# Exploring Fama-French Five-Factor Model on Chinese A-Share Stock Market

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**ABSTRACT**

Motivated by the valuation theory and recent empirical findings on the strong profitability and investment effects in asset returns. Fama and French propose a five-factor model contains the market factor and factors related to size, book-to-market equity ratio, profitability and investment, which outperforms the Fama-French Three-Factor Model in their paper 2014. This paper explores Fama-French Five-Factor Model on Chinese A-Share Stock Market and the empirical results show that the explanatory power of profitability and investment factors differs among different sets of portfolios. In comparison with Fama-French Three-Factor Model, the presence of profitability and investment factors RMW and CMA seem not capture more variations of expected stock returns than the original three-factor model at least for Size-B/P portfolios; there is no significant evidence that Fama-French Five-Factor Model performs better than Fama-French Five-Factor Model on Chinese A-share stock market over the research period.

**Keywords:** Fama-French Five-Factor Model, Chinese A-Share Stock Market

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## 1 Introduction

Fama and French (1993) draw a conclusion that risk (market beta) was not able to identify all the stock return variations during 1963-1990 on US stock market, two other factors, size and book-to-market equity, combined to capture the cross-sectional variation in average stock returns unite with market β, which is the famous Fama-French Three-Factor Model (FF3F model hereafter). According to Fama and French, firm size and book-to-market equity ratio are related to the systematic pattern of profitability and growth. They are potentially major sources of risk in return. These two mentioned variables were known in most studies as two specific market indicators that raise questions about the model. These findings diminished the credence of this model, and a new wave was formed in the development field of financial theories with the aim of explaining the causes of these special consequences.

Based on the valuation theory and recent empirical findings on the strong profitability and investment effects in asset returns, Fama and French (2014) propose a five-factor model contains the market factor and factors related to size, book-to-market equity ratio, profitability and investment. This paper explores the Fama-Frech Five-Factor Model (FF5F model hereafter) on Chinese A-share stock market, providing the latest evidence of factor model and an update to the existing asset pricing literature on Chinese stock market, which is our main contribution to the literatures.

## 2 Reviews of Fama-French Five-Factor Model

Motivated by the valuation theory and recent empirical findings on the strong profitability and investment effects in asset returns[3]. Fama and French (2014) propose a five-factor model contains the market factor and factors related to size, book-to-market equity ratio, profitability and investment, which performs better than the three-factor model of Fama and French (1993):

$$R_{i,t} - R_f = a_i + b_i(R_{M,t} - R_f) + s_i SMB + h_i HML + r_i RMW + c_i CMA + e_{i,t} \quad (1)$$

Where:

$R_{i,t} - R_f$ is the excess returns of portfolio i at time t;

$R_{M,t} - R_f$ is the excess market returns (market factor);

*SMB*, *HML*, *RMW* and *CMA* are respectively the size factor, value factor, profitability factor and investment factor;

[3] Recently, Novy-Marx (2013) identifies a proxy today that predicts expected earnings tomorrow - the profitability factor, which is strongly related to average stock return, and the investment factor was documented by Aharoni, Grundy, and Zeng (2013), see also Titman, Wei and Xie (2004), although it has a high correlation with the value and profitability factors, the investment effect is perhaps half as strong, but it is still reliable and significant.

$a_i$ is the constant;

$b_i$, $s_i$, $h_i$, $r_i$ and $c_i$ are respectively the coefficient for corresponding factors;

$e_{i,t}$ is the error term for portfolio i at time t.

From equation (1), it is obvious that the five-factor model have two more factors than three-factor model, RMW and CMA. RMW is the factor related to firm's profitability which is the difference between the returns on portfolios of robust (high) profitability and weak (low) profitability firms. CMA is the one related to investment, which is the difference between the returns of conservative (low) investment portfolios and aggressive (high) investment portfolios.

In their paper, Fama and French suggest that the theoretical starting point is the "Dividend Discount Model":

$$m_t = \sum_{\tau=1}^{\infty} E(d_{t+\tau})/(1+r)^{\tau} \qquad (2)$$

Where, $m_t$ is the share price at time t, $E(d_{t+\tau})$ is the expected dividend per share for period $t+\tau$, and $r$ is (approximately) the long-term average expected stock return or, more precisely, the internal rate of return on expected dividends. This model states that the value of a stock today will be the sum of the discounted present value of all its future dividends.

With a little bit manipulation, the dividend per share $d_{t+\tau}$ is the difference between $Y_{t+\tau}$, the equity earnings for period t+τ, and $dB_{t+\tau} = B_{t+\tau} - B_{t+\tau-1}$, which is the change in book equity. Then the dividend discount model (equation (1.3)) becomes:

$$M_t = \sum_{\tau=1}^{\infty} E(Y_{t+\tau} - dB_{t+\tau})/(1+r)^{\tau} \qquad (3)$$

Divided by book equity at time t gives,

$$\frac{M_t}{B_t} = \frac{\sum_{\tau=1}^{\infty} E(Y_{t+\tau} - dB_{t+\tau})/(1+r)^{\tau}}{B_t} \qquad (4)$$

Equation (4) implies three statements about expected stock returns.

- Firstly, fix everything except the expected stock return $r$ and current value of the stock $M_t$, a lower market value $M_t$, or equivalent to a higher book-to-market equity (B/M) ratio implies a higher expected stock return.

- Next, fix everything except the expected earnings $Y_{t+\tau}$ and expected stock returns $r$, more profitable companies which with higher expected earnings have higher expected returns.
- Finally, controlling for the expected growth $dB_{t+\tau}$ (investment) and expected stock returns while fixing other elements, firms with higher expected growth in book equity implies a lower expected return.

The dividend discount model and its transformation indicate the relationship between the variables and average asset returns. FF point out that the nature of equation (2) and (4) is the reason why they choose profitability and investment factors to augment the model. The construction of profitability factor and investment factor and the portfolios are demonstrated in section 5.

## 3 Status Quo of Research on Fama-French Five-Factor Model

Early in 2006, Fama and French (2006) has already studied for the three variables, B/M ratio, profitability, and investment effects, which are related to expected stock returns according to dividend discount model and the valuation equation. And they confirm the implies of valuation theory that high rates of investment are related to low expected returns when controlling B/M ratio and profitability, while controlling two other variables, high profitable stocks have higher expected stock returns.

Titman et al. (2004) shows that firms which increase capital investment tend to have future negative risk-adjusted returns. Finally, Novy-Marx (2013) uncovers a positive relationship between profitable firms and expected returns. Haugen and Baker (1996) and Cohen et al. (2002) find that, controlling for book-to-market equity, average returns are positively related to profitability. Fairfield et al. (2003), Richardson and Sloan (2003) and Titman et al. (2004) show a negative relation between average returns and investment.

Especially, Hou et al. (2014) examine nearly 80 anomalies in the literatures from January 1972 to December 2012 on U.S. market based on q-theory, but about one-half of the anomalies seems exaggerated their explaining power for average stock returns. They come to a conclusion that a four-factor model which includes the market factor, size factor, profitability factor and investment factor explains the cross-sectional average stock returns to a large extent, and outperforms the FF3F model and Carhart (1997) four-factor models.

Inspired by recently researches that give evidence to the remarkable existence of profitability and investment effects, based on the dividend discount model, Fama and French (2014) propose a five-factor model contains the market factor and factors related to size, book-to-market equity ratio, profitability and investment and test the performance of the five-factor model for the U.S.

market using the data from July 1963 to December 2013. (Data period July 1963-December 2013). They use three sets of factors[4] in order to examine whether the specifics of factor construction do have important impact on the results of the test of asset pricing models. Furthermore, they show GRS statistic of Gibbons et al. (1989) to test whether the intercepts are indistinguishable from zero in the regressions of the portfolios' excess returns on the models' factor returns, so that to distinguish whether a model can completely capture expected returns.

The results show that the factors from the 2x3, 2x2 and 2x2x2x2 sorts obtain much the same results in testing of a given model, and although the GRS tests indicate that all the models are incomplete descriptions of expected average returns, the FF5F model outperforms FF3F model by adding profitability and investment factors. As FF themselves say, "*Despite rejection on the GRS test, the five-factor model performs well: unexplained average returns for individual portfolios are almost all close to zero*"[5].

Meanwhile, they draw a conclusion that the value factor HML is a redundant factor for describing average returns in FF5F model, *the five-factor model and the four-factor model which excludes HML are similar on all measures of performance, including the GRS statistic.* They explain this outcome is because *"the average HML return is captured by the exposures of HML to other factors (market factor, SMB, HML and especially RMW and CMA)"*

Their results suggest that a five-factor model performs better than the three-factor model of Fama and French (1993). But the five-factor model fails to capture low average returns on small stocks with high investment and low profitability. They also show that the model's performance is not affected by the way the factors are calculated. With two additional factors, their results also suggest that the value factor (HML) becomes redundant.

There is not much research on FF Five-Factor model out of America. Fama and French (2015) proceed the international tests of FF5F model in North America, Europe, Japan and Asia Pacific. Expected stock returns increase with the B/M ratio and profitability and decrease with investment for North America, Europe, and Asia Pacific, however, the average stock returns show little relation to profitability or investment factors.

On Brazilian market, Martinsa and Eid Jr (2015) test the performance of FF5F model during the period January 2002- December 2012 and find that FF5F model performs better than their

[4] The three sets of factors are: 2x3 sorts on Size and B/M, or Size and OP, or Size and Inv; 2x2 sorts on Size and B/M, or Size and OP, or Size and Inv; and 2x2x2x2 sorts on Size, B/M, OP and Inv (see details in Fama and French, 2014). 2x3 sorts on Size and B/M is that the size and value factors are independently sort stocks into two size groups and three B/M groups, and construct the size factor SMB and value factor HML as of FF3F model; the 2x3 sorts on Size and OP or Size and Inv are the same as Size and B/M except the sort for B/M groups are replaced by operating profitability or investment. 2x2 sorts method is similar as 2x3 sorts except that the stocks are all independently sorted into two groups. In 2x2x2x2 sorts is that the size factor SMB equal weights high and low B/M, robust and weak OP, and conservative and aggressive Inv portfolio returns.

[5] Fama and French (2014)

previous work in three-factor model. The market factor, SMB and HML capture most of the variation in average returns in the time-series regressions, however, the two new factors RMW and CMA have shown less explanatory power. Chiah, Chai, and Zhong (2015) investigate the FF5F model on Australia market, and they find that the profitability and investment factors have significantly positive premium. FF5F proved to be able to explain average stock returns better than FF3F model in Australia, in contrary to FF (2014) results, the value factor (HML) remains its explanatory power in the presence of the investment and profitability factors.

## 4 Chinese Stock Market and Several Special Features

In the past 30 years China experienced extraordinary economic growth and has become an increasingly important member of the global economy. One of the critical economic reforms was the introduction and the development of the stock markets. Still young and immature, the Chinese stock markets have grown rapidly and now become the second largest in terms of market capitalization.

On Chinese stock market, there are three kinds of stocks: A-share stocks, B-share 'stocks and H-share stocks. The 'A-shares' do not refer to ta 'class' of common or preferred stocks as usual, it refers to shares that are purchased and traded on the Shanghai Stock Exchange (SSE) and Shenzhen Stock Exchange (SZSE). These companies are incorporated in mainland China and their shares are denominated in the local currency Chinese yuan, or RenMinBi (RMB). For individual investors, these stocks of the A-share market are strictly off limits to non-Chinese investors. Meanwhile, some Chinese companies are listed in Shanghai and Shenzhen, but their shares trade in U.S. dollars. These stocks, known as 'B-Share', were designed to give Chinese companies a way to raise capital from overseas. 'B-Shares' also allow foreign (non-Chinese) investors to invest in this market without the restrictions associated with 'A-shares'. 'H-shares' are also Chinese companies, but these securities are traded on the Hong Kong Stock Exchange rather than on the mainland, and they are priced in Hong Kong dollars.

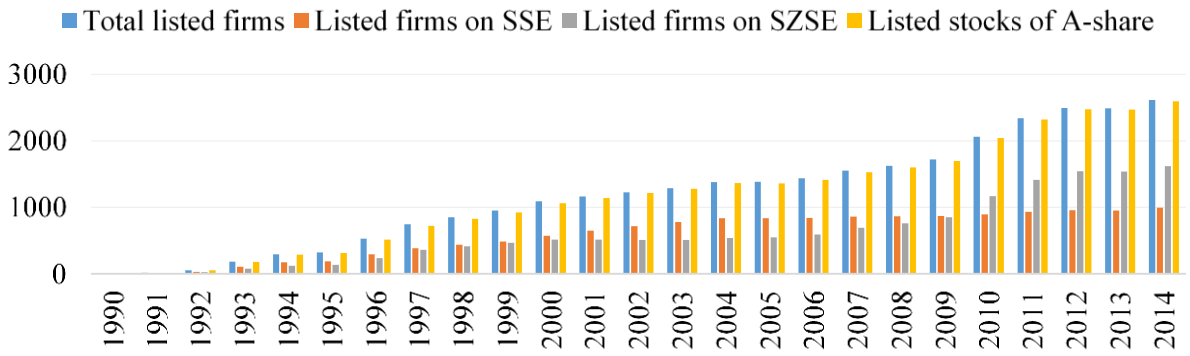
Much of the literature[6] has focused on the segmentation of the market and mispricing between A shares, denominated in domestic currency, and B shares, traded in foreign currency. However, this anomaly has been significantly reduced following the opening of the B market to domestic investors in 2001[7]. B-shares account for a very small part of the total market capitalization (2.93% of year 2001 and even 0.46% of year 2014). Our research will focus only on Chinese A-share stock market.

[6]See Sun and Tong (2000), Chen et al. (2001), Fung et al. (2000) and Fernald and Rogers (2002), etc.
[7] Ahlgren et al. (2009)

The Chinese stock market is a young market with relative short history, and it has grown and expanded rapidly since the establishment of Shanghai stock exchange (SSE) on November 26th, 1990 - in operation on December 19th of the same year and the other stock exchange- Shenzhen stock exchange(SZSE) on December 1st, 1990 (opened in July 3rd, 1991). The total listed firms on A-share stock market increase rapidly from 14 of year 1991 to more than 1000 of year 2001, and more than 2500 until now (in SSE and in SZSE).

Figure1 shows the total listed firms and that of SSE and SZSE from 1990 to 2014, listed stocks of A-share stock market are also presented. Figure 2 represents the total market capitalization of whole stock market and also respectively of A-share stock market and B-share stock market from 1992 to 2014. The total listed firms increase sharply during 25 years (from 10 total listed firms in 1990 to 1088 in 2000, and 2613 total listed firms in year 2014), and total market capitalization from RMB 104.8 billion (year 1992) to 37 254.7 billion (year 2014). The total listed stocks in A-share stock market increased from 53 (year 1992) to 2592 (year 2014) with a combined market capitalization of RMB 97.8 billon in 1992 to 37 082.3 billion in 2014. Once again, the percentages of B-share market capitalization in total market capitalization show that A-share account for the vast majority of the total market capitalization (more than 99% after 2006), and B-shares account for only a very small part of the total market capitalization after 2001 and even less than 1% from 2007.

**Figure 1 Total listed firms and that of SSE and SZSE, listed stocks of A-share stock market (1990-2014)[8]**



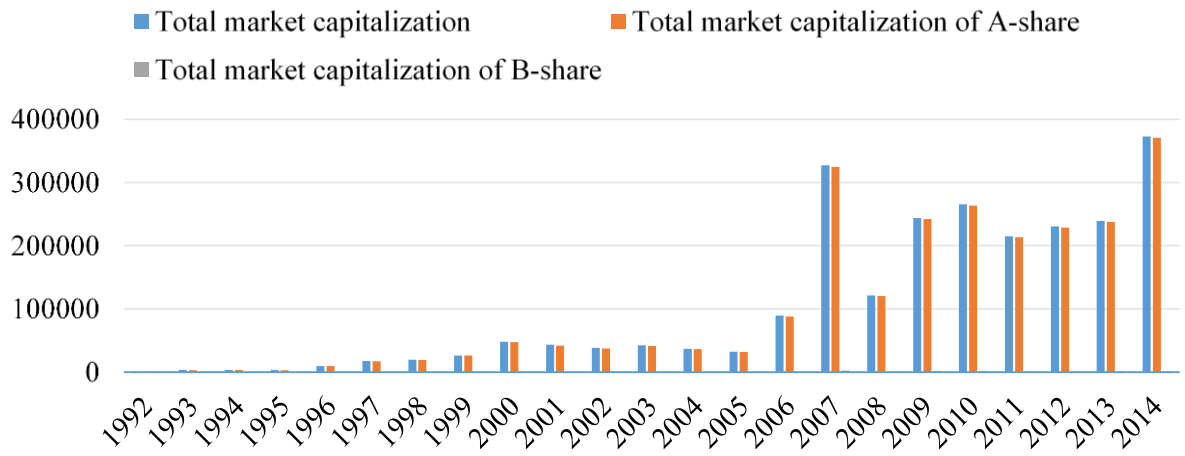

This rapid growth has attracted considerable academic interests. Many studies have examined the ability of FF3F model to predict the stock price movements of Chinese stocks, and almost all the researches find the market beta is not able to explain cross-sectional stock returns on Chinese stock market, but some researchers find there exist size effect or (and) value effect[9]. To the best of our knowledge, there is no such a work of applying on Chinese stock market so far. In next

[8] Data source: http://www.stats.gov.cn/

[9] Drew et al. (2003), Eun and Huang (2007), Wang and Di Iorio (2007) and Chen et al. (2015) etc.

section we will present the empirical results that we apply FF5F model on Chinese A-share stock market.

**Figure 2 Total market capitalization and that of A-share and B-share stock market (unit:100 million yuan, period:1992-2014)[10]**




The emerging empirical literatures suggest that Chinese market has some special features, and it is inevitable to consider those special features if researchers want to have a more accurate results in China. Such as Zhan-hui (2004), Zhang and Xu (2013) and Hung et al. (2015) all do their researches considering one or several special features on Chinese stock market. We summarize three primary features which are also most frequently employed by literatures.

- Firstly, it is well known that China, like many markets in the Asian region, have substantial holdings of non-traded shares which means that these shares are not effectively valued. Before April 2005, listed companies had two kinds of shares outstanding which are tradable shares and non-tradable shares. Non-tradable shares were held by government agencies or government-related enterprises and were non-tradable in the public market. Chinese government started the share-structure reform in April 2005 to legally convert non-tradable shares to tradable shares. Almost all Chinese listed companies completed the reform by the end of 2006. Using only tradable shares or all shares to value weight stock returns is necessary to investigate.
- Secondly, China has two main boards for the firms to go public, the Shanghai Stock Exchange and the Shenzhen Stock Exchange. In addition, the Small Medium Enterprise Board (SME) and the Growth Enterprise Board (GEB) were set up in May 2004 and October 2009, respectively, and both are hosted by the Shenzhen Stock Exchange. Fama

[10] Data source: http://www.stats.gov.cn/

and French use NYSE-listed firms to determine the breakpoints between small and big firms in order to avoid the overwhelming influence of the large number of small NASDAQ firms. Therefore, whether SME and GEB listed firms should be excluded in determining the breakpoints for the size factor in China need to be examined.

- The third special feature is the segmentation of Chinese stock market, more than 170 Chinese listed firms have issued multiple class shares which have the same cash flow and voting rights but are traded in different markets. Some of them have A-shares and B-shares, some have A-shares and H-shares and others have the A-shares and shares in other foreign markets. Since these shares share the same cash flow and voting rights, they usually have the same claim on the firm's book value of equity. Our research focus only the Chinese A-share stock market, in order to obtain the book-to-market equity ratio per A-share of a company with multiple class shares, it is incorrect to divide the firm's total book value equity from its balance sheet by the total market value. Instead, the correct way is to calculate the book value equity per share divided by the A-share price.

Based on these special features of Chinese stock market, Zhang and Xu (2013) construct FF three factors and process the regressions separately with and without these special features. They come to the conclusions that the performance of FF3F model is better when the non-tradable shares are excluded from the sample and when the book-to-price ratio (B/P) are used instead of the book-to-market ratio. Furthermore, the SME and GEB stocks are included or excluded of the sample to divide firms into size groups do not have distinct difference.

On account of the special features of Chinese stock market study in literatures, we choose to construct value-weighted stocks by their tradable shares, construct of size factor by the total market capitalization including SME and GEB, and use B/P ratio instead of B/M ratio.

## 5 Data and Construction of Fama-French Five Factors

Similar to FF three factors that are constructed using the 6 value-weighted portfolios formed on size and book-to-market equity[11]. The FF five factors are constructed using the 6 value-weight portfolios formed on size and book-to-market (Size-B/M portfolios), the 6 value-weight portfolios formed on size and operating profitability (Size-OP portfolios), and the 6 value-weight portfolios

[11] In June of each year t, the stocks are sorted into two size groups: small firms (S) and big firms (B), according to their total market value. Independently stocks are sorted into three B/P groups instead of B/M ratio at each December of year t-1: low B/P ratio (L), medium B/P ratio (M) and high B/P ratio (H) firms, according to the breakpoint 30% and 70% of values of B/P equity for all the stocks. The intersections of these groups are constructed into six portfolios: small low (SL), small medium (SM), small high (SH), big low (BL), big medium (BM), and big high (BH) portfolios. The value-weighted monthly returns are calculated from July of year t to June of year t+1, during which the portfolios remain the same, and the portfolios are reconstructed in July of year t+1.

formed on size and investment (Size-Inv portfolios). The Size-OP portfolios and Size-Inv portfolios are formed in the same way as the Size-B/M portfolios, except the second sort variable is operating profitability or investment.

The operating profitability (OP) for June of year t is calculated as annually revenues minus cost of goods sold, interest expense, and selling, general, and administrative expenses divided by book equity for the last fiscal year end in t-1. The Investment portfolios are formed on the change in total assets from the fiscal year ending in year t-2 to the fiscal year ending in t-1, divided by t-2 total assets at the end of each June using NYSE breakpoints. To be more clear:

$$OP = (Gross\ Profitability - Interest\ Expense - Selling,\ General\ and\ Administrative\ Expenses) / (Book\ Equity)_{t-1} \quad (5)$$

$$Inv = \left[(Total\ Asset)_{t-1} - (Total\ Asset)_{t-2}\right] / (Total\ Asset)_{t-1} \quad (6)$$

Where,

$OP$ represents the operating profitability;

$Gross\ Profitability$ equals annual revenue minus the cost of goods sold;

$Book\ Equity$ is book value of equity;

$Inv$ represents the investment opportunities;

$(Total\ Asset)_{t-1}$ is the total value of assets in year t-1;

$(Total\ Asset)_{t-2}$ is the total value of assets in year t-2.

The size breakpoint for year t is the median NYSE market equity at the end of June of year t. The construction of portfolios on OP and investment are similar with that of portfolios on book-to-market equity. At the end of each June, the firms are sorted into three OP portfolios based on the breakpoints of the 30th and 70th NYSE percentiles, and the three investment portfolios are formed in the same way using NYSE breakpoints-30th and 70th NYSE percentiles.

Then at the end of each June, the intersections of two portfolios formed on size - small (S) and big (B), and 3 portfolios formed on profitability – weak profitability (W), neutral profitability (N) and robust profitability (R) are constructed into six "Size-OP" portfolios: SW, SN, SR, BW, BN and BR[12]. Similarly, the "Size-Inv" portfolios, which are also constructed at the end of each June, are the intersections of 2 portfolios formed on size and 3 portfolios formed on investment-

[12] Portfolio SW contains firms with small size and weak profitability, SN contains firms with small size and neutral profitability, SR contains firms with small size and robust profitability, similarly to BW, BN and BR, which contains firms with big size and weak profitability, neutral profitability and robust profitability separately.

conservative investment (C), neutral investment (N) and aggressive investment (A). Thus, the six Size-Inv portfolios are constructed: SC, SN, SA, BC, BN and BA[13].

In Fama-French five-factor (FF5F) model, the market factor which is the excess market return that computed as the difference between the value-weighted returns of all A-shares and the risk-free rate, and value factor remain the same as in three-factor model, while the size factor SMB need to be reconstructed with profitability and investment factors, which is the average return on the nine small stock portfolios minus the average return on the nine big stock portfolios. The two additional factors are directed at capturing the profitability and investment patterns, which are indicated by RMW and CMA. As shown in equation (12) and equation (13), RMW is the difference between returns on portfolios with robust and weak profitability, and CMA is the difference between returns on portfolios of the stocks of low and high investment firms, which is called conservative and aggressive, separately. In detail:

$$HML = \frac{1}{2}(Small\ High + Big\ High) - \frac{1}{2}(Small\ Low + Big\ Low) \tag{7}$$

$$\begin{aligned} SMB_{B/M} = {} & \frac{1}{3}(Small\ Low + Small\ Medium + Small\ High) \\ & - \frac{1}{3}(Big\ Low + Big\ Medium + Big\ High) \end{aligned} \tag{8}$$

$$\begin{aligned} SMB_{OP} = {} & \frac{1}{3}(Small\ Robust + Small\ Neutral + Small\ Weak) \\ & - \frac{1}{3}(Big\ Robust + Big\ Neutral + Big\ Weak) \end{aligned} \tag{9}$$

$$\begin{aligned} SMB_{Inv} = {} & \frac{1}{3}(Small\ Conservative + Small\ Neutral + Small\ Aggressive) \\ & - \frac{1}{3}(Big\ Conservative + Big\ Neutral + Big\ Aggressive) \end{aligned} \tag{10}$$

$$SMB = \frac{1}{3}(SMB_{B/M} + SMB_{OP} + SMB_{Inv}) \tag{11}$$

$$RMW = \frac{1}{2}(Small\ Robust + Big\ Robust) - \frac{1}{2}(Small\ Weak + Big\ Weak) \tag{12}$$

[13] Portfolio SC contain firms with small size and conservative investment, SN contains firms with small size and neutral investment, SA contains firms with small size and aggressive investment, similarly to BC, BN and BA portfolios.

$$CMA = \frac{1}{2}(Small\ Conservative + Big\ Conservative) - \frac{1}{2}(Small\ Aggressive + Big\ Aggressive) \quad (13)$$

## 6 Empirical Results on Chinese A-Share Stock Market

Table 1 shows the annual firm numbers which have available data of firm size, B/P ratio, OP and Inv. The OP numbers are always less available than Inv numbers, and before 2009, there are few (less than 30) available OP numbers.

**Table 1 Annual firm numbers that have available data of size, B/P ratio, OP and Inv (2004-2014)**

| Year | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Size | 1105 | 1158 | 1175 | 1254 | 1352 | 1408 | 1662 | 1977 | 2189 | 2248 | 2224 |
| B/P | 929 | 1020 | 1008 | 1106 | 1218 | 1286 | 1500 | 1846 | 2069 | 2110 | 2040 |
| OP | 12 | 17 | 24 | 26 | 27 | 131 | 294 | 392 | 777 | 1043 | 2417 |
| Inv | 1154 | 1237 | 1346 | 1402 | 1624 | 1981 | 2241 | 2355 | 2361 | 2525 | 2525 |

The annual available numbers of OP and Inv are visually displayed in Figure 3, the blue bar is operation profitability and the red bar is investment opportunity, the x-axle indicates the years and the y-axle is the firm numbers. To be more accurate and reduce the bias generated because of the very few firm numbers (when we sort firms into portfolios, there may be no firms in portfolios with firm numbers less than 30 in a year), we exclude the data before 2009.

**Figure 3 Annual firm numbers which have available data of size, B/P ratio, OP and Inv**

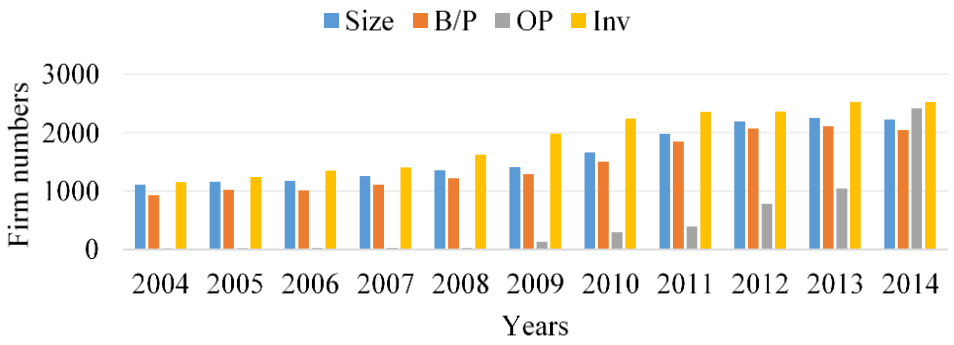


**Table 2 Annual number of stocks in six Size-OP portfolios and six Size-Inv portfolios**

This table presents the annual firm numbers of six Size-B/P ratio (Panel A), six Size-OP portfolios (Panel B) and six Size-Inv portfolios (Panel C) from 2009 to 2014. Across the first row is the years. Across the first column of Panel A are the six Size- B/P portfolios (SL, SM, SH, BL, BM and BH), across the first column of Panel B are the six Size-OP portfolios (SW, SN, SR, BW, BN and BR), and across the first column of Panel C are the six Size-Inv portfolios (SC, SN, SA, BC, BN and BA).

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Panel A Size-B/P portfolios** | | | | | | |
| SL | 193 | 200 | 227 | 265 | 267 | 254 |
| SM | 280 | 286 | 391 | 446 | 488 | 510 |
| SH | 192 | 192 | 241 | 301 | 350 | 322 |
| BL | 206 | 206 | 288 | 342 | 395 | 392 |
| BM | 252 | 257 | 296 | 363 | 396 | 360 |
| BH | 207 | 215 | 275 | 307 | 313 | 324 |
| **Panel B Size-OP portfolios** | | | | | | |
| SW | 5 | 11 | 22 | 92 | 154 | 488 |
| SN | 1 | 7 | 7 | 52 | 107 | 483 |
| SR | 0 | 5 | 9 | 7 | 13 | 146 |
| BW | 34 | 76 | 95 | 140 | 157 | 233 |
| BN | 51 | 104 | 147 | 210 | 255 | 468 |
| BR | 28 | 57 | 93 | 87 | 121 | 403 |
| **Panel C Size-Inv portfolios** | | | | | | |
| SC | 328 | 374 | 392 | 404 | 457 | 465 |
| SN | 262 | 288 | 310 | 380 | 412 | 444 |
| SA | 105 | 167 | 289 | 314 | 258 | 244 |
| BC | 187 | 203 | 244 | 277 | 274 | 268 |
| BN | 301 | 373 | 468 | 492 | 496 | 479 |
| BA | 206 | 251 | 276 | 330 | 358 | 409 |

FF (2014) proceed the regressions using 25 Size-B/M Portfolios, 25 Size-OP portfolios and 25 Size-Inv portfolios. Following the same method, we construct the same portfolios on Chinese A-share stock market (see Appendix Table A.1). However, there are number of portfolios which contain no firms or less than five firms. So we have to sort portfolios into six Size-B/P portfolios, Size-OP portfolios and six Size-Inv portfolios, the annual number of firms in the three sets of portfolios are displayed in Table 2. The small size groups of Size-OP portfolios relatively have less stocks than that of big size groups and the SR portfolio has no stocks in year 2009 and only one stock in SN portfolio. Therefore, because of the lack of data on firm numbers of Chinese A-share stock market, the interval of our research to processing FF5F model is from July 2010 to May 2015 (59 months).

As shown in Table 3, Panel A is the summary statistics of FF five factors on Chinese stock market, the mean, standard deviation, standard error, sample variance, etc. Panel B is the correlation coefficients among the FF five factors, the profitability and investment factors are both positive related to market factor with low correlation coefficients (0.0418 and 0.1190) and negative related to size factor (-0.2227 and -0.2199). RMW is negatively related to value factor HML (-0.0217), while CMA is positively and relative highly related to HML with correlation coefficients of 0.4621. And the correlation coefficients between RMW and CMA is -0.3121.

**Table 3 Summary statistics of Fama-French five factors (period: July 2010-May 2015)**

Panel A summarizes the mean, standard deviation and standard error of FF 5 factors, and Panel B is the correlation coefficients among those factors.

**Panel A: Summary statistics of FF five Factors**

| | $R_{M,t} - R_f$ | SMB | HML | RMW | CMA |
|---|---|---|---|---|---|
| Mean | -0.0014 | 0.0106 | -0.0059 | -0.0061 | 0.0008 |
| Standard error | 0.0084 | 0.0038 | 0.0046 | 0.0036 | 0.0025 |
| Median | -0.0024 | 0.0117 | -0.0075 | -0.0128 | 0.0001 |
| S.D | 0.0646 | 0.0294 | 0.0355 | 0.0273 | 0.0196 |
| Sample Variance | 0.0042 | 0.0009 | 0.0013 | 0.0007 | 0.0004 |
| Kurtosis | 0.2068 | 6.4386 | 5.9071 | -0.4204 | -0.2635 |
| Skewness | 0.1439 | -1.2015 | 0.5658 | 0.3288 | 0.2217 |

**Panel B: Correlation coefficients among FF five factors**

| | RM-RF | SMB | HML | RMW | CMA |
|---|---|---|---|---|---|
| RM-RF | 1 | | | | |
| SMB | 0.1165 | 1 | | | |
| HML | -0.0013 | -0.6970 | 1 | | |
| RMW | 0.0418 | -0.2227 | -0.0217 | 1 | |
| CMA | 0.1190 | -0.2199 | 0.4621 | -0.3121 | 1 |

Table 4 presents the average excess return of six Size-B/P portfolios (Panel A), Size-OP portfolios (Panel B) and Size-Inv portfolios (Panel C). Across the columns are the two size groups and across the rows are the three B/M groups, three OP groups and three Inv groups, respectively. It is apparently that there is the size effect, the big size portfolios always have the lower returns than the small size portfolios in each panel. Across the OP groups in Panel B, it is strange that the robust portfolios have lower returns than weak portfolios, perhaps the few data of OP cause the bias. Across the Inv groups in Panel C, it seems the neutral investment portfolios have the highest excess returns (0.0158 for small size and neutral investment portfolio, 0.0050 for big size and neutral investment portfolio) than the conservative and aggressive investment portfolios.

**Table 4 Average monthly excess returns for portfolios formed on Size-B/M, Size-OP and Size-Inv (period: July 2010-May 2015, 59 months)**

The average excess returns of six Size-B/M portfolios, Size-OP portfolios and Size-Inv portfolios are presented in panel A, B and C respectively. Across the columns are the two size groups (Small and Big) and across the rows are the three B/M groups (Low, Medium and High), three OP groups (Weak, Neutral and Robust) and three Inv groups (Conservative, Neutral and Aggressive), respectively.

| **Panel A: Excess returns of size-B/M portfolios** | | | |
|---|---|---|---|
| | L | M | H |
| S | 0.0236 | 0.0231 | 0.0207 |
| B | 0.0151 | 0.0092 | 0.0061 |
| **Panel B: Excess returns of Size-OP portfolios** | | | |
| | W | N | R |
| S | 0.0172 | 0.0170 | 0.0081 |
| B | 0.0046 | 0.0082 | 0.0016 |
| **Panel C: Excess returns of Size-Inv portfolios** | | | |
| | C | N | A |
| S | 0.0136 | 0.0158 | 0.0121 |
| B | 0.0033 | 0.0050 | 0.0031 |

To understand how FF five factors explain the excess return of these portfolios, the time-series regressions are performed on six Size-B/P portfolios, Size-OP portfolios and Size-Inv portfolios on FF five factors for the period of July 2010 to May 2015 (59 months). The results are demonstrated in Table 5, Panel A, Panel B and Panel C are the time-series regressions results for the six value-weighted Size-B/P portfolios, six value-weighted Size-OP portfolios and six value-weighted Size-Inv portfolios, separately. The left part of the table reports the regression coefficients and adjusted R-square, while the corresponding t-statistics corrected for heteroscedasticity and autocorrelation using the Newey-West estimator with five lags and residual standard error are presented in the right part.

The loadings on market factor (*b*) are similar for the three sets of portfolios, the coefficients of market factor are highly significant at 5% confident level. We now look at each panel, in Panel A, five out of six (except the portfolio of big size and high B/P ratio) loadings on size factor SMB are significant at 5% confidence level, and the signs of slopes indicate that portfolios of small size have returns that are positively related to SMB, while returns of big size portfolios are negatively related to SMB. All the loadings on HML are highly significant, there exists consistently size and value effect in the regressions of six value-weighted SBP portfolios on FF5F Model. However, none of the loadings on the profitability factor RMW is significant, while three out of six loadings on the investment factor CMA are significant at 5% confidence level.

**Table 5 Time-series regressions of value-weighted six Size-B/P portfolios, six Size-OP portfolios and six Size-Inv portfolios on FF5F Model on Chinese A-share stock market (period: July 2010 to May 2015, 59 months)**

This table presents the time-series regressions results of FF5F model. In each panel, the regression intercept $a$, the regression coefficients $b$, $s$, $h$, $r$ and $c$ of market factor, size factor, value factor, profitability factor and investment factor, adjusted R square are respectively presented in the left part of the table, the corresponding t-statistics corrected for heteroscedasticity and autocorrelation using the Newey-West estimator and residual standard error are presented in the right part. Panel A is the regressions on six Size-B/P portfolios, across the columns are the two size groups (Small and Big) and across the rows are the three B/P groups (Low, Medium and High). Panel B is the regression results of six Size-OP portfolios, same as Panel A, across the columns are the two size groups and across the rows are the three OP groups (Weak, Neutral and Robust). Panel C is the regression results of six Size-Inv portfolios, across the columns are the two size groups and across the rows are the three Investment groups (Conservative, Neutral and Aggressive). Numbers in bold are the t-stats which are significant at 5% confidence level.

Regression: $R_{i,t} - R_f = a_i + b_i(R_{M,t} - R_f) + s_i SMB + h_i HML + r_i RMW + c_i CMA + e_{i,t}$

**Panel A Time-series regressions of six Size-B/P portfolios**

| | Book-to-Price (B/P) ratio | | | | | |
|---|---|---|---|---|---|---|
| | L | M | H | L | M | H |
| | | $a$ | | | t($a$) | |
| S | 0.0102 | 0.0105 | 0.0108 | **7.4308** | **4.4938** | **5.6696** |
| B | 0.0124 | 0.0091 | 0.0118 | **6.8522** | **3.8634** | **6.4458** |
| | | $b$ | | | t($b$) | |
| S | 0.9637 | 0.9964 | 0.9703 | **41.1513** | **36.2183** | **35.8284** |
| B | 0.8361 | 1.0214 | 0.8295 | **27.6969** | **28.5669** | **20.8687** |
| | | $s$ | | | t($s$) | |
| S | 1.0039 | 0.9383 | 0.8557 | **15.9153** | **16.3385** | **11.3131** |
| B | -0.1946 | -0.2434 | -0.0465 | **-2.8370** | **-2.4971** | -0.5165 |
| | | $h$ | | | t($h$) | |
| S | -0.5849 | -0.5197 | -0.2689 | **-6.2171** | **-6.9004** | **-3.9751** |
| B | -0.9928 | -0.6007 | 0.6912 | **-12.4860** | **-7.2244** | **5.1532** |
| | | $r$ | | | t($r$) | |
| S | -0.0695 | -0.1448 | -0.0617 | -1.1264 | -1.9122 | -0.7331 |
| B | 0.0188 | -0.0456 | 0.0110 | 0.2597 | -0.6538 | 0.1965 |
| | | $c$ | | | t($c$) | |
| S | 0.2515 | 0.1051 | 0.3064 | **2.6156** | 1.0264 | **2.3582** |
| B | 0.1114 | 0.2802 | 0.0565 | 1.2338 | **3.4851** | 0.5584 |
| | | Adj. R square | | | Residual standard error | |
| S | 0.9782 | 0.9714 | 0.9606 | 0.0120 | 0.0137 | 0.0148 |
| B | 0.9625 | 0.9609 | 0.9513 | 0.0122 | 0.0136 | 0.0134 |

**Table 5 Continued**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Panel B: Time-series regressions of six Size-OP portfolios** | | | | | | |
| | Operating Profitability | | | | | |
| | W | N | R | W | N | R |
| | | *a* | | | t( *a* ) | |
| S | 0.0012 | 0.0020 | -0.0018 | 0.5498 | 0.4592 | -1.0778 |
| B | -0.0009 | 0.0028 | 0.0021 | -0.5008 | 1.4503 | 0.6190 |
| | | *b* | | | t( *b* ) | |
| S | 1.0075 | 1.0408 | 1.0492 | **35.8879** | **20.1490** | **31.7018** |
| B | 1.1300 | 1.0253 | 1.0883 | **26.7879** | **34.3991** | **25.3012** |
| | | *s* | | | t( *s* ) | |
| S | 1.1712 | 0.9800 | 1.5637 | **13.2828** | **5.5382** | **18.1679** |
| B | 0.2480 | 0.2628 | -0.1445 | **2.3517** | **3.3480** | -1.1030 |
| | | *h* | | | t( *h* ) | |
| S | -0.4482 | -0.7244 | -0.2020 | **-4.5108** | **-3.9157** | -1.9726 |
| B | -0.4560 | -0.5496 | -0.7022 | **-4.4978** | **-5.9760** | **-6.6825** |
| | | *r* | | | t( *r* ) | |
| S | -0.3429 | -0.2601 | 1.1319 | **-4.6763** | **-2.5519** | **15.7233** |
| B | -0.2265 | -0.1198 | 0.2987 | **-3.5011** | -1.3591 | **3.4009** |
| | | *c* | | | t( *c* ) | |
| S | 0.2644 | 0.1610 | 0.5398 | **2.4244** | 0.7310 | **4.2483** |
| B | 0.4613 | 0.0414 | 0.1860 | **5.8956** | 0.3561 | 1.3955 |
| | | Adj. R square | | | Residual standard error | |
| S | 0.9720 | 0.9301 | 0.9653 | 0.0143 | 0.0238 | 0.0172 |
| B | 0.9643 | 0.9640 | 0.9486 | 0.0150 | 0.0139 | 0.0172 |
| **Panel C: Time-series regressions of six Size-Inv portfolios** | | | | | | |
| | Investment | | | | | |
| | C | N | A | C | N | A |
| | | *a* | | | t( *a* ) | |
| S | -0.0017 | 0.0018 | -0.0016 | -1.0068 | 0.8186 | -0.9026 |
| B | -0.0029 | 0.0003 | -0.0030 | -1.5573 | 0.1566 | -1.5819 |
| | | *b* | | | t( *b* ) | |
| S | 1.0274 | 1.0548 | 1.0708 | **35.4151** | **33.9728** | **31.3516** |
| B | 1.1116 | 1.0704 | 1.0683 | **27.7982** | **32.5243** | **27.9726** |
| | | *s* | | | t( *s* ) | |
| S | 1.1998 | 1.1137 | 1.2837 | **14.5888** | **14.7519** | **18.0777** |
| B | 0.4978 | 0.3165 | 0.4139 | **5.5174** | **4.7070** | **4.0713** |

**Table 5 Continued**

| | Investment | | | | | |
|---|---|---|---|---|---|---|
| | C | N | A | C | N | A |
| | | *h* | | | t(*h*) | |
| S | -0.5135 | -0.5369 | -0.2393 | **-4.8437** | **-6.2005** | **-2.2282** |
| B | -0.3527 | -0.4482 | -0.6269 | **-3.2055** | **-5.6888** | **-5.9485** |
| | | *r* | | | t(*r*) | |
| S | -0.0871 | -0.0789 | -0.1329 | -0.9804 | -0.8737 | -1.3784 |
| B | 0.0023 | -0.0330 | 0.0481 | 0.0249 | -0.5768 | 0.5404 |
| | | *c* | | | t(*c*) | |
| S | 0.5330 | -0.0210 | -0.7507 | **3.2129** | -0.2007 | **-4.8137** |
| B | 0.4623 | 0.0445 | -0.2540 | **3.7475** | 0.4260 | -1.9740 |
| | | Adj. R square | | | Residual standard error | |
| S | 0.9739 | 0.9713 | 0.9722 | 0.0141 | 0.0149 | 0.0148 |
| B | 0.9595 | 0.9680 | 0.9607 | 0.0160 | 0.0135 | 0.0157 |

Comparing the time-series regressions in Panel A with those (results are shown in Table A.2 of Appendix) of the six value-weighted SBP portfolios on FF3F model over the same time interval (July 2010 to May 2015), the results are quite similar for FF three factor (market beta, SMB and HML). The adjusted R-squares are much close between both regressions on FF3F Model and FF5F Model, it is suggested that FF profitability and investment factors seems not add explanatory power in capturing time-series variation of excess stock returns on Chinese A-share stock market during the sample period.

In Panel B, the regression results for market beta, SMB and HML are fairly close to those of Panel A, the big difference is in profitability factor RMW, all loadings on RMW except the BN portfolio are significant; and in each size group, portfolios with robust profitability tend to have higher excess returns than portfolios with weak profitability. Three out of six coefficients of investment factor CMA are significant, two are the portfolios with weak profitability (0.2644 for portfolio SW with t-stats 2.4244 and 0.4613 for portfolio BW with t-stats 5.8956) and one is the portfolio SR (coefficients 0.5398 with s-tats 4.2483).

In Panel C, the regression results of market factor, SMB and HML are all satisfactory significant. The loadings on RMW are similar to Panel A, none of which is significant at 5% confidence level. As for the CMA factor, three out of six loadings are significant, furthermore the three significant loadings are of the portfolios with conservative and aggressive investment. And the investment effect is close to the results of 25 Size-Inv portfolios in Fama and French (2014), the aggressive investment portfolios tend to have smaller even negative regression loadings, while the

conservative investment portfolios have relatively bigger regression loadings. In other words, the investment factor is negatively related to average excess stock returns.

To summarize, market beta always plays an important role in explaining time-series variation of excess portfolio returns. For all the three sets of portfolios, there exists size effect that the excess returns are negatively related to firm size; while the value effect exists only in SBP portfolios, not in Size-OP and Size-Inv portfolios. For the profitability factor RMW, the coefficients are only significant in the set of portfolios sorted by size and OP, but not in two other sets of portfolios. As to the CMA factor, there is positive relationship to the average returns for the small size-robust OP portfolio and negative relationship for the small size-aggressive investment portfolio (Size-Inv portfolios). However, for the Size-B/M portfolios, the CMA significant coefficients are relatively dispersive. In short, whether FF5F Model performs better than FF3F Model on Chinese A-share stock market over the sample period is not clear. The explanatory power of FF5F Model seems differs among different sets of portfolios. In comparison with FF3F Model, the presence of profitability and investment factors seem not capture more variations of expected stock returns than the three-factor model for at least for the six value-weighted portfolios formed on size and B/P ratio.

## 7 Comparing with U.S. stock market (FF5F Model)

Similarly, we compare the performance of FF5F Model on both Chinese A-share stock market and on U.S. stock market. We implement the same regressions in the previous section as reported in Table 5 using data of U.S. market. The six value-weighted Size-B/M portfolios, six Size-OP portfolios and six Size-Inv portfolios are downloaded directly from Kenneth R. French's website, the time-series regression results of the three sets of portfolios are presented in Appendix (Table A.3). The loadings on the excess market return are always strongly positive for all three sets of portfolios of both countries. The loadings on SMB are strongly positive for small stocks and slightly positive or negative for big stocks, there exists size effect on both stock markets.

We next compare between each panels of Table 5 (Chinese market) and Table A.3 (U.S. market). Comparing 'Panel A' of both tables, there exists value effect on both stock markets. As to the profitability factor RMW, four out of six loadings on RMW are statistically significant and specially all three loadings on small portfolios are negative significant in U.S.; while none of the loadings on RMW is significant at 5% confidence level in China.

Comparing Panel B of both tables, the regression results of six Size-OP portfolios are approximately close. All the loadings on profitability factor RMW are strongly significant, among which the loadings are strongly negative for the weak OP portfolios (low profitability) and strongly positive for the robust OP portfolios (high profitability) on U.S. stock market; while five

out of six loadings on RMW are significant on Chinese A-share stock market with the same pattern as U.S. market. It is noticed that the loadings on CMA factor are significant only for the three big size portfolios in U.S. We find no apparent value effect when regressing the six Size-OP portfolios on FF5F Model on both stock markets.

The regression results for the six Size-Inv portfolios are quite different comparing Panel C of both markets. First, most loadings on HML lose their significance (only one out of six is significant) in U.S.; while all the portfolios have strong negative exposure to HML on Chinese stock market but no value effect. Then the small size portfolios always have significant exposure to RMW in U.S.; while none of the loadings on RMW is significant on Chinese A-share stock market for the Size-Inv portfolios. Last, CMA factor seems explains more time-series variation of excess stock returns in U.S. than in China, since all the loadings on CMA are significant while only four out of six loadings are significant on Chinese stock market. The slopes of conservative (low investment) portfolios are positive and the slopes of aggressive (high investment) portfolios are negative on both markets, which is consistent with FF's expected pattern.

Furthermore, the adjusted R-squares of six Size-OP portfolios (with averaged adjusted R-squares 0.9545 on Chinese market, and 0.9861 on U.S. market) and six Size-Inv portfolios (with averaged adjusted R-squares 0.9676 on Chinese market, and 0.9855 on U.S. market) are slightly bigger in U.S than that in China, which indicates that FF5F Model explains the two sets of portfolios slightly better on U.S. stock market than on Chinese A-share stock market. In addition, the profitability factor and investment factor are able to capture partially time-series variation of all three sets of portfolios' returns on U.S. stock market, while on Chinese stock market, the profitability factor seems to be an explanatory factor only for the six value-weighted Size-OP portfolios.

## 8 Conclusions and Discussions

We apply the latest FF5F model on Chinese A-share stock market during the period July 2010 to May 2015 and construct three sets of portfolios following FF (2014), six value-weighted Size-B/P portfolios, six value-weighted Size-OP portfolios and six value-weighted Size-Inv portfolios. For all the three sets of portfolios, market factor, size factor and value factor have strong explanatory power for the expected excess returns in the presence of profitability and investment factors. There always exists size effect that the excess returns are negatively related to firm size, and the value effect exists only in SBP portfolios not in Size-OP and Size-Inv portfolios. The CMA factor do have explanatory power for certain portfolios in all three sets of portfolios. However, the RMW factor seems not so convincible, profitability effect exists only in six Size-OP portfolios, which excess returns are positively related to firms' profitability.

In comparison with FF3F Model, the presence of profitability and investment factors seem not having much additional explanatory power, and FF5F Model does not have significant improvement in explaining average excess stock returns comparing with the original three-factor model on Chinese A-share stock market during the research period July 2010 to May 2015.

Since the research period is relatively short in this study, we suggest to apply the examination with longer time interval for the FF5F Model on Chinese stock market in the future. Furthermore, since there exist several special features on Chinese stock market, the determinants for asset returns might be different from those in developed countries such as U.S. One possible extension of this study is to consider alternative factors instead of profitability and investment factors, such as factors related to macroeconomic variables (GDP growth, money supply and interest rate, etc.) and industry factors (such as industrial production), or particularly country factors considering Chinese special characteristics (such as policy of Chinese government) for the following researches.

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# Appendix

Table A.1 shows the annual number of stocks in 25 Size-OP portfolios and 25 Size-Inv portfolios, however, there is no firms in several Size-OP portfolios (portfolio S1P2 of year 2010, portfolio S2P5 of year 2010 and 2012), and all the portfolios except one (portfolio S2P1 of year 2011) of year 2010 and 2011 have no more than 5 firms. In this case we use the frame of six portfolios to test FF5F model on Chinese A-share stock market instead of the 25 portfolios.

**Table A.1 Annual number of stocks in 25 Size-OP portfolios and 25 Size-Inv portfolios**

This table presents the annual firm numbers in each 25 Size-OP portfolios (left-hand part) and 25 Size-Inv portfolios (right-hand part) from 2010 to 2014, in which, S indicates the size group, P is the profitability groups and I is the Investment groups. For instance, S1P1 portfolio indicates the intersection of firms in the bottom 20% size quintile and firms in the bottom 20% OP quintile, etc.

| | Year | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 | 2011 | 2012 | 2013 | 2014 | | 2010 | 2011 | 2012 | 2013 | 2014 |
| S1P1 | 1 | 5 | 27 | 38 | 167 | S1I1 | 155 | 131 | 130 | 152 | 149 |
| S1P2 | 0 | 4 | 20 | 39 | 131 | S1I2 | 82 | 67 | 89 | 111 | 112 |
| S1P3 | 1 | 1 | 7 | 15 | 86 | S1I3 | 44 | 56 | 72 | 70 | 80 |
| S1P4 | 1 | 1 | 2 | 6 | 44 | S1I4 | 32 | 52 | 49 | 52 | 56 |
| S1P5 | 3 | 1 | 2 | 4 | 21 | S1I5 | 19 | 90 | 100 | 64 | 64 |
| S2P1 | 5 | 8 | 25 | 41 | 129 | S2I1 | 87 | 88 | 116 | 105 | 121 |
| S2P2 | 2 | 2 | 17 | 34 | 113 | S2I2 | 68 | 97 | 92 | 108 | 113 |
| S2P3 | 1 | 2 | 16 | 23 | 104 | S2I3 | 60 | 56 | 69 | 93 | 97 |
| S2P4 | 2 | 2 | 3 | 6 | 73 | S2I4 | 50 | 48 | 73 | 63 | 68 |
| S2P5 | 0 | 4 | 0 | 5 | 28 | S2I5 | 66 | 108 | 88 | 83 | 62 |
| S3P1 | 5 | 5 | 30 | 42 | 88 | S3I1 | 66 | 94 | 82 | 109 | 92 |
| S3P2 | 3 | 8 | 31 | 42 | 107 | S3I2 | 81 | 89 | 101 | 99 | 101 |
| S3P3 | 3 | 2 | 7 | 27 | 104 | S3I3 | 71 | 69 | 98 | 86 | 100 |
| S3P4 | 0 | 0 | 2 | 5 | 101 | S3I4 | 54 | 60 | 73 | 84 | 94 |
| S3P5 | 1 | 3 | 3 | 5 | 45 | S3I5 | 60 | 82 | 86 | 73 | 75 |
| S4P1 | 21 | 25 | 33 | 45 | 54 | S4I1 | 55 | 69 | 77 | 72 | 69 |
| S4P2 | 18 | 21 | 37 | 46 | 83 | S4I2 | 60 | 90 | 99 | 83 | 95 |
| S4P3 | 9 | 17 | 31 | 44 | 110 | S4I3 | 81 | 84 | 84 | 106 | 95 |
| S4P4 | 9 | 12 | 9 | 27 | 126 | S4I4 | 65 | 78 | 85 | 100 | 96 |
| S4P5 | 2 | 4 | 5 | 10 | 69 | S4I5 | 69 | 75 | 95 | 91 | 108 |
| S5P1 | 27 | 35 | 40 | 41 | 42 | S5I1 | 35 | 41 | 55 | 51 | 59 |
| S5P2 | 34 | 43 | 48 | 45 | 49 | S5I2 | 64 | 90 | 71 | 83 | 66 |
| S5P3 | 42 | 53 | 75 | 78 | 72 | S5I3 | 77 | 112 | 113 | 98 | 91 |
| S5P4 | 39 | 62 | 72 | 78 | 109 | S5I4 | 84 | 100 | 128 | 125 | 122 |
| S5P5 | 31 | 53 | 46 | 61 | 166 | S5I5 | 71 | 53 | 72 | 94 | 124 |

**Table A.2 Time-series regression of six Size-B/P portfolios on FF3F Model on Chinese A-share stock market (period: July 2010- May 2015, 59 months)**

In this table, across the columns are the two size groups and across the rows are the three B/P ratio groups. The left part of the table is the coefficients obtained from the regressions ( $a$ is the intercept, $b$, $s$ and $h$ are the regression slopes of FF three factors separately) and adjusted R-square. Correspondingly, the right part of the table is t-statistics corrected for heteroscedasticity and autocorrelation using the Newey-West estimator with five-lags and the standard error of the estimation $e_{i,t}$. Numbers in bold are the t-statistics which are significant at 5% confidence level.

Regression: $R_{i,t} - R_f = a_i + b_i(R_{M,t} - R_f) + s_i SMB + h_i HML + e_{i,t}$

| | Book-to-Price (B/P) ratio | | | | | |
|---|---|---|---|---|---|---|
| | L | M | H | L | M | H |
| | | $a$ | | | t ( $a$ ) | |
| S | 0.0113 | 0.0113 | 0.0112 | **7.4842** | **4.5837** | **6.1412** |
| B | 0.0123 | 0.0092 | 0.0123 | **6.2322** | **3.3146** | **6.4849** |
| | | $b$ | | | t ($b$) | |
| S | 0.8979 | 0.9231 | 0.9059 | **32.6701** | **27.0157** | **32.2014** |
| B | 0.8504 | 1.0340 | 0.8424 | **27.3918** | **22.4104** | **22.1472** |
| | | $s$ | | | t ($s$) | |
| S | 0.9057 | 0.8874 | 0.8548 | **27.9738** | **15.5660** | **19.8422** |
| B | -0.1441 | -0.1149 | -0.0931 | **-3.4693** | -1.3686 | **-2.7201** |
| | | $h$ | | | t ($h$) | |
| S | -0.4025 | -0.3497 | -0.0262 | **-5.0751** | **-4.3756** | -0.4383 |
| B | -0.9630 | -0.4761 | 0.6607 | **-15.1937** | **-5.5671** | **7.1594** |
| | | Adj. R-square | | | Residual standard error | |
| S | 0.9803 | 0.9782 | 0.9746 | 0.0114 | 0.0120 | 0.0119 |
| B | 0.9623 | 0.9545 | 0.9542 | 0.0122 | 0.0147 | 0.0130 |

**Table A.3 Time-series regressions of six value-weighted Size-B/M portfolios, Size-OP portfolios and Size-Inv portfolios on FF5F Model on U.S. stock market (period: July 2010 to May 2015, 59 months)**

This table presents the time-series regressions results of FF5F model. In each panel, the regression intercept $a$, the regression coefficients $b$, $s$, $h$, $r$ and $c$ of market factor, size factor, value factor, profitability factor and investment factor, adjusted R square are respectively presented in the left part of the table, the corresponding t-statistics corrected for heteroscedasticity and autocorrelation using the Newey-West estimator and residual standard error are presented in the right part. Panel A is the regressions on six Size-B/M portfolios, across the columns are the two size groups (Small and Big) and across the rows are the three B/M groups (Low, Medium and High). Panel B is the regression results of six Size-OP portfolios, same as Panel A, across the columns are the two size groups and across the rows are the three OP groups (Weak, Neutral and Robust). Panel C is the regression results of six Size-Inv portfolios, across the columns are the two size groups and across the rows are the three Investment groups (Conservative, Neutral and Aggressive). Numbers in bold are the t-stats which are significant at 5% confidence level.

Regression: $R_{i,t} - R_f = a_i + b_i(R_{M,t} - R_f) + s_i SMB + h_i HML + r_i RMW + c_i CMA + e_{i,t}$

**Panel A: Time-series regressions on six Size-B/M portfolios**

| | Book-to-Market (B/M) ratio | | | | | |
|---|---|---|---|---|---|---|
| | L | M | H | L | M | H |
| | | $a$ | | | t ($a$) | |
| S | -0.2123 | -0.0328 | 0.2391 | -1.2440 | -0.3040 | 1.4394 |
| B | 0.0339 | -0.0369 | 0.0197 | 0.2766 | -0.2794 | 0.1673 |
| | | $b$ | | | t ($b$) | |
| S | 0.9867 | 1.0036 | 0.8091 | **18.0426** | **37.3893** | **18.0305** |
| B | 1.0715 | 1.1142 | 1.0577 | **30.4708** | **21.6453** | **42.6438** |
| | | $s$ | | | t ($s$) | |
| S | 0.7036 | 0.7975 | 0.4312 | **13.4733** | **17.5148** | **5.5548** |
| B | 0.2231 | 0.1980 | 0.1550 | **4.6577** | **3.4748** | **2.2473** |
| | | $h$ | | | t ($h$) | |
| S | -0.2137 | 0.2549 | 0.3912 | **-2.0573** | **4.1878** | **3.8325** |
| B | -0.2152 | 0.0582 | 0.6456 | **-4.9748** | 0.9063 | **9.2306** |
| | | $r$ | | | t ($r$) | |
| S | -0.7327 | -0.1351 | -0.3846 | **-5.4871** | **-2.2599** | **-3.0270** |
| B | -0.1506 | -0.0322 | 0.0110 | **-2.7377** | -0.3318 | 0.1531 |
| | | $c$ | | | t ($c$) | |
| S | -0.3047 | -0.2155 | -0.0974 | **-2.7655** | **-2.3334** | -0.7657 |
| B | -0.2294 | -0.0887 | -0.1666 | **-2.3567** | -1.1923 | -1.4554 |
| | | Adj. R-square | | | Residual standard error | |
| S | 0.9517 | 0.9733 | 0.9084 | 0.0115 | 0.0080 | 0.0125 |
| B | 0.967 | 0.9591 | 0.958 | 0.0077 | 0.0088 | 0.0089 |

**Table A.3 Continued**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Panel B: Time-series regressions on Size-OP portfolios** | | | | | | |
| | Operating Profitability | | | | | |
| | W | N | R | W | N | R |
| | | *a* | | | t ( *a* ) | |
| S | -0.0188 | 0.0898 | -0.0396 | -0.3438 | 1.1708 | -0.4349 |
| B | -0.0842 | 0.0989 | -0.0640 | -0.7461 | 2.2880 | -1.9871 |
| | | *b* | | | t (*b*) | |
| S | 0.9812 | 0.9853 | 1.0646 | **81.0285** | **51.1117** | **32.7726** |
| B | 1.1136 | 0.9412 | 1.0298 | **27.2225** | **50.5000** | **97.2971** |
| | | *s* | | | t (*s*) | |
| S | 0.8675 | 0.9675 | 0.9317 | **33.4687** | **20.9395** | **14.3934** |
| B | -0.0693 | -0.0541 | -0.1339 | -1.0857 | -1.2950 | **-4.5316** |
| | | *h* | | | t (*h*) | |
| S | -0.1143 | 0.2669 | 0.2011 | **-4.5007** | **6.3486** | **3.9980** |
| B | 0.2443 | 0.0392 | -0.0708 | **4.5818** | 1.0984 | **-2.7060** |
| | | *r* | | | t (*r*) | |
| S | -0.6348 | 0.2597 | 0.4475 | **-18.4610** | **5.1374** | **9.5450** |
| B | -0.5864 | -0.1016 | 0.3304 | **-8.4796** | **-2.7847** | **12.2607** |
| | | *c* | | | t (*c*) | |
| S | 0.0768 | -0.0627 | -0.1247 | 1.6662 | -1.0611 | -1.5351 |
| B | -0.2849 | 0.1389 | -0.0839 | **-3.0221** | **2.6995** | **-2.0856** |
| | | Adj. R-square | | | Residual standard error | |
| S | 0.9945 | 0.9851 | 0.9826 | 0.0040 | 0.0058 | 0.0063 |
| B | 0.9775 | 0.9863 | 0.9903 | 0.0069 | 0.0041 | 0.0033 |
| **Panel C: Time-series regressions on Size-Inv portfolios** | | | | | | |
| | Investment | | | | | |
| | C | N | A | C | N | A |
| | | *a* | | | t ( *a* ) | |
| S | -0.0540 | 0.1144 | 0.0071 | -0.8730 | **2.3620** | 0.1573 |
| B | 0.0831 | -0.0428 | 0.0259 | 1.1236 | -0.7299 | 0.4733 |
| | | *b* | | | t (*b*) | |
| S | 1.0880 | 0.9710 | 0.9681 | **81.6853** | **35.9423** | **47.1125** |
| B | 0.9326 | 0.9912 | 1.0521 | **32.4959** | **48.6599** | **77.8118** |
| | | *s* | | | t (*s*) | |
| S | 0.8760 | 0.8942 | 0.9702 | **19.7427** | **26.8312** | **30.5318** |
| B | -0.0835 | -0.0167 | -0.1786 | **-2.1632** | -0.9118 | **-5.7904** |

**Table A.3 Continued**

| | Investment | | | | | |
|---|---|---|---|---|---|---|
| | C | N | A | C | N | A |
| | | *h* | | | t (*h*) | |
| S | -0.0163 | 0.1754 | 0.0238 | -0.3663 | **5.4018** | 0.7234 |
| B | -0.0260 | 0.0615 | -0.0658 | -0.4450 | 1.3401 | -1.4661 |
| | | *r* | | | t (*r*) | |
| S | -0.2339 | 0.1339 | -0.2181 | **-5.6108** | **3.5684** | **-4.7274** |
| B | -0.0001 | 0.0573 | -0.0174 | -0.0013 | 1.1884 | -0.3659 |
| | | *c* | | | t (*c*) | |
| S | 0.3567 | 0.1159 | -0.4264 | **5.2777** | **2.0770** | **-7.7210** |
| B | 0.6429 | 0.1819 | -0.5734 | **7.3145** | **3.4479** | **-8.1165** |
| | | Adj. R-square | | | Residual standard error | |
| S | 0.9908 | 0.9879 | 0.9907 | 0.0051 | 0.0051 | 0.0048 |
| B | 0.9764 | 0.9872 | 0.9799 | 0.0054 | 0.0041 | 0.0052 |