Explanatory power of three-factor model on A-share market of Shanghai Exchange in China

Zijing Meng[1,a] and Ronghua Ju[2,b,*]

[1,2]College of Economics and Management, China Agricultural University, Beijing, China
[a] meng.zijing@qq.com, [b] juronghua@aliyun.com
* Corresponding author

Abstract

In foreign countries, Fama-French three factor model of size effect and BM (book-to-market) effect shows good explanatory power. As an emerging market, using three-factor model to explain Chinese stock market anomalies is worthy of study. This paper built portfolios of Shanghai A-shares and found size effect and BM effect, that is, rate of return of small-cap portfolio is higher than large-cap portfolio, and high BM ratio portfolio is higher than low BM ratio portfolio. Econometric analysis found that three-factor model can explain A-share market of Shanghai Exchange well.

Keywords: Three-factor model; Size effect; Book-to-market effect

1. Introduction

Foreign studies have found size effect and BM (book-to-market) effect which can't be explained by the traditional capital asset pricing model.[1]Size effect is defined that small-cap portfolio has higher return than large-cap portfolio.[2] BM effect is defined that high BM ratio portfolio has higher return than low BM ratio portfolio. Fama and others added size factor and BM ratio factor based on the capital asset pricing model, and found the two factors have high significance.[3]

Three-factor model's explanatory power of anomalies in the emerging Chinese stock market is worthy of study. Recent studies have found that there also are size effect and BM effect in Chinese stock market.[4] For example, Wu (2011) studied all trading stocks in July, 1999 to June, 2010, found that size effect, BM effect, PE(price-earnings) effect exist significantly.[5] But earlier studies denied existence of anomalies, for example, Yi et al(2001), using Shenzhen stock market's monthly data in July, 1996 to June, 1999 for research, concluded that three-factor model was not applicable in Chinese stock market and proposed a two-factor model excluding BM ratio factor.[6] Literatures made different conclusions, so further study is necessary. This paper uses the latest stock market data to test whether three-factor model can explain Chinese stock market.

2. Variable definitions and descriptive analysis introduction

2.1. Model and variable definitions

According to the theory of capital asset pricing model, the rate of return of each stock should equal the risk-free rate plus the stock market risk β. This theory has occupied a central position in economic theories for more than 40 years, but large number of later empirical studies have

shown that there are many stock market anomalies, such as investment in small-cap or high BM ratio portfolio can obtain higher return, while market risk β almost has no explanatory power on size effect and BM effect.[7]

Then scholars put forward other theories to explain these anomalies. Fama and French's empirical study of non-financial stocks in three major U.S. stock exchanges in 1963 to 1990 found that size and BM ratio have more explanatory power than market risk β. The three-factor model is proposed by them in 1993, which believes that the return of a portfolio minus risk-free rate can be explained by the following three factors: R_m-R_f (market factor), *SMB* (size factor) and *HML* (BM ratio factor). Fama-French three factor model is as follows:

$$R_i - R_f = \alpha_i + \beta_i\left(R_m - R_f\right) + s_i SMB + h_i HML + \varepsilon_i$$

Thereinto: R_i : portfolio monthly returns; R_f : using central bank bill yield to measure the risk-free rate; R_m : market monthly returns. The dependent variable R_i-R_f is the excess return of the portfolio, that is the rate of return of the portfolio minus the risk-free rate; explanatory variable R_m-R_f is the rate of return of market portfolio minus the risk-free rate; explanatory variable *SMB* is the rate of return of small-cap portfolio minus the rate of return of large-cap portfolio; explanatory variable *HML* is the rate of return of high BM ratio portfolio minus the rate of return of low BM ratio portfolio. This paper uses the reciprocal of PB (price-to-book) ratio indicates BM ratio. β_i : the risk coefficients of market factor ; s_i : the risk coefficients of size factor; h_i : the risk coefficients of BM ratio factor. α_i is the intercept, which means the part that can't be explained by three factors. For the intercept α_i , if α_i is equal to 0, three-factor model has completely sufficient explanatory power.

2.2. Sample data

These data come from RESSET database (www.resset.cn) and CSMAR.

We select the sample of Shanghai A-shares once a year by the end of June when listed companies published financial statements. To avoid the impact on the portfolio of large-cap and high BM ratio stocks, we exclude financial stocks. In order to prevent excessive weight stocks affecting the results, we also exclude Petrochina and other mega-caps. Some of the ST stock's BM ratios are negative, which results in grouping ranking difficulty and ST stocks often have return volatility, thus ST stocks are also excluded. Finally, negative PB ratio stocks and stocks which miss data during the study period are excluded.

Study period ranges from July, 2005 to June, 2012. Selecting only Shanghai A-shares as sample can weaken the large difference between small-cap and large-cap. Variables are calculated by market value weighted average method. The sample period is after the split share structure reform which can reduce the size difference between non-tradable shares and tradable shares. Table 1 lists the number of stocks during the seven years in the sample.

Table 1: Number of Stocks Each Year

Time range	2005	2006	2007	2008	2009	2010	2011
Number of stocks	777	778	785	798	801	801	826

As can be seen from Table 1, the sample contains different number of shares each year. We can use statistical grouping method to see whether there are size effect and BM effect in A-share market. If these two kinds of anomalies exist, we can use size factor and BM ratio factor to explain the portfolio return besides β. Firstly, we must group the stocks to build portfolios, as our study focuses on the rate of return of portfolio. According to Fama and French(1996) grouping method,

we group the sample respectively into five groups in accordance with size and BM ratio in the end of June each year to form 25 cross combinations, Table 2 lists the average monthly returns of 25 portfolios.

Table 2: Statistics of Average Monthly Returns of Portfolios

Size	BM ratio				
	small	2	3	4	big
small	0.191	0.163	0.502	0.139	0.173
	(8.06)	(7.90)	(8.58)	(8.42)	(8.19)
2	0.045	0.072	0.069	0.082	0.074
	(8.88)	(7.31)	(8.08)	(8.39)	(8.44)
3	0.028	0.038	0.052	0.057	0.063
	(7.81)	(8.29)	(8.20)	(8.86)	(8.58)
4	0.020	0.037	0.046	0.044	0.041
	(8.49)	(4.51)	(8.68)	(7.88)	(8.58)
big	0.029	0.016	0.025	0.028	0.035
	(3.88)	(4.29)	(4.77)	(10.13)	(9.82)

Note: The value in parentheses is t-value of the coefficient.

As can be seen from Table 2, in each BM ratio group, return of small-cap portfolio is significantly higher than large-cap portfolio, and the return shows decreasing trend with the larger size, indicating there might be size effect in stock market. Except the group of minimum size, in other size groups, return of high BM ratio portfolio is greater than low BM ratio portfolio, and the return shows decreasing trend with the smaller BM ratio, although it isn't always absolute between two adjacent groups, we can confirm the existence of BM effect. As can be seen by the grouping statistics, the return of portfolio is negatively correlated with size and is positively correlated with BM ratio. Therefore, we can use size and BM ratio to explain the portfolio return besides β in Shanghai A-share market. That is, using market factor (R_m-R_f), size factor (*SMB*), BM ratio factor (*HML*) as explanatory variables.

2.3. Descriptive statistics for the explanatory variables

Table 3 lists the minimum, maximum, and other descriptive statistical indicators of the explanatory variables.

Table 3: R_m-R_f , *SMB* and *HML* descriptive statistics

	Mean	SD	Max	Min
R_m-R_f	0.0136	0.0955	0.2706	-0.2526
SMB	-0.0041	0.0263	0.0770	-0.0611
HML	0.0006	0.0093	0.0267	-0.0188

As can be seen from Table 3, the minimum value of market factor is negative, market factor is the return of market portfolio minus risk-free rate, a negative value may be due to stock market fluctuation during the study period; market factor's averages is 0.0136 which is relatively high income level. Besides, the maximum of *SMB* and *HML* are positive numbers, indicating that small-cap portfolio has higher return than large-cap portfolio in some months and high BM ratio portfolio has better performance than low BM ratio portfolio, which means there are size effect and BM effect in Chinese stock market.

3. Three-factor model regression analysis and its explanatory power

Learning from Fama-French model, the time series regression model of three-factor model that we use is as follows:

$$R_{it} - R_{ft} = \alpha_i + \beta_i \left(R_{mt} - R_{ft}\right) + s_i SMB_t + h_i HML_t + \varepsilon_{it}$$

To know if we can use R_m-R_f, *SMB* and *HML* to explain the return of the portfolio, we need to examine multicollinearity among these factors firstly. The correlation coefficients among R_m-R_f , *SMB*, *HML* are shown in Table 4:

Table 4: Correlation Coefficients Matrix

	R_m-R_f	*SMB*	*HML*
R_m-R_f	1.0000	-0.0878	0.2637
SMB	-0.0878	1.0000	-0.1222
HML	0.2637	-0.1222	1.0000

As can be seen from Table 4, the absolute values of the correlation coefficients among R_m-R_f , *SMB* and *HML* are small, indicating that R_m-R_f , *SMB*, and *HML* have no strong correlation and no multicollinearity.

To know if three-factor model has a fully adequate explanatory power, we need to see if α is significantly different from 0 next, and observe the variation of α, β, s, h to know whether the explanation of three-factor model for size effect and BM effect is powerful. Three-factor model regression results are shown in Table 5.

Table 5 Three-factor Model Time Series Regression Results (2005.07-2012.06)

	BM ratio									
Size	Small	2	3	4	Big	Small	2	3	4	Big
	α					t(α)				
Small	0.002	0.001	0.005	0.004	0.004	0.42	0.29	1.05	0.96	0.88
2	0.002	0.003	0.001	0.001	0.001	0.54	0.69	0.15	0.17	0.12
3	0.004	0.002	0.002	0.003	0.000	0.96	0.34	0.34	0.66	0.09
4	0.003	0.002	0.003	0.001	0.002	0.74	0.38	0.65	0.26	0.37
Big	0.005	0.003	0.001	0.000	0.000	1.05	0.75	0.27	0.05	0.02
	β					t(β)				
Small	1.013	0.986	1.013	1.035	1.055	21.34*	20.77*	21.34*	21.81*	22.22*
2	1.098	1.074	1.013	1.053	1.024	23.13*	22.62*	21.35*	22.18*	21.58*
3	0.978	1.041	1.052	1.050	1.075	20.61*	21.93*	22.17*	22.12*	22.65*
4	0.978	0.999	1.082	1.054	1.117	20.62*	21.04*	22.80*	22.21*	23.53*
Big	0.995	1.052	1.104	1.113	0.942	20.96*	22.16*	23.26*	23.45*	19.84*
	s					t(s)				
Small	1.481	1.406	1.435	1.493	1.251	17.59*	16.70*	17.04*	17.73*	14.86*
2	1.325	1.279	1.263	1.391	1.364	15.75*	15.19*	15.00*	16.53*	16.21*
3	1.162	1.138	1.194	1.292	1.145	13.81*	13.52*	14.19*	15.35*	13.61*
4	0.867	0.904	0.944	0.985	0.977	10.30*	10.74*	11.22*	11.70*	11.61*
Big	-0.517	-0.480	-0.676	-0.598	-0.380	-13.86*	-12.84*	-18.10*	-16.03*	-10.17*
	h					t(h)				
Small	-0.012	-0.013	-0.015	-0.019	-0.019	-0.35	-0.36	-0.43	-0.53	-0.53
2	-0.019	-0.012	-0.015	-0.010	-0.012	-0.56	-0.34	-0.42	-0.29	-0.35
3	-0.025	-0.044	-0.020	-0.004	0.016	-0.71	-1.25	-0.56	-0.10	0.46
4	-0.089	-0.080	-0.015	0.013	0.046	-2.56*	-2.30*	-0.44	0.38	1.31
Big	-0.554	-0.369	-0.100	0.542	0.468	-15.90*	-10.60*	-2.88*	15.54*	13.41*

Note: The left part is α, β, s, h coefficients of each portfolio, the right part is t-value for these coefficients; * denotes that coefficient is significant at the 5% level.

As can be seen from the regression results listed in Table 5, intercept α is not significantly different from 0, and the value is almost 0, showing the return of portfolio minus risk-free rate can be basically explained by three factors.

Average t-value of regression coefficient β of R_m-R_f (market factor) is higher than 20, showing market factor's highly significant, indicating that market factor represents the most important part of the change in the return. Moreover, each group has relatively modest number of stocks, because we group Shanghai A-shares into 25 parts. So it is no wonder β is very significant and is close to 1. Since β is around 1, systemic risk of these 25 portfolios are similar to market risk, we can exclude the possibility that difference in the systemic risk of portfolios lead to difference in the rate of return of portfolios.

The t-value of coefficient s of *SMB* (size factor) is greater than 10 in all portfolios, and is very significant, indicating that *SMB* can explain the part of stock return change that can't be explained by market factor. We also found that coefficient is significantly positive in the respect of small-cap portfolio and is negative in the respect of large-cap portfolio, indicating that size factor has greater impact on return of small-cap. And coefficients have a significant decreasing trend with the increase of size, indicating that return of small-cap portfolio is higher than large-cap portfolio. If the reasoning above is correct, then, whether the market prefers low BM ratio stocks or high BM ratio stocks, small-cap portfolio is more likely to perform better than large-cap portfolio.

The absolute value of t-value of coefficient h of *HML* (BM ratio factor) is small, indicating that although *HML* can explain part of return that can't be explained by market factor and size factor, the explanatory power is not very strong. The coeffi-

cient is significantly negative in the respect of low BM ratio portfolio and is significantly positive in the respect of high BM ratio portfolio, showing that high BM ratio portfolio has higher return compared to low BM ratio portfolio. And because coefficients have a significant decreasing trend with the increase of size among low BM ratio groups, and coefficients have a significant increasing trend with the increase of size among high BM ratio group, indicating that when the market prefers high BM ratio stocks, investors prefer large-cap of high BM ratio stocks, followed by small-cap of high BM ratio stocks, with the low BM ratio stocks of small-cap behind, and low BM ratio stocks of large-cap is the last. Although more than half of coefficients are negative, it does not conflict with three-factor model, because the model only requires *h* to perform a certain trend that increases as BM ratio becomes larger.

4. Conclusions

Based on the portfolio construction of Shanghai A-share from July, 2005 to June, 2012, we found size effect and BM effect, that is, small-cap portfolio has higher return than large-cap portfolio, and high BM ratio portfolio has higher return than low BM ratio portfolio. And we also found that market factor, size factor, and BM ratio factor can explain size effect and BM effect. The explanatory power of market factor is best, it explains stock return change in the main part; followed by size factor; BM ratio factor can explain the rest of the change in stock return, but its explanatory power is not very strong. Compared to the findings of previous scholars, the time range of sample in this paper is relatively new, literatures around 2000 basically use the 1990s data, because early stock market is irregular and immature, the previous conclusions that three-factor model has no explanatory power in Chinese stock market may not be robust. In selecting stock sample, we remove the financial stocks, ST stocks, etc, increasing the reliability of the results. We formed the portfolio that contained a reasonable number and variety of stocks by grouping, which made explanatory power of the model become stronger. In general, we found that three-factor model can explain size effect and BM effect in Shanghai A-share market.

5. References

[1] N. Chen, R. Roll, and S. Ross, "Economic Forces and the Stock Market," *The Journal of Business*, pp. 383-403, 1986.

[2] F. Eugene and R. F. K. French, "The cross-section of expected stock returns" *The Journal of finance*, 1992.

[3] F. Eugene and K. R. French, "Common Risk Factors in the Returns on Stocks and Bonds" *Journal of Financial Economics*, 1993.

[4] A. Wang, "Empirical Analysis of the Adaptability of the Three-factor Model in Chinese Stock Market" *Foreign Economic and Trade University*, 2007

[5] D. Wu, "Shanghai and Shenzhen A-share Market Returns Anomalies Empirical Research" *Fudan University*, 2011.

[6] C. Yi, X. Huang, N. Wang and T. Yang, "Analysis of Three-Factors Model in Chinese Stock Market" *Journal of Nanjing Institute of Economics*, 2001 (5).

[7] L. Wang, "The Study of the Chinese Stock Market Anomalies" *Northeast University of Finance*, 2011.