Fama-French Five-factor Model under Liquidity Adjustment——An Empirical Study Based on China's A-share Market

Zhanqian Shi

International Business School, Dongbei University of Finance and Economics Dalian, 116025, China
siboffice@dufe.edu.cn

Abstract

The liquidity of assets is one of the important factors affecting the return on assets. This paper takes the monthly trading data of China's A-share market from January 2005 to December 2020 as the sample space for the empirical research, and takes Amihud illiquidity index as the liquidity index to test the relationship between stock liquidity and stock return. The results of grouping analysis and regression analysis show that there is a significant liquidity premium in China's A-share market. At the same time, the capital asset pricing model with liquidity factor constructed by Amihud illiquidity index has better explanatory ability than the traditional Fama-French five- factor model.

***Keywords**-Liquidity Premium; Fama-French five-factor model; Amihud illiquidity index*

1. INTRODUCTION

Liquidity index measures the possibility of rapid cash out of a financial product within the appropriate fair value range. The speed of liquidity has an important impact on the expected return of stocks. The stock with good liquidity has low transaction cost, low liquidity risk and high attraction to investors. The stock with poor liquidity has high transaction cost, high liquidity risk and low attraction to investors. Therefore, illiquid stocks must be given higher risk compensation, so they have a higher rate of return. The liquidity premium theory initiated by Amihud and Mendelson also confirms that stocks with low liquidity have high yield. The return rate of highly liquid stocks is relatively low [1].

Harris (1990) measured the liquidity level of a stock from four aspects: immediacy, width, depth and elasticity, which has been widely recognized by the academic community [2]. The following researches construct measurement methods such as bid spread method, transaction volume method, price volume combination method and time method based on the four dimensions of liquidity. The Amihud illiquidity index used in this paper is constructed by using the price-volume combination method, comprehensively considering the width and depth of liquidity.

2. LITERATURE REVIEW

2.1. Liquidity Premium

Many scholars have found that the liquidity premium is very obvious in the global capital market, especially in developed countries (Amihud, 2015) [3]. Jun et al. (2003) found that in the capital markets of emerging countries, the yield of individual stocks increases with the increase of liquidity, mainly because of the low concentration of emerging capital markets [4].

Su and mai (2004) found that there is a very obvious liquidity premium in China's stock market [5]. Zhou and Zhang (2011) found that although liquidity premium in China's stock market is significant, the liquidity premium cannot be well explained by the modified Fama-French three-factor model [6]. After introducing liquidity factor, Li and Wei (2015) found that Fama-French three-factor model did not play a significant role in explaining the improvement of stock liquidity [7].

2.2. Fama-French Factor Model

Fama-French three-factor model and five-factor model have made some progress in ability to explain the reasons for the increase of stock return, but there is no way to fully explain it (Geng Jun, 2014; Li Zhibing et al., 2017) [8][9]. Domestic researches on market liquidity

premium mainly use CAPM model and Fama-French three-factor model, and there are few researches using five-factor model. This paper introduces the liquidity factor into Fama-French five-factor model to explore its interpretation of stock excess return.

3. CONSTRUCTION OF FACTORS AND OTHER VARIABLES

3.1. Research Hypothesis

Starting with asset liquidity, this paper introduces the liquidity factor into Fama-French five-factor model to explore whether the explanatory ability of the model has been improved, and also judges whether the liquidity premium exists in China's stock market. This paper puts forward the following basic hypothesis：

H1: Liquidity premium is very obvious in China's stock market, and there is a significant reverse relationship between Chinese stock liquidity and expected return, and the liquidity premium of companies with large market value is more significant than that of companies with small market value.

H2: Adding liquidity factors can improve the accuracy of Fama-French five-factor model in analyzing the causes of stock excess return. The model with liquidity factor instead of RMW factor and CMA factor is better than the traditional five-factor model.

3.2. Data Sources

The data of this paper comes from the monthly and annual transaction data and financial data of listed companies from January 2005 to December 2020, including individual stock return, circulating market value, book to market ratio, return on net assets and growth rate of total assets, excluding financial stocks, stocks with negative book to market ratios, ST stocks, * ST stocks PT shares, as well as shares in the six months before IPO and 30% of the company's shares with the lowest market value. The risk-free interest rate adopts the one-year time deposit interest rate. The data is taken from CSMAR database.

Amihud illiquidity index is used to measure liquidity, and its calculation formula is as follows:

$$\text{illiqit} = \sum_{i=1}^{T} \frac{|R_{i,t}|}{|V_{i,t}|}/T \tag{1}$$

In which R represents the yield of asset i on day t, $V_{i,t}$ represents the turnover and T represents the trading days. The larger the indicator, the smaller the liquidity.

3.3. Factor Construction

Considering the lag of financial data annual report disclosure, this paper selects July of the t year to June of the t+1 year as the portfolio construction cycle. And the circulation market value at the end of June in t year is selected as the scale grouping index. The book value at the end of t-1 year is divided by the circulating market value of stocks at the end of t-1 year as the grouping index of book to market ratio, and the operating profit at the end of t-1 year divided by the total of shareholders' equity is the grouping index of profitability. The increase of total assets at the end of t-1 year compared with that in t-2 year divided by the total assets at the end of t-2 is used as the grouping index of investment mode.

This paper is based on individual stock(size), book to market ratio (B/M), profitability (OP), investment model (Inv) and liquidity (liq) in A-share market, separately constructs Size-B/M, Size-O/P, Size-Inv and Size-liq portfolios. According to the circulating market value at the end of June in year T, the stocks are divided into groups and large groups, and each group is based on B/M, OP, Inv and liq. According to the ratio of 30%, 40% and 30%, it is further divided into three groups: high, middle and low. A total of 24 asset portfolios are constructed, and the weighted average rate of return of each portfolio is calculated. The table is constructed based on the following factors: $SMB_{B/M}$, SMB_{op}, SMB_{Inv}, SMB_{liq}, HML, RMW, CMA and IMF. SMB of this group is the arithmetic mean of $SMB_{B/M}$, SMB_{op}, SMB_{Inv} and SMB_{liq}.

TABLE 1.   CALCULATION FORMULAS FOR FACTORS

Grouping	Calculation formulas for factors
2*3 groups Size-B/M Size-OP Size-Inv Size-liq	$SMB_{b/m}$= (SH+SN+SL)/3-(BH+BN+BL)/3 SMB_{op}= (SR+SN2+SW)/3-(BR+BN2+BW)/3 SMB_{inv}= (SC+SN3+SA)/3-(BC+BN3+BA)/3 SMB_{liq}= (SI+SN4+SF)/3-(BI+BN4+BF)/3 SMB=($SMB_{b/m}$+SMB_{op}+SMB_{inv}+SMB_{liq})/4 HML=(SH+BH)/2- (SL+BL)/2 RMW=(SR+BR)/2- (SW+BW)/2 CMA=(SC+BC)/2- (SA+BA)/2 IMF=(SI+BI)/2- (SF+BF)/2

3.4. Construction of Other Variables

Size refers to the circulating market value of individual shares in the month, and beme refers to monthly book to market ratio.

4. LIQUIDITY PREMIUM TEST

4.1. Grouping Analysis

This paper selects size-BM-liq, size-OP-liq, and size-Inv-liq as three different grouping methods to construct 50 asset portfolios respectively. First, according to the circulation market value at the end of June each year, it is divided into two groups, and then divided into five groups according to the book market value ratio, roe and

total asset growth rate at the end of December last year respectively. Finally, it is divided into five groups according to the liq index at the end of December last year, a total of 50 groups by each grouping method. Count the weighted average rate of return of the monthly circulating market value of each asset portfolio, and then calculate the average monthly value of the rate of return in the sample period,which is from January 2005 to December 2020.

According to the statistical results of three grouping methods, there is a liquidity premium for companies with small market value while the liquidity premium for companies with large market value is not obvious.

TABLE 2.   MONTHLY AVERAGE RETURNS (%) OF 25 ASSETS PORTFOLIOS CONSTRUCTED BY THE SIZE-BM-LIQ GROUPING METHOD

Size	Small				
	High liq	4	3	2	**Low liq**
Low B/M	-0.05	1.41	1.47	1.24	1.38
2	0.63	1.36	1.51	1.39	1.43
3	0.51	1.43	1.91	1.70	1.64
4	0.64	1.77	2.03	1.55	1.73
High B/M	0.92	1.23	1.49	1.56	1.72
Size	Big				
	High liq	4	3	2	Low liq
Low B/M	1.35	1.26	1.17	1.17	0.73
2	1.13	1.36	0.94	1.13	1.66
3	0.98	1.38	1.26	1.01	1.38
4	1.02	1.33	1.38	1.29	0.96
High B/M	0.84	1.02	1.04	1.64	0.23

TABLE 3.   MONTHLY AVERAGE RETURNS (%) OF 25 ASSETS PORTFOLIOS CONSTRUCTED BY THE SIZE-OP-LIQ GROUPING METHOD

Size	Small				
	High liq	4	3	2	Low liq
Low OP	0.18	1.18	1.58	1.41	1.29
2	1.24	1.53	1.74	1.56	1.50
3	1.53	1.50	1.64	1.69	1.68
4	0.40	1.68	1.94	1.49	1.83
High	0.30	1.56	1.42	1.32	1.84
OP					
size	big				
	High liq	4	3	2	Low liq
Low OP	0.90	1.08	0.67	1.02	1.12
2	0.83	0.95	1.38	0.70	0.18
3	0.68	1.30	0.86	1.26	1.19
4	0.92	1.13	1.41	1.32	1.50
High OP	1.45	1.58	1.16	1.32	1.44

TABLE 4.   MONTHLY AVERAGE RETURNS (%) OF 25 ASSETS PORTFOLIOS CONSTRUCTED BY THE SIZE-INV-LIQ GROUPING METHOD

Size	Small				
	High liq	4	3	2	**Low liq**
Low Inv	0.43	1.48	1.76	1.69	1.44
2	0.69	1.53	1.68	1.62	1.71
3	1.28	1.20	1.63	1.47	1.48
4	1.12	1.61	1.85	1.57	1.53
High Inv	0.70	1.40	1.60	1.32	1.64
size	big				
	High liq	4	3	2	Low liq
Low Inv	0.90	1.33	0.94	1.29	0.94
2	0.74	1.33	1.26	0.75	1.29
3	1.07	1.17	1.27	1.61	1.85
4	1.22	1.45	1.40	1.43	0.56
High Inv	1.27	1.13	0.70	1.15	1.05

4.2. Fama-Macbeth Regression

Model 1: $r_{i,t+1} = a + b_1 liq_{i,t} + e_t$ (2)

Model 2: $r_{i,t+1} = a + b_1 beta_{i,t} + b_2 liq_{i,t} + b_3 lnsize_{i,t} + b_4 lnbeme_{i,t} + e_t$ (3)

Model 3: $r_{i,t+1} = a + b_1 beta_{i,t} + b_2 liq_{i,t} + b_3 lnsize_{i,t} + b_4 lnbeme_{i,t} + b_5 roe_{i,t} + b_6 grta_{i,t} + e_t$ (4)

In which $lnsize_{i,t}$ and $lnbeme_{i,t}$ are the natural logarithms of the current market value and the book value ratio in the current month respectively, $roe_{i,t}$ and $grta_{i,t}$ are return on net assets and growth rate of total assets that are updated annually, taking the ending value of the previous period, $liq_{i,t}$ is the non-liquidity index of individual stock Amihud in the current month, $r_{i,t+1}$ is the return rate of individual stocks in the next month.

TABLE 5.   FAMA-MACBETH REGRESSION RESULTS OF LIQ ON YIELD

	Intercept	beta	liq	lnsize	lnbeme	roe	grta
Model 1	0.003 (0.05)	-	0.143** (2.20)	-	-	-	-
Model 2	0.002 (0.03)	0.034 (1.37)	0.075** (2.36)	-0.023 (-1.60)	-0.003 (-0.29)	-	-

Model 3	0.001	0.035	0.090***	-0.024	-0.002	0.011*	-0.138***
	(0.01)	(1.40)	(2.77)	(-1.63)	(-0.20)	(1.92)	(-2.95)

Notes：***, **, * respectively represent significant at the confidence level of 1%, 5% and 10%. The value in brackets is the T value, the same below.

Fama-Macbeth regression results show that the liquid regression coefficients of three models are all positive. The liquid regression coefficients of model 1 and model 2 are significantly more than 5%, and the liquid regression coefficients of model 3 are significantly more than 1%. Therefore, the stock return ratio has a significant reverse relationship with liquidity, so the liquidity premium exists.

4.3. Cross-grouping Portfolio Regression

The grouping method of this part is the same as that of the grouping analysis above. Each group runs the following models respectively.

$$r_{i,t} - r_{ft} = a_i + b_i(r_{mt} - r_{ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + k_i IMF_t + e_{it} \qquad (5)$$

The regression results show that compared with the portfolios with strong liquidity, the liquidity factor parameters of the portfolios with weak liquidity are basically significantly positive, which indicates that liquidity premium is very obvious in China. The liquidity factor parameters of the stocks of companies with large market value are generally higher than those of companies with small market value, indicating that companies with large market value obtain more liquidity compensation. Domestic retail investors tend to invest in companies with small market value with weak liquidity, but they are highly sensitive to stock price fluctuations, which makes the liquidity premium of companies with small market value less obvious than that of companies with large market value.

5. EMPIRICAL ANALYSIS OF FAMA-FRENCH FIVE-FACTOR MODEL WITH LIQUIDITY FACTOR

5.1. GRS Test

This paper makes multiple regression analysis according to the grouping results of size-BM-liq, size-OP-liq and size-Inv-liq, and calculates the GRS indicators of different measurement models of each group's asset portfolio. Considering the strong correlation between RMW factor and other factors, this paper orthogonalizes RMW factor as RMWO.

TABLE 6.   THE RESULT OF GRS TEST

2*5*5 Size-BM-Liq portfolios		
Model	GRS	A|αᵢ|
HML RMWO CMA	3.151	0.260
HML RMWO	3.448	0.266
IMF		
HML CMA IMF	3.188	0.249
HML RMWO CMA IMF	3.116	0.251
2*5*5 Size-OP-Liq portfolios		
Model	GRS	A|αᵢ|
HML RMWO CMA	3.901	0.248
HML RMWO IMF	3.532	0.237
HML CMA IMF	4.557	0.320
HML RMWO CMA IMF	3.801	0.237
2*5*5 Size-Inv-Liq portfolios		
Model	GRS	A|αᵢ|
HML RMWO CMA	2.124	0.248
HML RMWO IMF	2.278	0.250
HML CMA IMF	2.098	0.246
HML RMWO CMA IMF	2.151	0.245

In the above GRS analyses and test models, the market factor MKT and scale factor SMB always participate in the regression. The results show that after introducing the liquidity factor into the Fama-French five-factor model, the GRS test value and the absolute average value of intercept term of Size-BM-Liq constitution and Size-OP-Liq constitution are reduced to a certain extent compared with the result of the traditional five-factor model. Although in the Size-Inv-Liq constitution that the GRS test value of the six-factor model is higher than that of Fama-French five-factor model, the absolute value of the intercept term of the six-factor model is lower. This shows that the introduction of IMF factor can improve the interpretation ability of the model to a certain extent. In addition, in the Size-OP-Liq constitution, the GRS test value of model that replaces CMA factor with IMF factor is the lowest. In the Size-Inv-Liq constitution, when IMF factor is used to replace RMWO factor, the GRS test value is the lowest. Results above indicate that IMF factor has stronger explanatory power on the excess return of A-share stocks than RMW factor and CMA factor.

5.2. Factor Regression between Different Groups

Take each of the six factors as the dependent variable and the other five factors as the independent variable for multiple regression. The analysis results are as follows.

TABLE 7. THE RESULT OF FACTOR REGRESSION BETWEEN DIFFERENT GROUPS

	MKT	SMB	HML	RMW	CMA	IMF
MKT	-	-0.020	-0.002	-0.094***	-0.043***	-0.023
		(-0.914)	(-0.061)	(-4.574)	(-3.046)	(-1.098)
SMB	-0.245	-	-0.343***	-0.527***	-0.114**	0.253***
	(-0.913)		(-4.635)	(-8.486)	(-2.087)	(3.768)
HML	-0.016	-0.286***	-	-0.105	0.312***	-0.445***
	(-0.061)	(-4.974)		(-1.512)	(7.198)	(-7.385)
RMW	-1.681***	-0.773***	-0.186	-	-0.390***	0.022
	(-5.289)	(-11.507)	(-1.519)		(-7.200)	(0.249)
CMA	-1.258***	-0.270**	0.891***	-0.631***	-	0.575***
	(-2.846)	(-2.246)	(8.848)	(-6.785)		(5.429)
IMF	-0.324***	0.291***	-0.616***	0.018	0.279***	-
	(-1.135)	(4.130)	(-8.236)	(0.251)	(5.564)	
Int	1.615***	0.584***	0.420**	0.524***	0.036	0.151
	(2.693)	(3.762)	(2.338)	(3.856)	(0.337)	(0.943)
Adj-R^2	0.193	0.668	0.637	0.703	0.611	0.550

By analyzing the above table, it can be found that the proportion of factors except MKT that can be explained is very high.

5.3. *Panel Regression*

This paper carries out panel regression according to the following model.

$$r_{i,t} - r_{ft} = a_i + b_i(r_{mt} - r_{ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + k_i IMF_t + e_{it} \tag{6}$$

The results are as follows.

TABLE 8. THE RESULT OF PANEL REGRESSION

Variable	Model 1	Model 2	Model 3	Model 4
SMB$_t$	0.804***	0.719***	0.767***	0.728***
	(61.78)	(43.33)	(47.39)	(43.28)
HML$_t$	-0.106***	-0.094***	-0.190***	-0.122***
	(-6.97)	(-7.25)	(-14.44)	(-7.91)
RMW$_t$	-	-0.181***	-0.144***	-0.147***
		(-10.18)	(-7.07)	(-7.21)
CMA$_t$	0.179***	-	0.174***	0.087***
	(7.92)		(7.28)	(3.34)
IMF$_t$	0.153***	0.179***	-	0.155***
	(8.44)	(10.73)		(8.56)
a$_i$	0.014	0.095	0.114**	0.091*
	(0.30)	(0.04)	(2.35)	(1.89)
Adj-R^2	0.7167	0.7171	0.7165	0.7172

Compared with RMW factor and CMA factor, IMF factor has stronger explanatory ability for stock excess return. At the same time, the introduction of IMF factor can improve the explanatory ability of Fama-French five-factor model.

6. CONCLUSION

The results show that the liquidity premium is very obvious in China's stock market. The lower the liquidity, the higher the stock price return. The higher the market value of a company, the more obvious the stock liquidity is. After adding liquidity factor, the explanatory ability of five-factor model to stock excess return is enhanced, and the explanatory ability of the model after replacing RMW factor and CMA factor with liquidity factor is better than the traditional five-factor model.

Based on this, this paper believes that the regulatory authorities should pay close attention to the stock liquidity of the company. By constructing a set of standardized and sound laws and regulations, those authorities can improve the punishment of insider trading and market manipulation in the financial market and formulate different policies for companies with different market capitalization. Investors should focus on the liquidity of stocks. If they want to obtain higher yield by taking liquidity risk, they should buy stocks of companies with large market value but low liquidity.

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