high minus low (HML) to mimicking market size effect and book-to-market effect respectively. This study will adopt Fama-French's method (1992). In order to calculate the mimicking portfolios

[16] The Standard & Poor's 500 Stock Index is a larger and more diverse index than the DJIA. Made up of 500 of the most widely traded stocks in the United States, it represents about 70% of the total value of U.S. stock markets. In general, the S&P 500 index gives a good indication of movement in the U.S. marketplace as a whole (Investopedia, 2018).

returns rate, companies are divided into six groups based on size and book-to-market ratio. This is achieved by first ranking all companies by market value (size) at the end of each year with the smallest 50 percent and largest 50 percent of stocks assigned to two different groups, which named by group B (big) and group S (small). After the size ranking and grouping, companies are then ranked and divided by book-to-market ratio at the end of each year with the smallest 30 percent, the middle 40 percent and the largest 30 percent assigned to three different groups. The intersections of the two size and three book-to-market groups produce six groups of stocks which are used to compute the SMB and HML factors. All six groups will be named as BH (big size and high book-to-market ratio), BM (big size and medium book-to-market ratio), BL (big size and low ratio), SH (small size and high ratio), SM (small size and medium ratio) and SL (small size and low ratio). Those six groups need to be regrouped once a year according to the market value and book-to-market ratio by the end of each year. Weighted average monthly return rate of each group needs to be calculated before the calculation of SMB and LMH, market value will be used as the weight. The returns of six groups are calculated for each month over the 12 months year by year following the portfolio groups formation.

The portfolio small minus big (SMB) is meant to mimic the return related to size. SMB is the difference between the simple average of the monthly return rate on the three small-size stock groups and the simple average of the monthly return rate on the three big-size stock groups. SMB is expressed as: MB = ((SL + SM + SH) – (BL + BM + BH))/3. So the variable SMB eliminate the effect of book-to-market ratio and keep the effect of market size on the return rate. This intuitively reflect the difference of return rate between small size company and big

size company. The portfolio low minus high (LMH) is meant to mimic the return related to value factor. LMH is the difference between the simple average of the monthly return rate on the two high book-to-market ratio groups (SH and BH) and the simple average of the monthly return rate on the two low book-to-market ratio groups (SL and BL). LMH is expressed in the way of: LMH = ((SL + BL) – (SH + BH))/2. So the variable LMH eliminate the effect of size factor and keep the effect of book-to-market ratio on the return rate. This reflect the difference of return rate between low value company and high value company. Regression model is run in SAS with the monthly date of both dependent variables and independent variables over ten years.

Table 3: Summary Statistics Three Factors

	n	mean	std. deviation	std. error mean	max	min
Rm - Rf	132	.001	.084	.007	0.269	-0.253
SMB	132	.005	.049	.004	0.139	-0.135
HML	132	.005	.031	.003	0.099	-0.080
	test value = 0					
	t	df	sig. (2-tailed)	mean difference	95% confidence interval of the difference	
					lower	upper
Rm - Rf	.136	131	.892	.001	-.013	.015
SMB	1.198	131	.233	.005	-.003	.014
HML	1.834	131	.069	.005	-.0003	.010

Table 4: Correlations Three Factors

		Rm - Rf	SMB	HML
Rm - Rf	Pearson correlation	1	-.014	.250**
	sig. (2-tailed)		.877	.004
	N	132	132	132
SMB	Pearson correlation	-.014	1	-.266**
	sig. (2-tailed)	.877		.002
	N	132	132	132
HML	Pearson correlation	.250**	-.266**	1
	sig. (2-tailed)	.004	.002	
	N	132	132	132
**. correlation is significant at the 0.01 level (2-tailed).				

Table 3 and table 4 present Statistics Summary of three factors. The value of three factors is the risk premium of these factors. The mean value of market factor is 0.000990, which is smaller than the mean value of SMB and HML. Both mean value of SMB and HML are close to 0.005. The MAX and MIN value of market risk is 0.2686 and -0.2534, the absolute value is beyond the mean value. The MAX value of market risk is bigger than the MAX value of both SMB and HML. The market risk data are spread out over a wider range and the positive values and negative values offset each other. This can be approved by the Std. Dev of market risk, which is 0.837889 and bigger than the Std. Dev of other two factors. The absolute value of MAX and MIN value of SMB is smaller than market risk but bigger than HML. Market risk is still dominant among all the risk factors of stock. In Chinese stock market, the size risk premium is bigger than the value risk premium.

In practice, meaningful multicollinearity can be as small as 0.4 (or -0.4) for positive (or negative) associations[17]. The market factor and size factor are negatively related according to the previous analysis, but the relation is not significant. Value factor is positively related with market risk factor but negatively related with size factor. The absolute values of the correlation from Table 4 are all smaller than 0.4, which means there no strong association between those three factors. There is no strong evidence our regression results will be affect by the correlation of the independent variables.

The Empirical Regression Result Analysis of Shanghai A-Share Market

Time series regression model are applied to the 25 portfolio groups. The regression results are as follows.

[17] Correlation values (off-diagonal elements) of at least 0.4 are sometimes interpreted as indicating a multicollinearity problem.

Table 5: Regression Results 25 Groups

market value	based on book-to-market ratio									
	A(low)	B	C	D	E(high)	A(low)	B	C	D	E(high)
	β					T(β)				
1(small)	0.981	1.001	1.016	1.041	1.003	28.556	29.385	30.254	29.801	25.261
2	1.111	1.021	1.019	1.005	0.979	25.544	28.579	28.849	26.360	28.447
3	0.931	0.986	1.003	1.011	1.028	25.513	26.166	24.608	25.106	28.933
4	0.937	1.026	1.085	1.036	1.075	20.930	24.871	30.325	25.971	26.570
5(big)	0.997	1.032	1.026	1.057	0.901	28.244	22.586	22.671	29.495	23.456
	s					T(s)				
1(small)	1.407	1.336	1.341	1.351	1.212	23.766	22.764	23.188	22.458	17.740
2	1.395	1.049	1.079	1.190	1.257	18.618	17.056	17.748	18.121	21.211
3	0.886	0.936	1.079	1.038	1.048	14.097	14.418	15.366	14.973	17.138
4	0.666	0.755	0.720	0.832	0.898	8.640	10.628	11.687	12.110	12.883
5(big)	0.047	0.095	0.091	0.148	0.032	0.774	1.202	1.169	2.406	0.480
	h					T(h)				
1(small)	-0.132	-0.111	-0.014	0.064	0.241	-1.387	-1.179	-0.147	0.660	2.200
2	-0.138	-0.089	-0.102	0.138	0.337	-1.150	-0.898	-1.049	1.305	3.542
3	-0.537	-0.312	0.042	0.055	0.321	-5.323	-2.995	0.370	0.494	3.268
4	-0.480	-0.304	-0.124	0.151	0.370	-3.876	-2.668	-1.257	1.373	3.308
5(big)	-0.872	-0.422	-0.039	0.522	0.879	-8.937	-3.341	-0.308	5.267	8.280
	F-test					R square				
1(small)	487.60	487.57	513.18	492.80	341.03	0.920	0.920	0.923	0.920	0.889
2	352.26	389.98	403.87	363.82	453.45	0.892	0.901	0.904	0.895	0.914
3	300.85	312.92	297.99	302.87	410.13	0.876	0.880	0.875	0.877	0.906
4	178.78	254.85	370.28	294.43	320.36	0.807	0.857	0.897	0.873	0.882
5(big)	269.87	173.36	182.43	348.74	257.81	0.863	0.802	0.810	0.891	0.858

Table 6: Statistics Summary Regression Results

	max	min	mean	standard deviation
β	0.007	-0.002	0.002	0.002
b	1.111	0.901	1.012	0.046
s	1.407	0.032	0.876	0.455
h	0.879	-0.872	-0.022	0.367

Market risk factor. The beta indicates the sensitivity of the stock return with the overall market risk. The regression results in table 5 indicate that the coefficients of market risk of 25 groups, β, are all close to 1. MAX value of β is 1.11, MIN value of β is 0.901 and mean is 1.012 according to Table 6. This conform to the hypothesis of CAPM, which is the excess return rate of stock portfolios is positively related to market risk factor. The standard deviation of β of all 25 groups is low as 0.046. Even though the coefficients of size factor and value factor of 25 groups are different, all the β values are tended to 1 and relatively stable. Overall speaking, all 25 portfolio groups have the same systemic risk in the long run and the risk factor tend to be a stable value. Stocks are separated into aggressive, defensive and neutral share according to the beta value. The stock is classified as aggressive share if the beta is larger than 1. These shares have higher exposure to systematic risk and stock price is theoretically more volatile than the market. In another word, the stock price increases more in a rising market and decrease more in a declining market. The stock is classified as defensive share when the beta smaller than 1 and tends to be less volatile than the market. These shares will generally experience smaller

gains in a rising market and smaller losses in a declining market. A beta of 1 means that the stock's price tends to move with the broader market and follow the market trend. In Chinese stock market, most of the stocks tend to move with the market since all β values are close to 1.

Market size factor. The coefficient of size factor SMB, S, is positive for all the portfolio groups. However, the coefficients of small size company are significantly bigger than the big size company if book-to-market ratio stay the same. All the SMB coefficient in the first two small size company group (Group 1 and Group 2) are bigger than 1 and the SMB coefficient in the last two big size company group (Group 4 and Group 5) are smaller than 1. S value will increase along with the decrease of company size. This can be explained by the fact that the size factor is more effective for small size company and small size stocks have generated higher returns than large size stocks. Small companies with rapid expansion generally have good profit prospects and high return rate. The risk-return tradeoff states that the potential return rises with an increase in risk. Small size companies are easy to fail and highly affected by the business cycle. So investors require higher return to compensate the addition risk they are taking.

Overall speaking the excess return rates of portfolios are positively related with size factor since all the SMB coefficients are positive. But the positive relation gets weaker as the company size getting bigger. This can be explained by the scale effect. The scale effect can help company reduce the cost and improve the production efficiency as the expansion of company. That is why the excess return of small size company is more sensitive to SMB factor. But according to the diminishing scale effect law, the benefit of the scale effect will decrease at a certain point, which might be cause by productivity decline and operational risk. This result is

different from the results of Fama-French's research on US stock market (Fama & French, 1992). In their research the coefficient of size factor is negative in the biggest size portfolio group and big size company's return is negatively related with size factor.

Book-to-market ratio factor. The coefficient of value factor HML (H) is negative in first three low book-to-market ratio columns (Group A, B and C), which means that the excess return rate of low book-to-market ratio groups is negatively related with value factor HML. By contrast, the coefficients of high book-to-market ratio groups (Group C and D) are all positive, which means excess return rate of high book-to-market ratio groups is positively related with value factor. H values also increases with book-to-market ratio if market size stay the same.

Companies with high book-to-market ratios, also known as value stocks, enjoy higher returns than companies with lower book-to-market ratio, also known as growth stocks. This confirm with our regression results from table 5. Value stocks are companies that tend to have lower earnings growth rates, higher dividends and lower market prices. Therefore value stocks have higher risk exposure versus growth stocks. Also, lower market prices of valued companies indicate that valued companies are undervalued and the market price have the potential to increase. In the long run, value stocks will generate higher returns than growth stocks because value stocks have higher risk and growth stocks have higher stock prices and earnings. H value also increase with market value if book-to-market ratio stay the same. This indicates that bigger companies are more sensitive to value factor. This is different from Fama and French's study on US stock market. In their study, the correlation between size and book-to-market ratio affects the regression results. Therefore part of the size effect in the regression is due to the fact that

small market size stocks are more likely to have high book-to-market ratios. Also, part of the book-to-market effect is due to the fact that high book-to-market ratio stocks tend to be small size.

Statistics analysis of three factors. The T-test value of each coefficient are in table 5. The T-test critical value is 1.98 with degree of freedom 133 and 2 tailed test at 0.05 significant level. T-value of β (market factor) is around 25 and bigger than 1.98. This indicates that beta value is significant and market risk has a significant effect on excess return rate of portfolios. The T-values of SMB coefficient decrease when the company size goes up. T-values of SMB coefficient are larger than 1.98 in the first four rows of smaller size company (Group 1, 2, 3, and 4) and size factor is significant for small size and medium size company. But T-values of SMB coefficient are smaller than 1.98 for the last row of biggest size company group (Group 5) and size factor is not significant for big size company. As for the value factor, all the LMH coefficients in the group with highest book-to-market ratio (Group E) are significant. While the medium book-to-market ratio groups (Group C, D) only have one significant LMH coefficient, which is D5 with T–stats value 5.26. Half of the LMH coefficients are significant in the low book-to-market ratio group (Group A and B). Table 5 also indicates that the bigger size portfolios seem to have more significant coefficients on HML. The value factor has significant effect on the high value or big size portfolios. This confirms with other researchers' study on Chinese stock market, the three factors model could well explain the stock return, especially market risk factor and size factor, though comparing to which the explanatory power of book-to-market ratio factor is relatively weak because only 12 out of 25 of the HML coefficient are significant.

All the R^2 values are larger than 0.80 and eight of them are larger than 0.9, which means that those three factors can explain more than 80 percent of the variability of the dependent variable. F critical value is 2.68 at 0.05 significant level in the degree of freedom: 3, 133. The F values of 25 portfolio groups are larger than the F critical value, so those three factors are significant jointly.

Chapter 4. Quantile Regression Analysis

A more comprehensive picture of the effect of independent variables on the dependent variable can be obtained by using Quantile regression. Quantile regression describes the relation between a set of predictor variables and specific percentiles (or quantiles) of the dependent variable. For example, a median regression (median is the 50th percentile) of stock return on Fama-French three factors model specifies the changes in the median quantile of stock return as a function of the three factors. The effect of market risk on median stock return can be compared to its effect on other quantiles of stock return. In linear regression, the regression coefficients represent how much the dependent variable will change in the response of one unit change of independent variables. The quantile regression parameter estimates the change in a specified quantile of the dependent variable produced by one unit change in the independent variable. This allows comparing how some percentiles of the stock return may be more or less affected by certain factors than other percentiles. While OLS can be inefficient if the errors are highly non-normal or the extreme outcomes in the tails are different from the median. Quantile regression promises to be a more effective tool than OLS when it comes to analyzing the extreme outcomes in the tails of return distributions. Quantile regression is a better method to test how Fama-French three factors affect stock return in the distribution tail and will help the investors make better decisions. When it comes to risk assessment, the tail distributions become more important for an investor or risk manager.

While OLS calculates the coefficients along the median (0.50) of the dependent variables, quantile regression calculates the regression coefficients at the 0.05 and 0.95 quantiles, at 95

percentile confidence levels. Quantile regression will be run in SAS with the same date to test our hypotheses regarding the quantiles regression method.

The following table provides the Fama-French three factors coefficients using quantile regression at 0.05 and 0.95 quantiles respectively. Appendix plots respectively provide the values of beta, SMB and HML across different quantiles of 25 Groups.

Table 7: Quantile Regression Results

quantile level: 0.05						
Groups	b	T(b)	s	T(s)	h	T(h)
Group1	0.96	12.25	1.70	12.52	-0.15	-0.67
Group2	0.93	12.04	1.44	10.79	-0.12	-0.57
Group3	0.99	5.58	1.38	4.53	-0.12	-0.24
Group4	1.00	15.61	1.54	13.99	0.13	0.73
Group5	0.96	10.29	1.42	8.80	0.55	2.11
Group6	1.00	13.97	1.18	9.60	-0.60	-3.04
Group7	0.94	4.10	0.90	2.29	-0.08	-0.12
Group8	0.94	11.33	1.36	9.51	0.18	0.80
Group9	0.87	13.46	1.32	11.92	0.41	2.32
Group10	0.90	8.31	1.28	6.87	0.34	1.13
Group11	0.87	6.30	0.82	3.44	-0.41	-1.07
Group12	0.93	10.71	1.19	7.93	-0.43	-1.77
Group13	0.91	9.41	1.17	7.00	-0.03	-0.10
Group14	0.87	9.37	1.17	7.38	-0.17	-0.68
Group15	1.03	8.91	1.14	5.74	0.15	0.46
Group16	0.88	6.91	0.78	3.56	-0.44	-1.24
Group17	1.03	7.13	1.04	4.18	-0.44	-1.11
Group18	0.98	9.53	0.78	4.40	-0.12	-0.43
Group19	0.89	8.76	0.80	4.59	0.18	0.64
Group20	1.03	6.20	0.85	2.97	0.21	0.46
Group21	0.92	5.61	0.17	0.59	-0.62	-1.38
Group22	1.07	4.14	0.19	0.42	-0.49	-0.69
Group23	0.99	5.28	0.25	0.77	-0.11	-0.21
Group24	0.99	9.10	0.38	2.05	0.69	2.29
Group25	0.85	6.16	0.18	0.76	1.07	2.82

quantile level: 0.95						
Groups	b	T(b)	s	T(s)	h	T(h)
Group1	1.12	8.81	1.31	5.98	-0.08	-0.23
Group2	1.00	5.02	1.52	4.43	-0.06	-0.11
Group3	1.26	10.76	1.11	5.51	-0.06	-0.18
Group4	1.32	6.51	1.38	3.94	-0.36	-0.64
Group5	1.20	5.49	1.25	3.31	0.39	0.64
Group6	1.39	9.32	1.61	6.28	-0.19	-0.47
Group7	1.25	5.93	1.25	3.45	-0.11	-0.19
Group8	1.28	15.23	1.12	7.75	-0.63	-2.71
Group9	1.07	4.66	1.18	2.99	0.04	0.07
Group10	1.09	7.80	1.30	5.42	0.30	0.78
Group11	1.07	6.07	0.82	2.69	-0.67	-1.37
Group12	1.19	8.84	0.81	3.48	-0.50	-1.35
Group13	1.13	7.41	1.17	4.46	-0.14	-0.33
Group14	1.11	5.83	1.29	3.93	0.04	0.08
Group15	1.30	14.84	0.92	6.06	0.02	0.10
Group16	1.08	3.90	0.56	1.18	-0.34	-0.45
Group17	0.97	6.16	0.85	3.14	-0.26	-0.61
Group18	1.26	10.08	0.72	3.37	-0.27	-0.79
Group19	1.32	7.19	1.11	3.50	0.07	0.13
Group20	1.34	6.70	1.09	3.15	0.42	0.76
Group21	0.99	5.06	0.19	0.55	-0.85	-1.56
Group22	1.32	8.08	-0.03	-0.10	-0.28	-0.61
Group23	1.18	5.52	0.06	0.16	0.04	0.06
Group24	1.17	8.58	0.08	0.34	0.40	1.06
Group25	0.98	4.32	0.02	0.05	1.14	1.83

Table 8: Summary Statistics of Quantile Regression Results

		max	min	mean	standard deviation
Level: 0.05	b	1.067	0.848	0.949	0.061
	s	1.695	0.165	0.978	0.452
	h	1.072	-0.624	-0.017	0.418
Level: 0.95	b	1.392	0.970	1.175	0.126
	s	1.614	-0.028	0.907	0.494
	h	1.140	-0.847	-0.078	0.413

The Table 7 indicates that, when it comes to boundary values in a distribution, the OLS method becomes inefficient and the returns of portfolios are not linearly dependent on three factors around the entire distribution of return.

The β represents the market risk factor. Figure 3 indicates the β values are similar in different quantiles. But overall, the value of β is bigger in the higher quantile than the value in the lower quantile. When the quantile is below 0.50, the β value is close but less than 1 for most of the portfolio groups, also the changes of β are relative low across the quantiles below 0.50 according to the slop of the β line. As the quantiles move up, beta values increase and are higher than 1 significantly. The slope of β is steeper after 0.50 quantile.

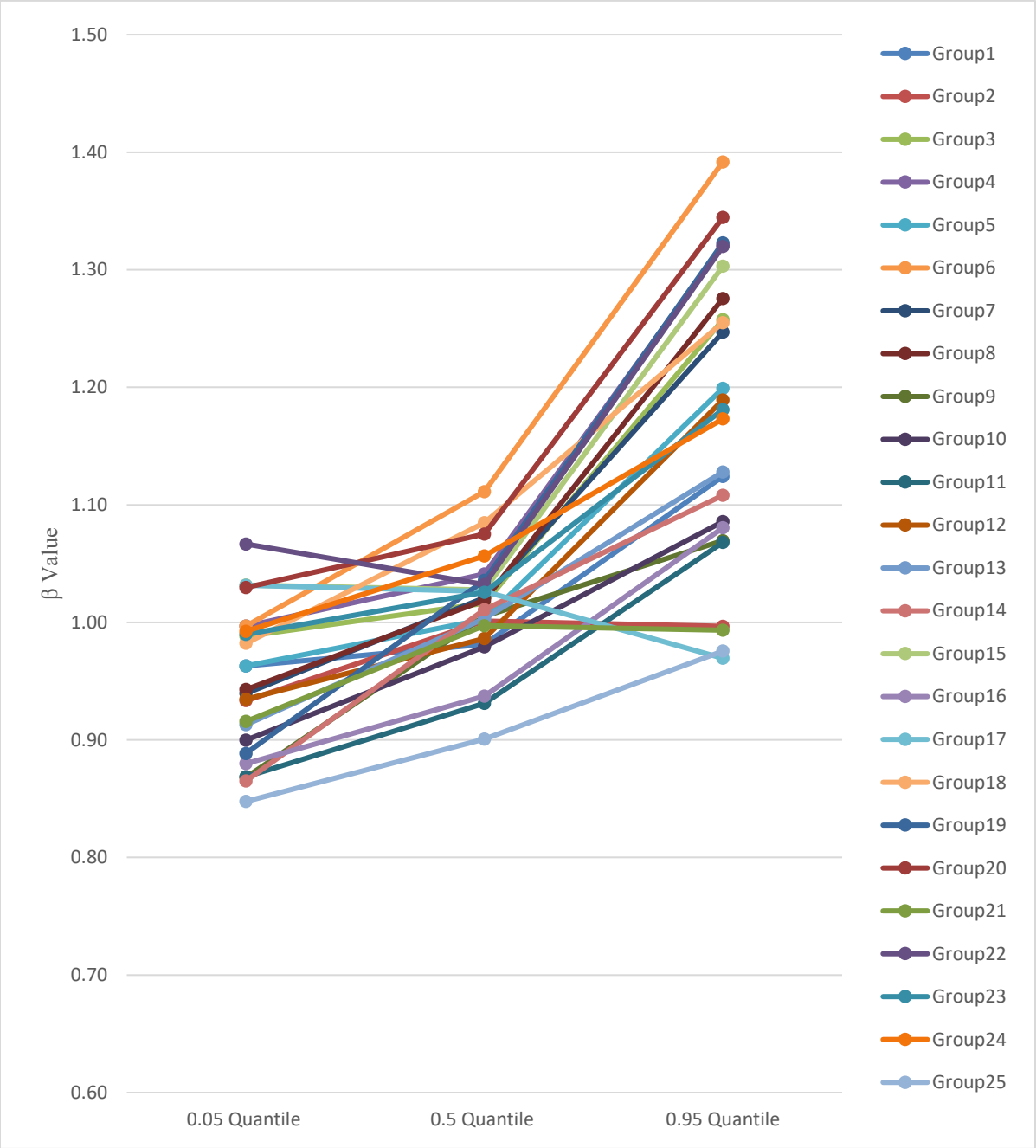

Figure 3: β Value Across Quantiles of 25 Groups

For example, the beta value is 1.016 under OLS method for group 3, but it is 0.99 on 0.05 quantile and 1.26 on 0.95 quantile. The difference of beta between OLS and quantile regression is significantly higher in the higher quantile. The positive relationship between market risk and portfolio return becomes stronger at higher quantile. So the higher of the portfolios return rate, the greater the impact of market risk on stock returns. This results are different from the study (Allen, Singh, & Powell, 2009) on US stock market. Their study indicates that the beta value is smaller in the two tail quantiles compare to the medium quantile and market risk has less effect on the stock return when it comes to the tail distributions of return. This is in line with the reality-extreme value of stock return is usually caused by company's characteristics or movement not the overall market risk. Company's mergers and acquisition, new product issue and government support can really drive the stock price up. By contrast, corporate scandals, government regulation and bad poor performance financial statement can really hurt the stock holder. Because all the stock holders sell their shares and drive the stock price under the fair value.

The beta values across different quantiles hold the implication of CAPM, which is the positive relation between market risk and portfolio return rate. However, the result is inconsistent with the quantile regression study done by Chiang and Li (2012) with US stock market data. Their study argued that the market risk beta is an upward function of the quantiles of the portfolios excess returns, but the relation between beta and excess returns evolves from negative to positive as the quantiles increase and the beta is negative below 0.50 quantile, which is different from the results in Shanghai stock market. Excess returns are

negatively related to expected market risk at lower quantiles and positively related to expected market risk at higher quantiles. Around the median, excess return is not correlated with expected market risk because the T-value is insignificant for the median regression. When economic conditions are optimism, which corresponds to the return distributions in the upper quantiles, investors expect that the higher volatility will be compensated by the expected higher return. However, when the market is dominated by the down trend of economic cycle, in general, corresponds to the return distributions in the lower quantiles, investors believe that high volatility will create more uncertainty, causing stock returns to fall. Thus, the relation between excess returns and expected volatility is negative and the beta values, which represent market volatility, are negative below 0.50 quantiles. In the median range of return quantiles, investors have no clear information about which direction of the stock return will go and what the overall market return will be. This ambivalent return and uncertainty cause an unclear risk-return relation. Their evidence suggests that when the excess return is expected to be relatively high, the risk-return hypothesis is likely to be hold. However, when the excess return is expected to be low or negative, there is no tradeoff between risk and return.

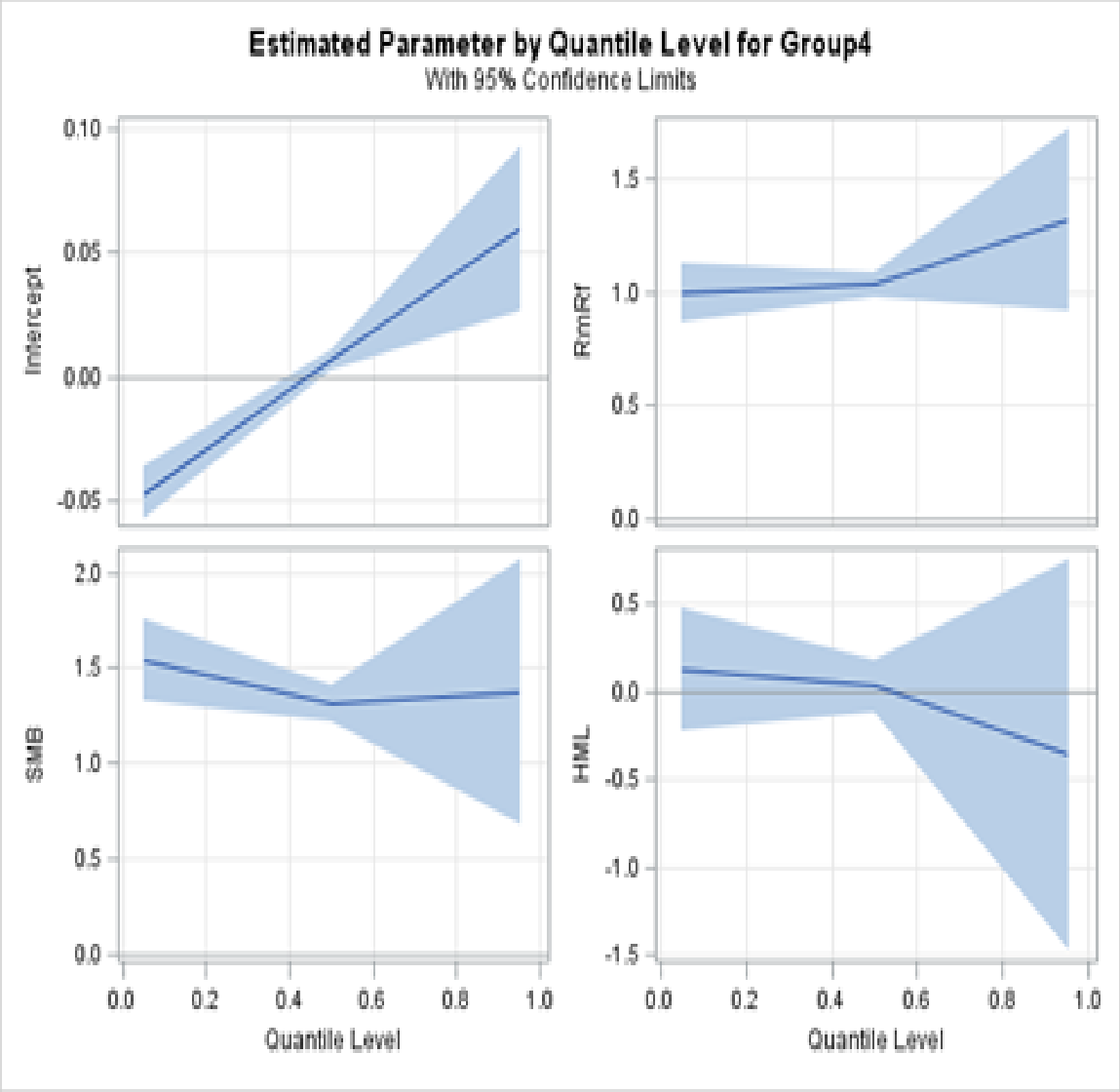

Figure 4: Estimated Coefficient by Quantile Level for Group D1 (Small size, high value)

The coefficients of market size factor at both ends of the quantiles are significantly higher than the median quantile. The SMB coefficient is v-shaped at different quintiles. Market size has a greater impact on stock returns at both ends of the statistical distribution of returns. The coefficients of value factor differ significantly in the entire quintiles. The values can go from

positive to negative and the differences between max value and min value are big for most of portfolios. Figure 4 depicts the coefficients of three factors cross the quantiles of Group D1 (Small size, high value). The HML coefficients move from positive to negative across the quantiles. The HML coefficients present a slow downtrend moving toward 0 in the lower half quantiles but the values drop rapidly after 0.5 quantile. The HML coefficient is -0.36 at 0.95 quantile and smaller than the HML coefficients from OLS method, 0.064. The expected positive relationship between high book-to-market ratio and portfolio return only holds across the lower quantiles. So quantile regression is a more efficient way to capture the effect of three factors on the return of portfolios.

Chapter 5. Summary and Conclusion

The Fama-French three factors model can explain more than 80% of the variation in the portfolio returns on Chinese A-shares. The excess returns of stock portfolios are positively related to overall market risk. The investors will make more profit by holding stocks with smaller company size and higher book-to-market ratio. However the explanatory power of book-to-market ratio factor is relatively weak compare to market risk and stock market size factor in Chinese stock market.

The study also compares the OLS results with quantile regression to see whether the quantile regression is a better method for all the explanatory variables across all the quantiles of dependent variables. The results indicate that all the coefficient of three factors spread out across the quantiles of portfolios return. Market risk coefficient β under OLS method only keep in line with the β value at lower quantile under quantile regression. The β value increase along with the quantiles after 0.50 quantile. The positive relationship between market risk and portfolio return becomes stronger when the portfolio return perform well. The coefficients of market size factor at both ends of quantiles are significantly higher than the median quantile. The coefficients of value factor differ significantly across quintiles and there is no common movement pattern of LMH coefficient for all 25 portfolio groups. Quantile regression is a better way for investors to exam the extreme values in the distribution tails when it comes to risk analysis.

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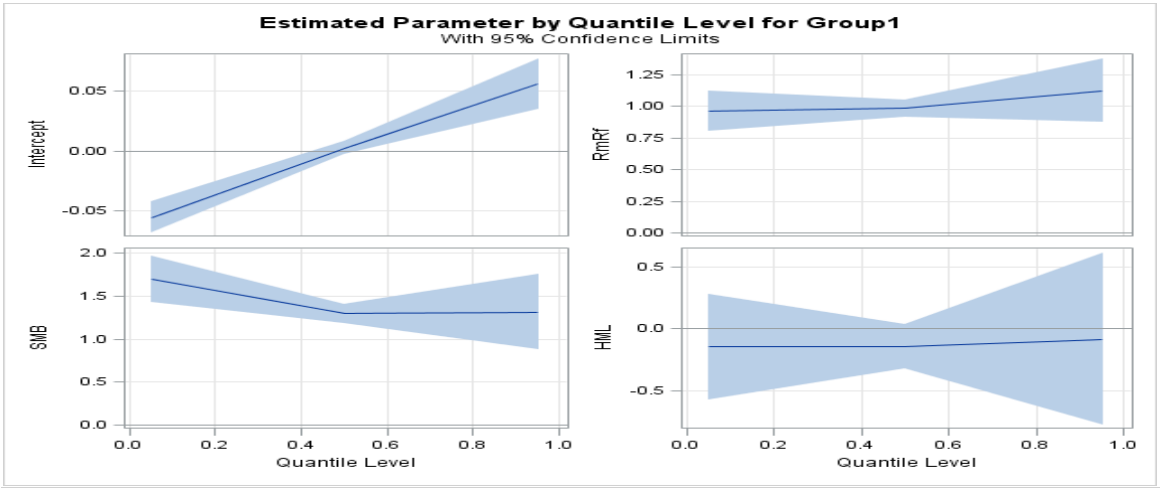
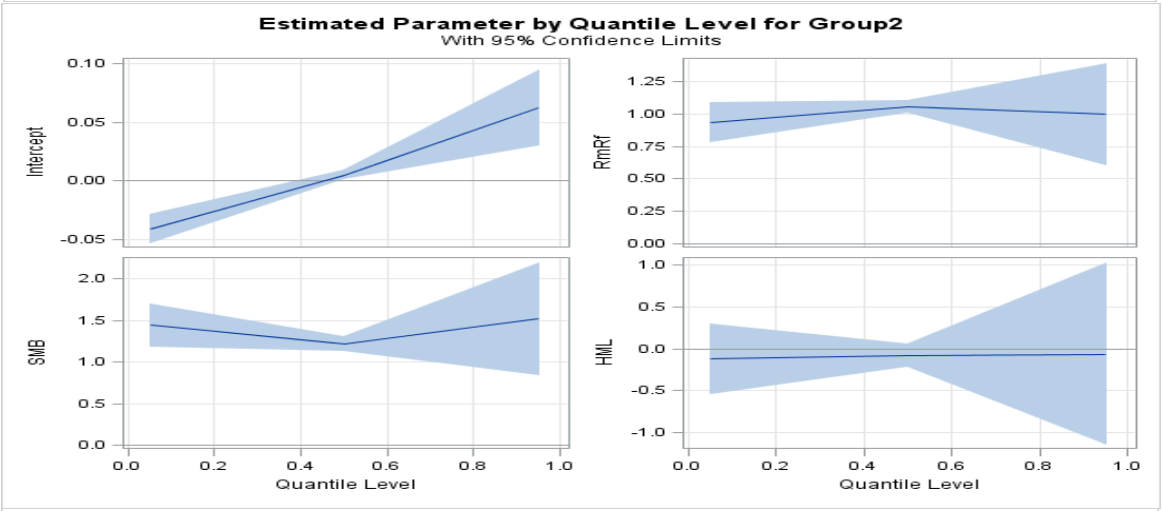
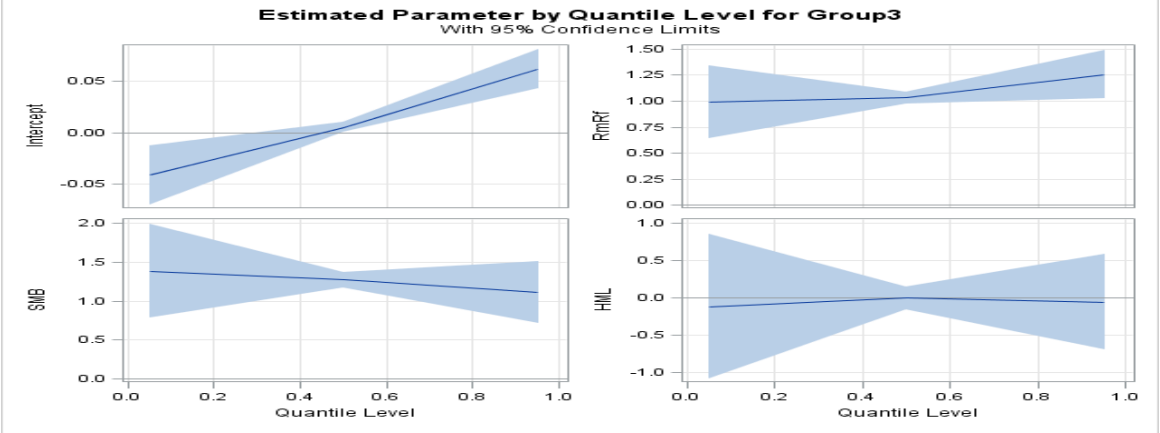
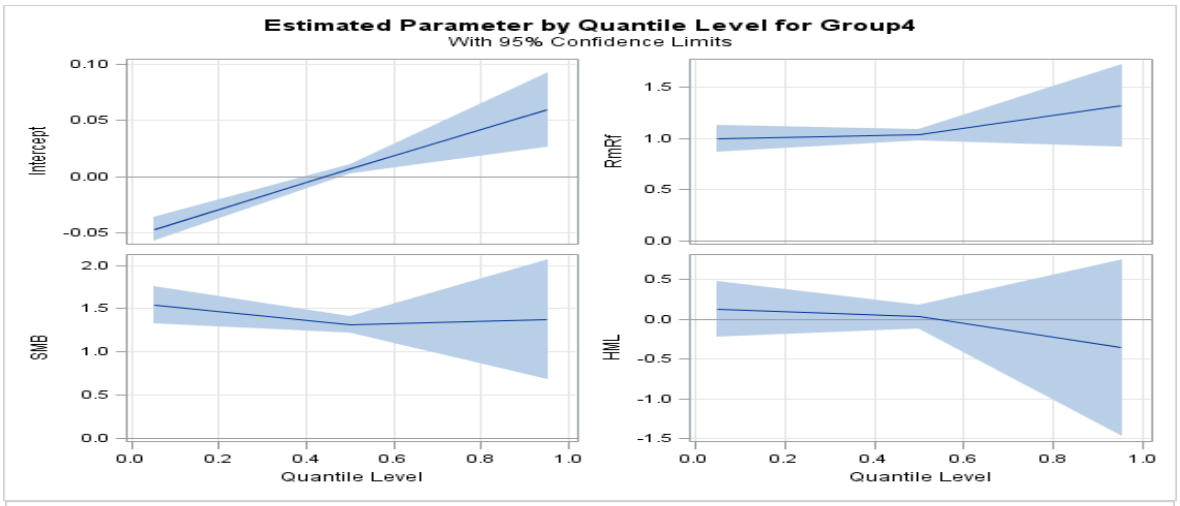
Appendix: Estimated Coefficient by Quantile Level of 25 Groups





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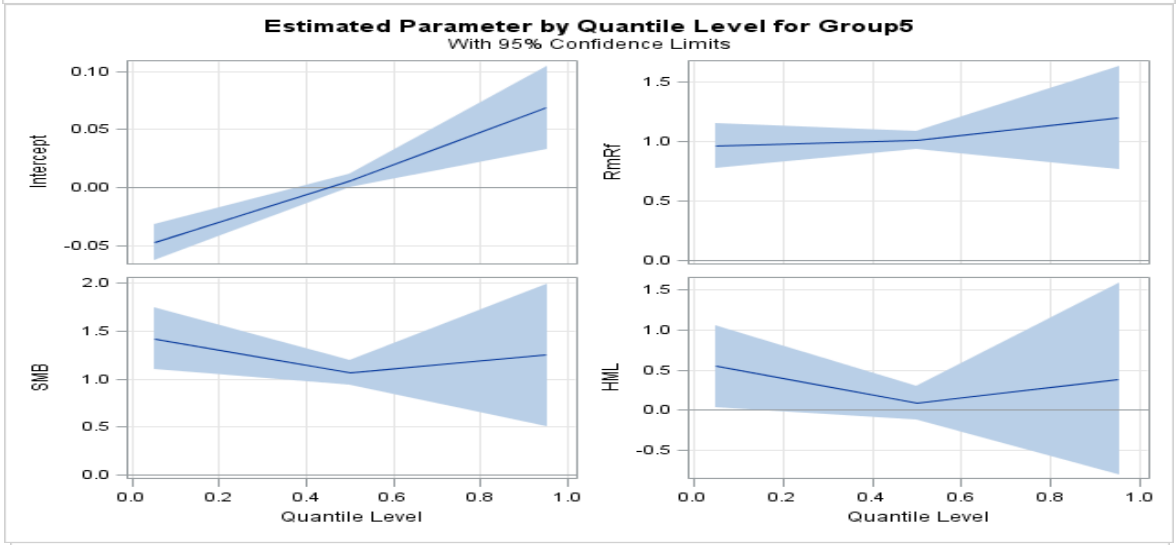
With 95% Confidence Limits
Intercept
RmRf
SMB
HML
Quantile Level
Quantile Level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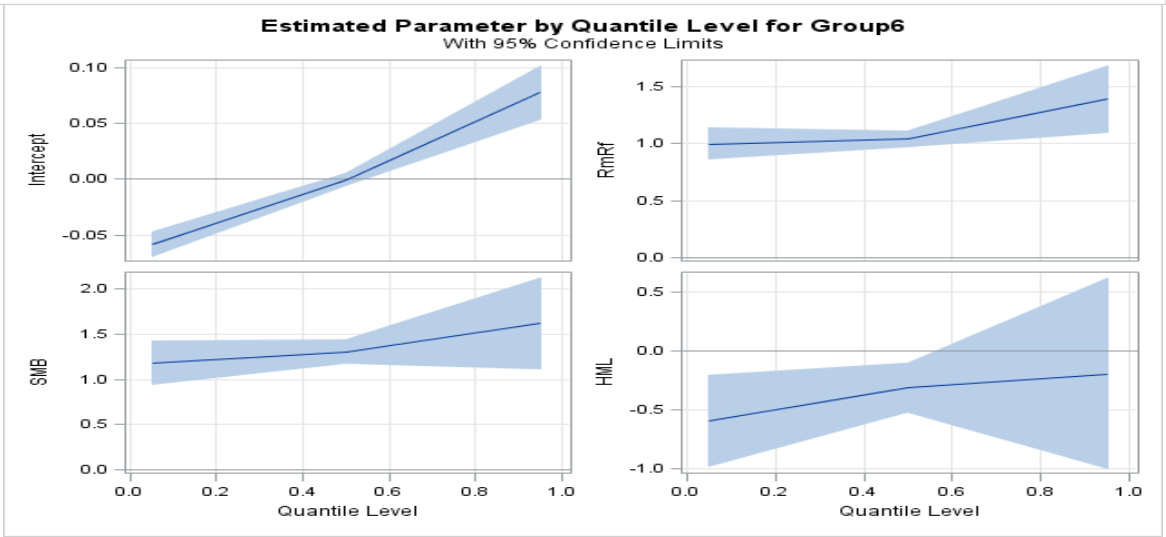
With 95% Confidence Limits
Intercept
RmRf
SMB
HML
Quantile Level
Quantile Level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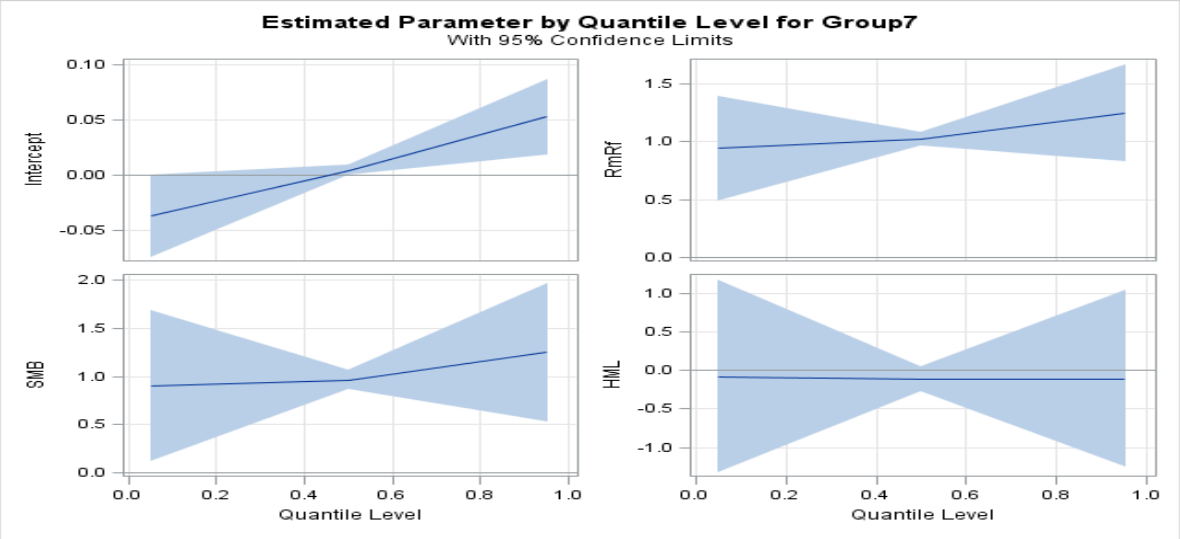
With 95% Confidence Limits
Intercept
RmRf
SMB
HML
Quantile Level
Quantile Level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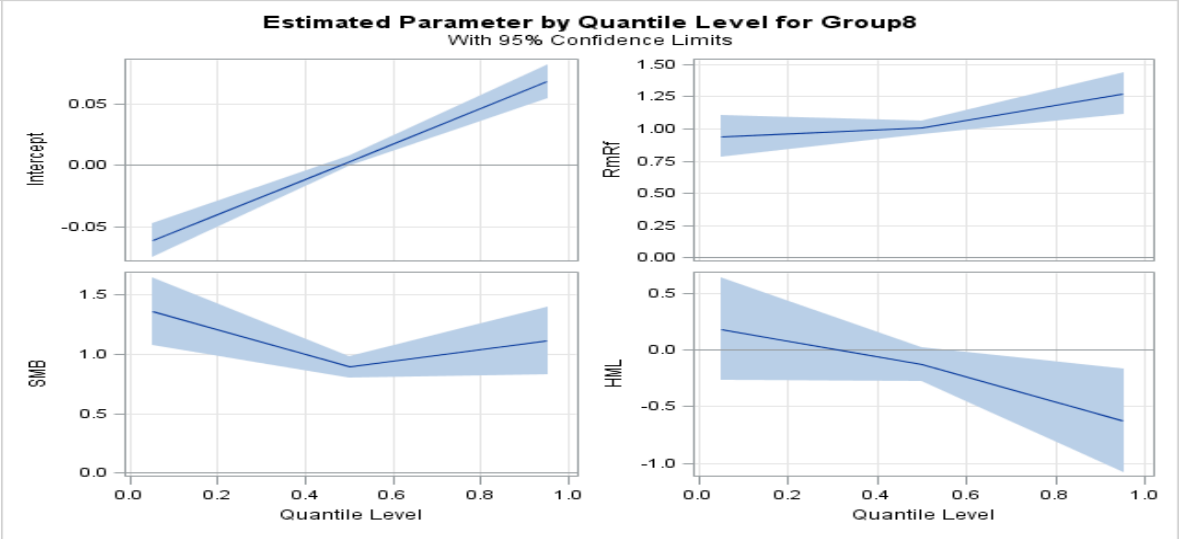
With 95% Confidence Limits
Intercept
RmRf
SMB
HML
Quantile Level
Quantile Level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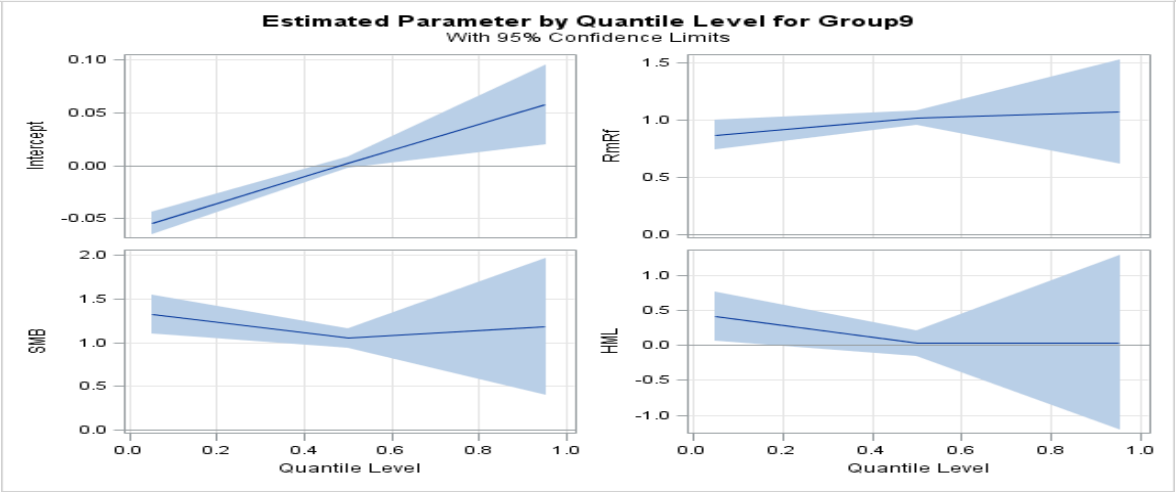
With 95% Confidence Limits
Intercept
RmRf
SMB
HML
Quantile Level
Quantile Level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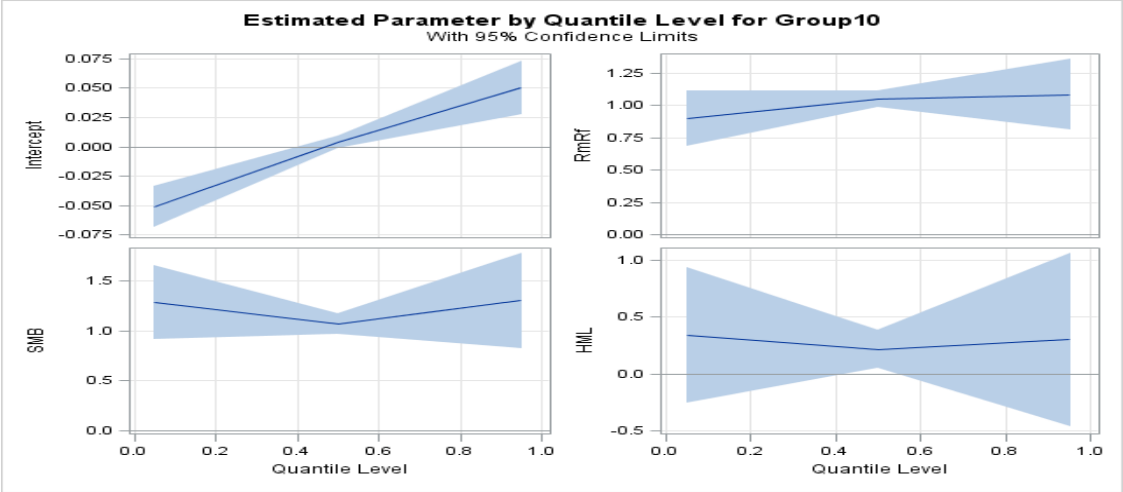
With 95% Confidence Limits
Intercept
RmRf
SMB
HML
Quantile Level
Quantile Level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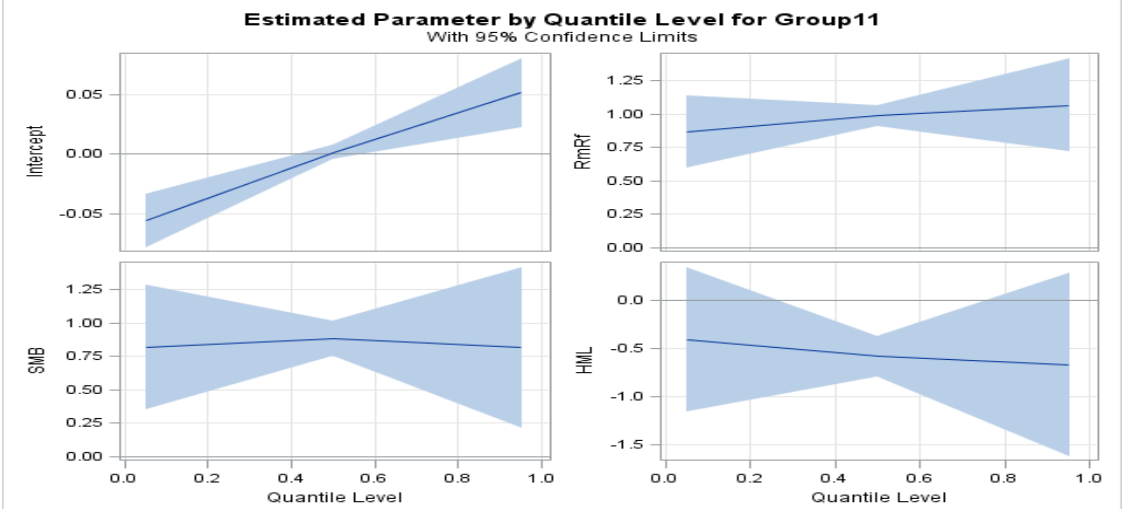
With 95% Confidence Limits
Intercept
RmRf
SMB
HML
Quantile Level
Quantile Level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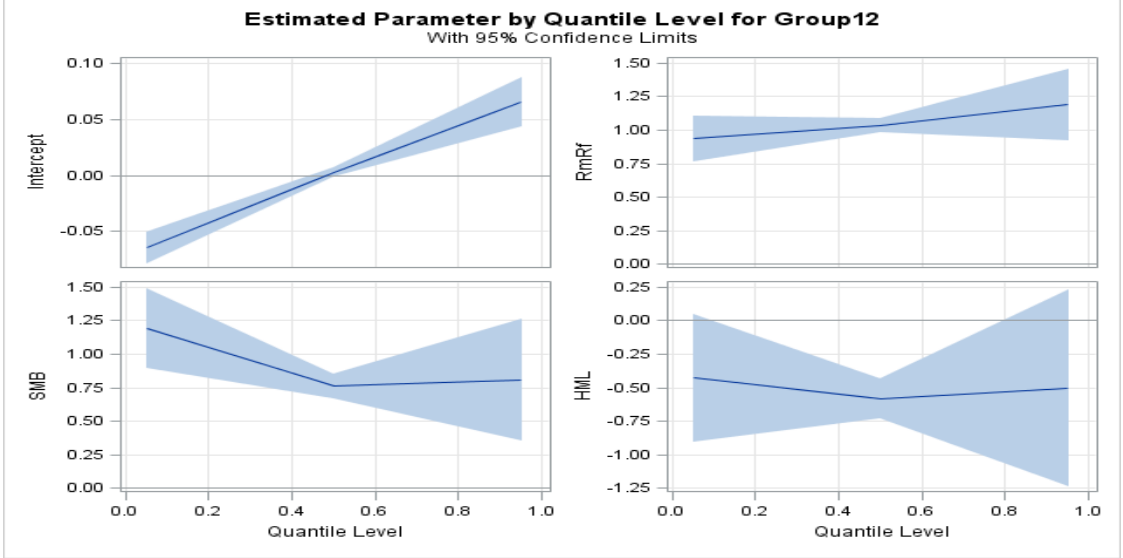
With 95% Confidence Limits
Intercept
RmRf
SMB
HML
Quantile Level
Quantile Level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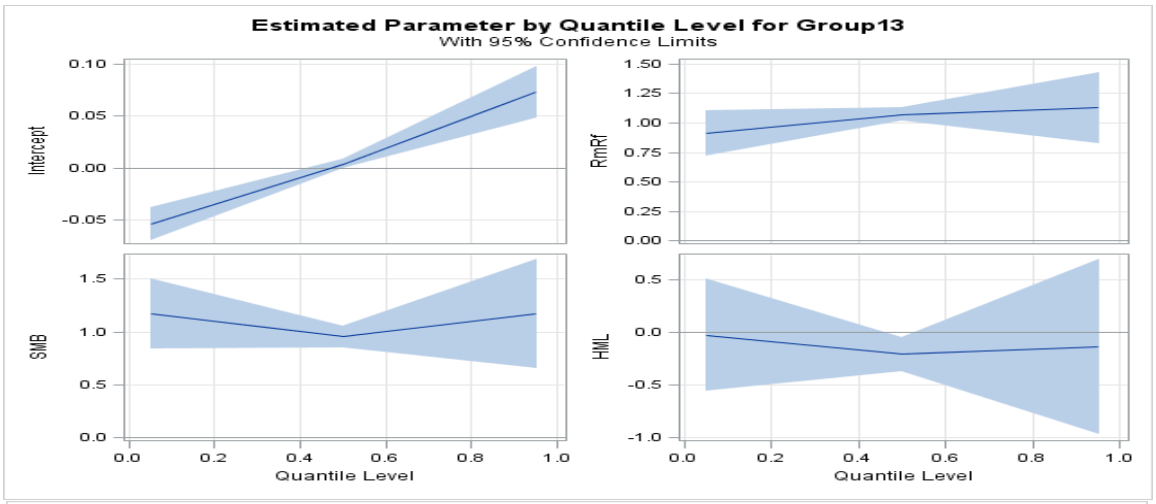
With 95% Confidence Limits
Intercept
RmRf
SMB
HML
Quantile Level
Quantile Level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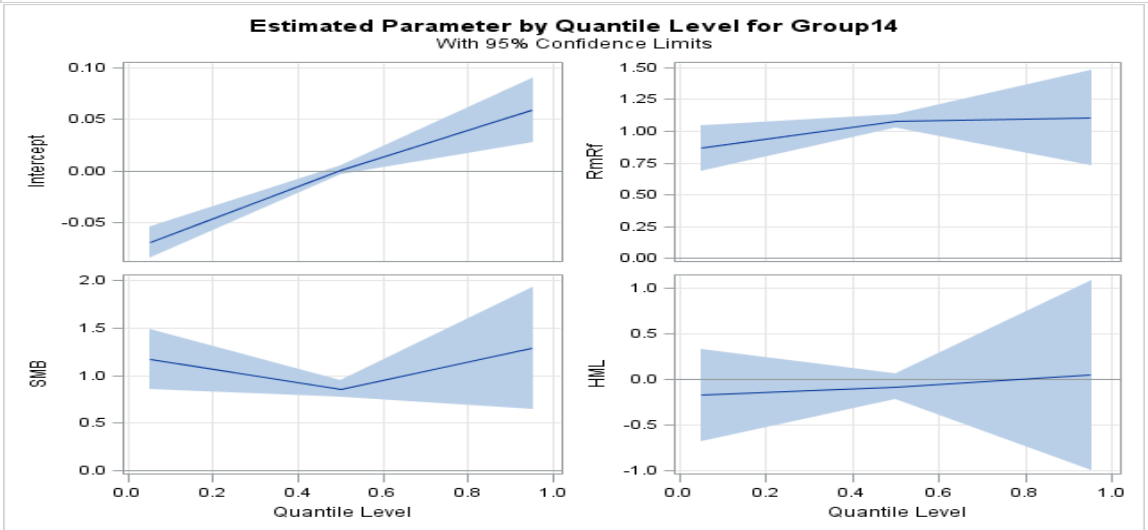
With 95% Confidence Limits
Intercept
RmRf
SMB
HML
Quantile Level
Quantile Level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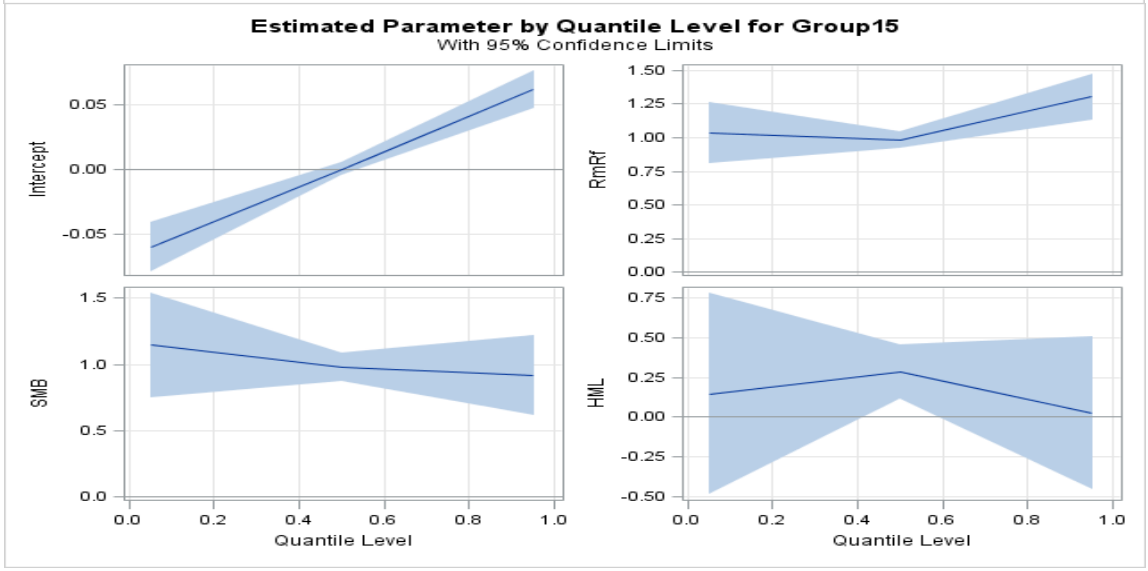
With 95% Confidence Limits
Intercept
RmRf
SMB
HML
Quantile Level
Quantile Level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With 95% Confidence Limits
Intercept
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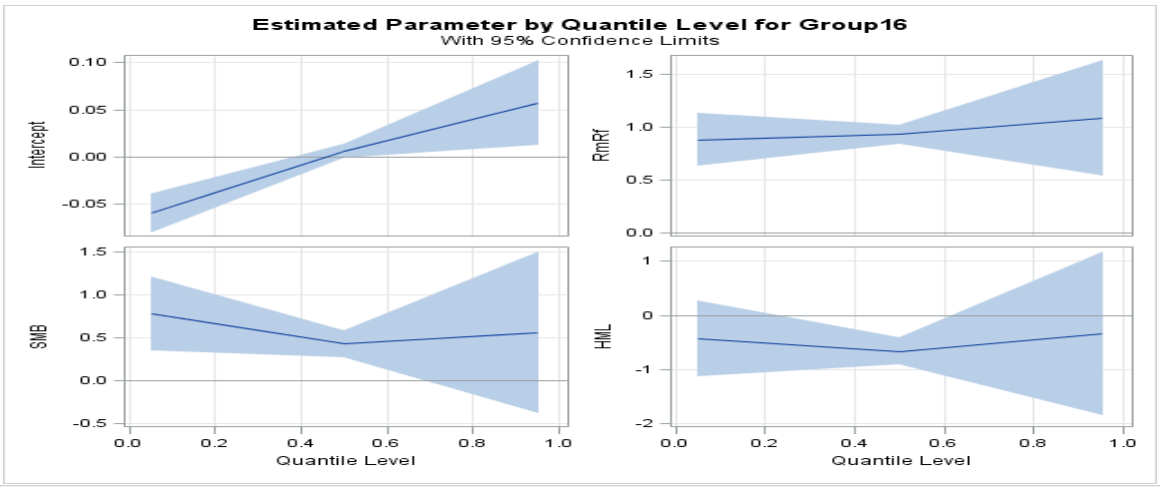
SMB
HML
Quantile Level
Quantile Level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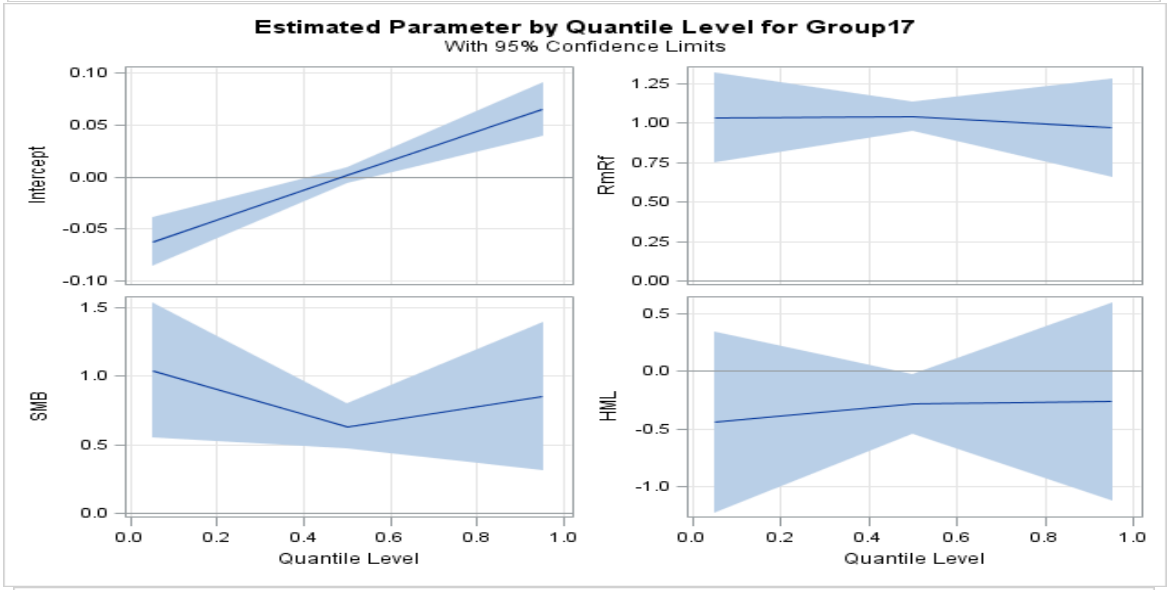
With 95% Confidence Limits
Intercept
RmRf
SMB
HML
Quantile Level
Quantile Level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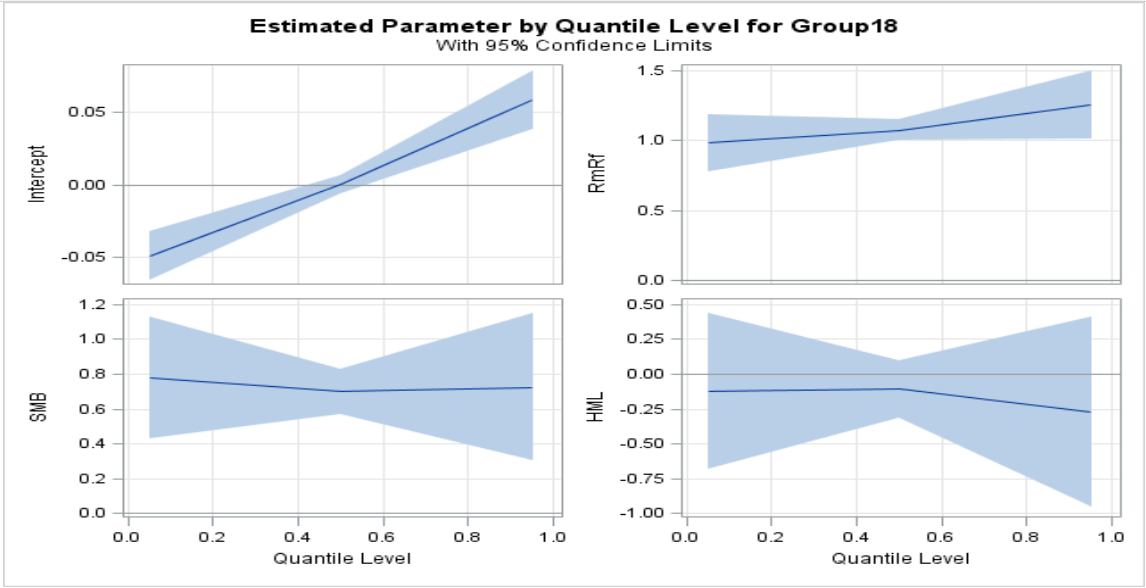
Intercept
RmRf
SMB
HML
Quantile Level
Quantile Level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Intercept
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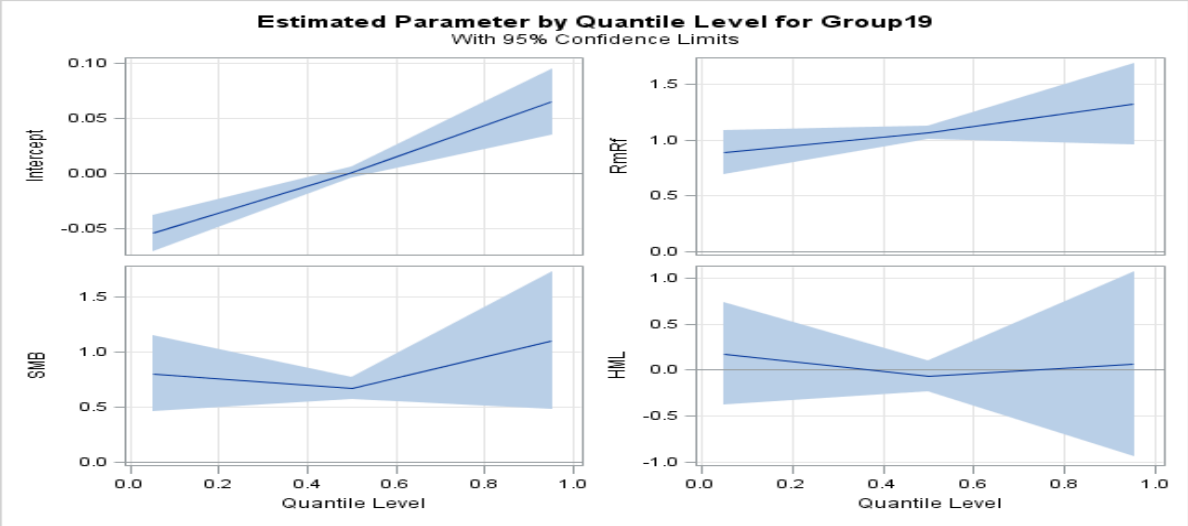
SMB
HML
Quantile Level
Quantile Level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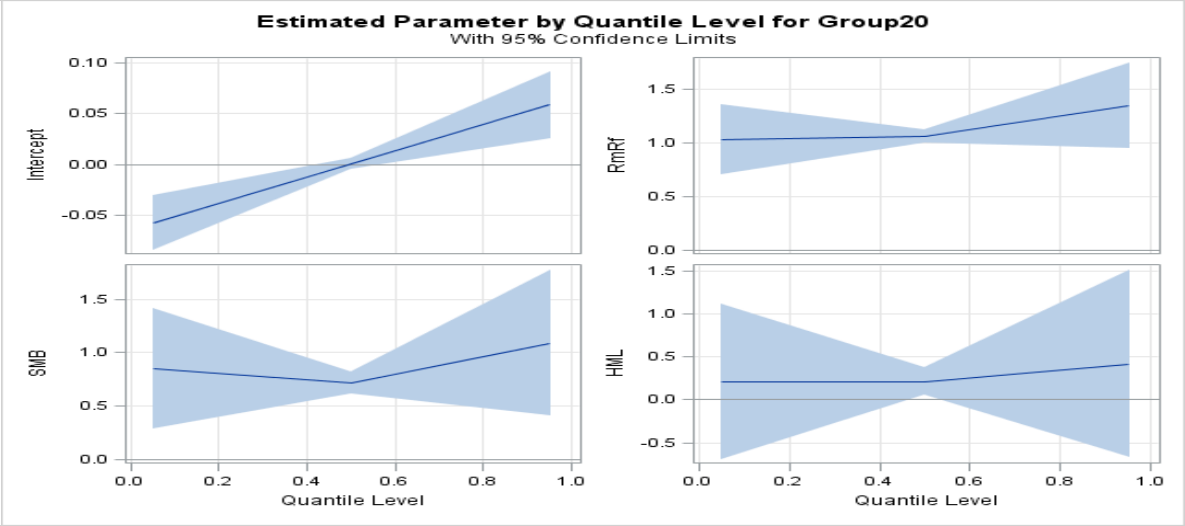
With 95% Confidence Limits
Intercept
RmRf
SMB
HML
Quantile Level
Quantile Level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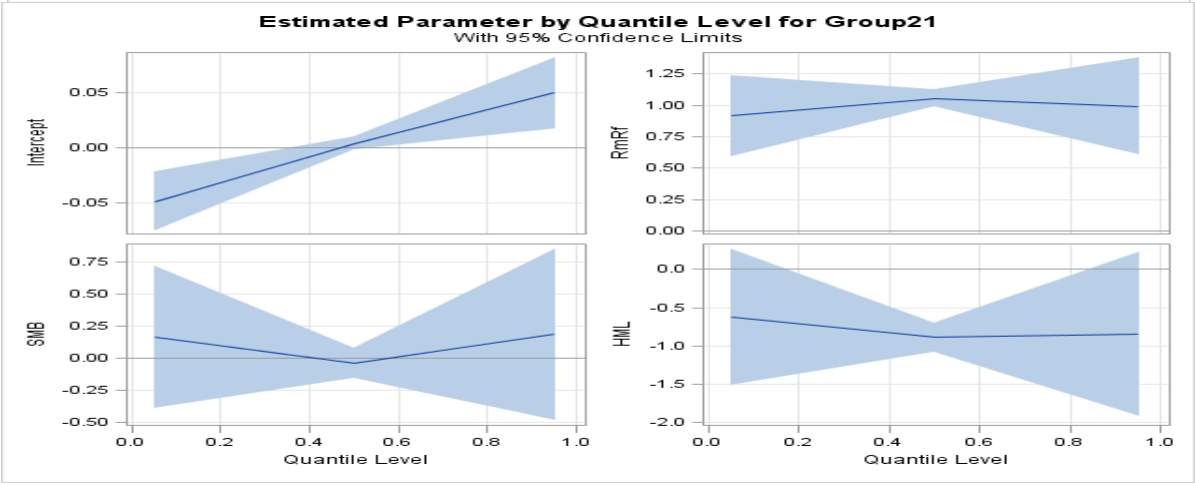
With 95% Confidence Limits
Intercept
RmRf
SMB
HML
Quantile Level
Quantile Level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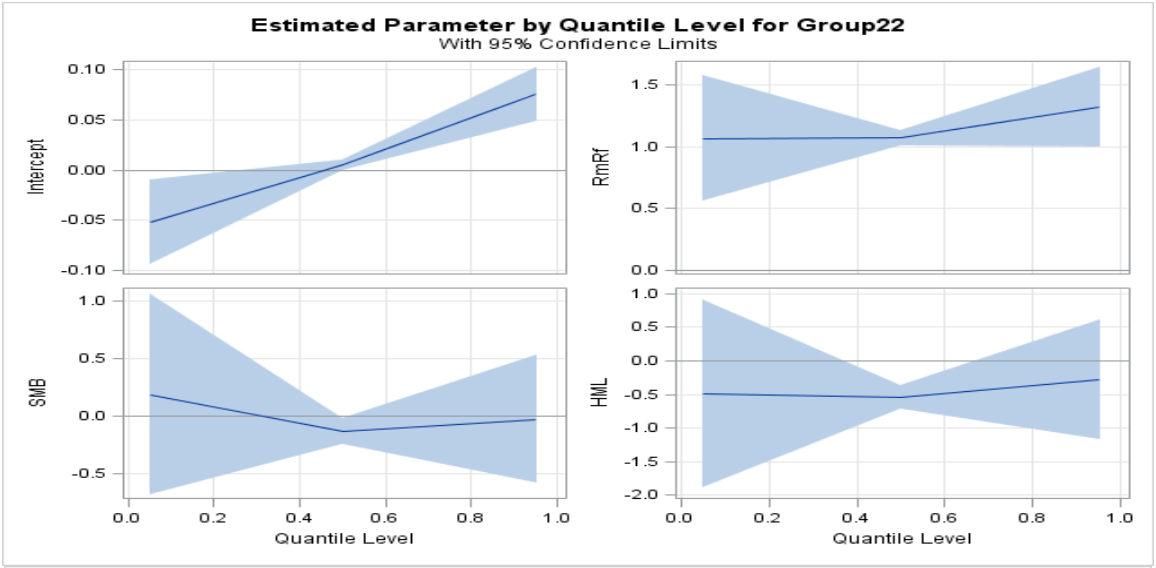
With 95% Confidence Limits
Intercept
RmRf
SMB
HML
Quantile Level
Quantile Level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With 95% Confidence Limits
Intercept
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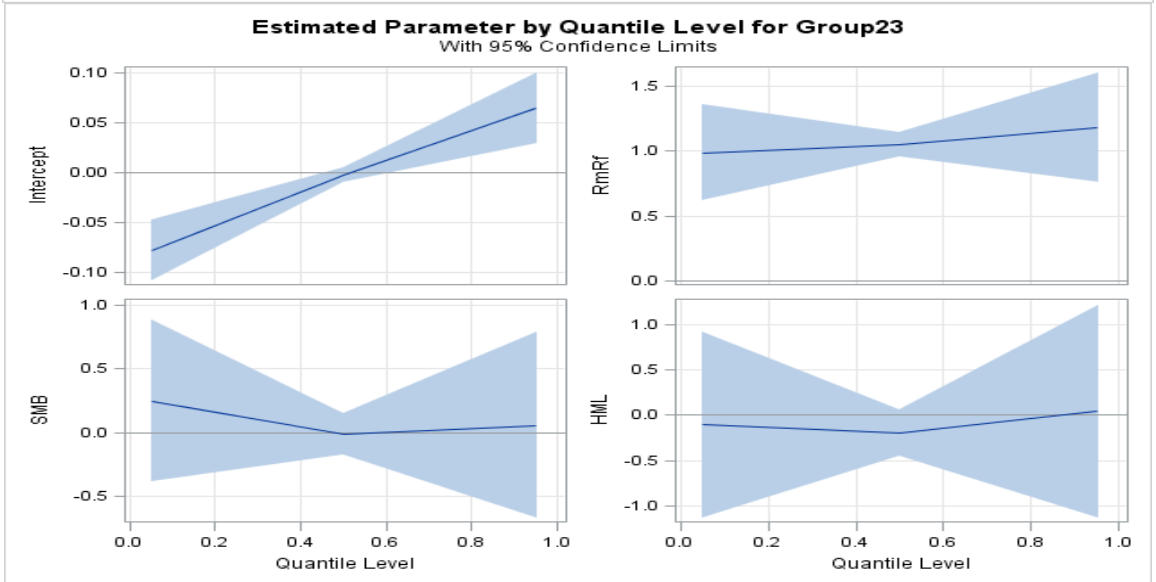
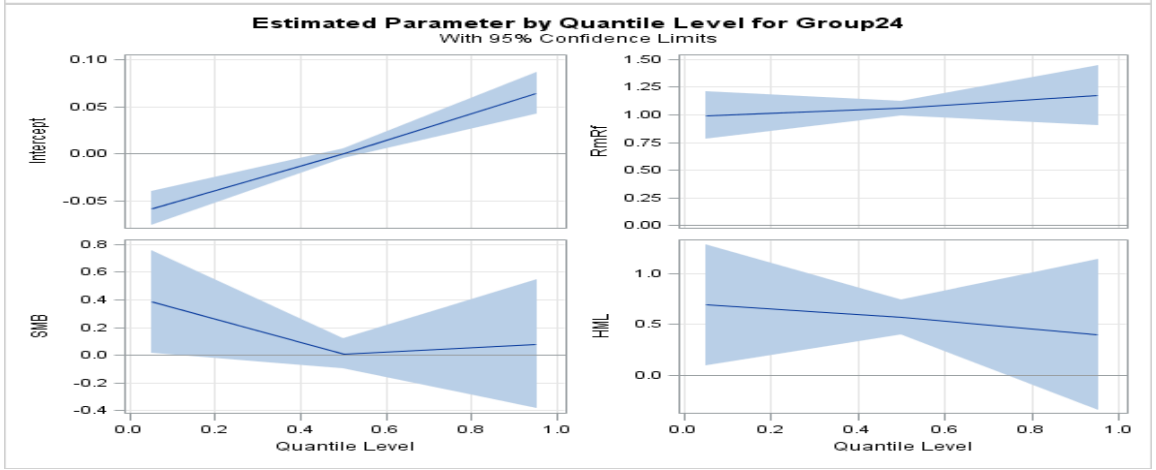
SMB
HML
Quantile Level
Quantile Level


Estimated Parameter by Quantile Level for Group23
With 95% Confidence Limits
Intercept
RmRf
SMB
HML
Quantile Level
Quantile Level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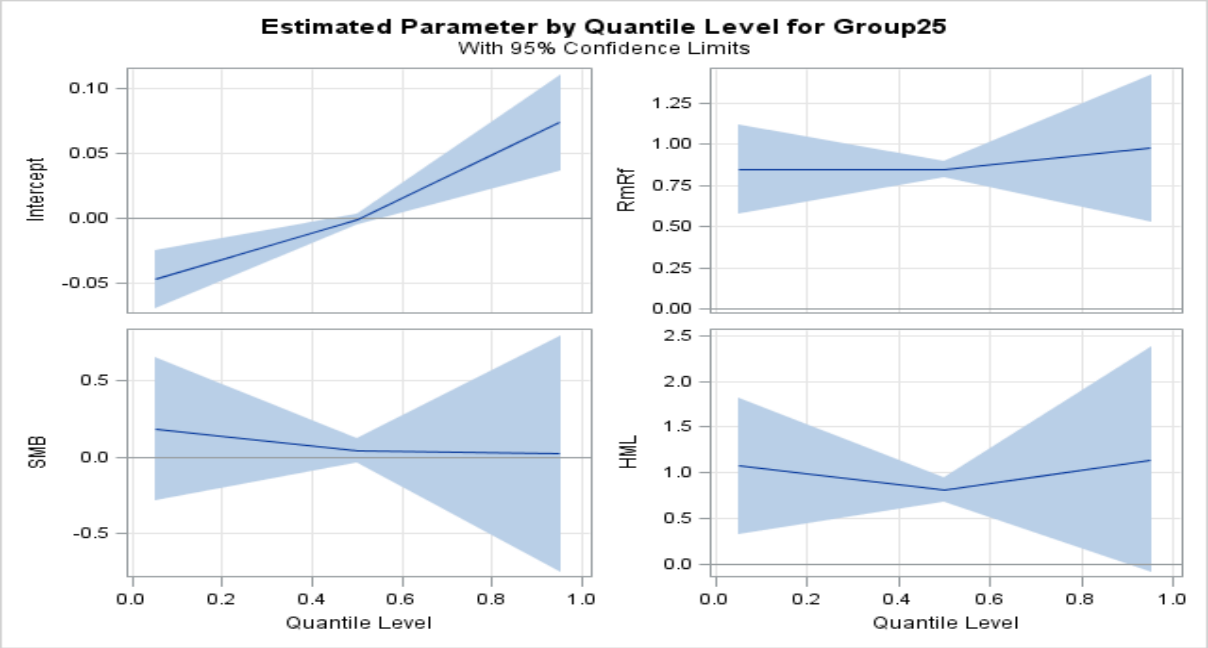
Intercept
RmRf
SMB
HML
Quantile Level
Quantile Level


Estimated Parameter by Quantile Level for Group25
With 95% Confidence Limits
Intercept
0.10
0.05
0.00
-0.05
RmRf
1.25
1.00
0.75
0.50
0.25
0.00
SMB
0.5
0.0
-0.5
HML
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.2
0.4
0.6
0.8
1.0
Quantile Level
Quantile Level