

# Does the Sci-Tech Innovation Board Make the Chinese Market Better? From the Perspective of the Factor Model

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**Abstract.** Given different views on the practicality of the multi-factor models in the Chinese stock market, this paper combines this very advanced pricing model with the newly established Chinese board, aiming to explore a pricing model applicable to the Chinese market. The selected data is all the quoted companies in the Sci-Tech Innovation Board from 2020/06/05 to 2022/04/15. The explanatory power of each multi-factor model to the board and their effects on the model are studied. In particular, this paper includes redundancy tests, GRS tests, and regressions. The main conclusions deduced from this experiment are: first, the three-factor model is very significant in all aspects; second, the five-factor model is more significant in some groups, and there is a significant difference after adjustment by the five-factor model—the book-to-market ratio effect and profitability effect. Nonetheless, since many imperfections exist within the system of the Chinese stock market and many regulations might have significant changes in the future, continuing to explore other pricing factors appropriate for the market is still the main research orientation in this field.

**Keywords:** The Sci-Tech Innovation Board, Asset Pricing Model, Return of Stock's Portfolio.

## 1. Introduction

With the continuous development of economic globalization, countries attach increasing importance to scientific and technological innovation [1]. In 2018, China entered a new era where technological innovation drives economic growth. Meanwhile, the Sino-US trade friction has intensified, and the technology blockade has forced China to speed up independent innovation. In this context, the Sci-Tech Innovation Board (STAR Market), focusing on high-tech and strategic emerging companies, has been listed on the Shanghai Stock Exchange. Since July 22, 2019, the STAR Market has shown good development momentum. As of April 15, 2022, there were 420 listed stocks in this sector with a total capitalization of 4.18 trillion yuan, an increase of nearly 660% compared with 0.55 trillion yuan at the beginning of the sector's issuance. Thus, as a rising sector that has occupied a considerable quota of the Chinese stock market (A-share Market), its ponderance cannot be ignored. So far, few scholars have evaluated the return of the STAR Market, so this paper intends to conduct a statistical evaluation of the STAR Market based on Fama-French (F-F)'s multi-factor models.

In finance, asset pricing behavior is crucial for a trader to decide, and there are abundant pricing models used on the market. A good pricing model may reflect the fundamental values of a portfolio of stocks well. On the contrary, mispricing assets might lead to a significant loss [2]. The multi-factor models proposed by Fama and French have been acknowledged widely in the academic community. The three-factor model reveals that beyond the constant risk, company size and book-to-market ratio are also essential [3]. Then, Carhart added a momentum factor for complement [4]. However, some scholars proved that the three-factor model loses to seize some variation in returns attached to profitability and investment. Aharoni showed a considerable negative correlation between capital investments and expected returns [5]. Marx showed that profitability is positively correlated with the expected returns [6]. Then, the five-factor model arose from the previous model, which considered

both profitability and investment factors. And its practicality has successfully conformed in the international market [7].

Unlike the developed stock market, the A-share market has developed for a comparatively shorter period. The early A-share market was incomplete, leading to obscure information disclosure of listed companies, so many uncertain factors disturbed stock prices. Moreover, since variations in factors can lead to different performances of the same asset pricing model, empirical results obtained by early scholars in China using F-F models are quite different [8]. Taking papers using the three-factor model as examples, Wu and Xu found a noticeable book-to-market ratio effect and size effect in the A-share market [9]. However, Wang et al. found that the effect of size is salient in the A-share market while the B/M ratio effect is insignificant [10]. Later, after Fama and French unveiled the five-factor model, scholars began to pay attention to the applicability of profitability and investment and updated their studies based on the three-factor model [7]. At the same time, there were still differences in their results. Yan et al. proposed that compared to the American market, the three-factor model is more pragmatic for the Chinese market. Neither profitability nor investment factors explain the returns of stock portfolios [11]. Otherwise, Gao and Zhou claimed that the laws of the Chinese market are better illustrated by the five-factor model [12]. Zhang et al. pointed out that size, profitability, and book-to-market ratio effects are remarkable in the A-share market, but the investment factor is redundant [13]. Furthermore, Li et al. claimed that the five-factor model has a stronger interpretative ability about the Chinese stock market than the three-factor model and the Carhart four-factor model [14]. Given that the academic circles on the feasibility of the five-factor model in China's stock market conclusions are different, this paper has pragmatic significance in combination with one of the forefront pricing models and the STAR Market.

On the basis of the F-F multi-factor models and the data of listed companies on the STAR Market, this paper mainly explores the interpretative ability of the multi-factor pricing models on the STAR Market and the effect of each factor on the board. This paper proceeds as follows. Section 2 introduces the STAR Market. Section 3 states the samples and methodology. Section 4 elaborates on the empirical results. And the last section concludes the paper.

## **2. The Sci-Tech innovation board**

Since the STAR Market's establishment, it has shown an excellent development trend. As of April 2022, the board has listed more than 400 companies, and the total market capitalization growth is more than 600% compared to the early days of its start-up. There are three main differences between the STAR Market and the originally existing mainboard.

One difference is the targeted type of listed companies. The STAR Market mainly focuses on supporting high-tech and strategic emerging industries like IT, bio pharmacy, and new energy. In contrast, the mainboard has more than 50 traditional sub-sectors, such as finance, real estate, and mining. Figure 1 is the specific industrial classification of the STAR Market.

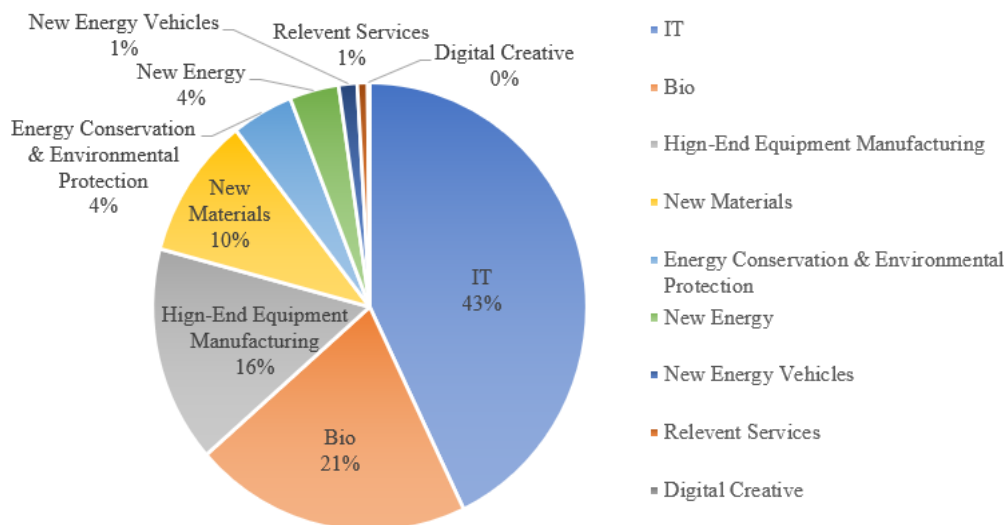


Figure 1. Industrial Distribution on the STAR Market

Second, the trading mechanism of the STAR Market is different from the originally existing mainboard. Compared with the mainboard, the STAR Market has expanded the trading limits, raising the limit on daily price variation from 10% to 20%. Although the price limit mechanism is considered one of the most critical market stabilization mechanisms globally, the debate on its effect is widespread [15]. Chen et al. found that when the equilibrium price deviates significantly from the current stock price, the limit on the price will cause informed investors to postpone the current transaction and delay the realization of the equilibrium price [16]. Hu's research also shows that the price limit mechanism of the Chinese stock market is inefficient [17]. Therefore, liberalizing the price limit is indispensable to a fully developed international market.

In addition, as opposed to the originally existing mainboard with no threshold for investors, opening the STAR Market investment authority requires the investor to have an account with at least two years of stock trading experience and 500,000 RMB. Thus, fewer retail investors are involved in the new board due to the threshold. To a certain extent, it may protect most inexperienced retail investors and reduce the valuation premium caused by irrational trading operations.

In summary, the development of the STAR Market is imperative because it can enhance market liquidity and promote the improvement of the Chinese stock market. Moreover, there are still minimal studies on the pricing and the returns of the board. Therefore, the research on the board is of great significance.

### 3. Sample, Variables, and Models

#### 3.1 Samples selection

We use the database provided by iFind and CSMAR, which are based on the integration of exchange authorization data and authoritative public information of the listed company. Since the listing of the STAR Market is not long, and some of the early data are insufficient, this paper excludes some of the early data. It only selects the weekly data of the listed companies from 2020/6/5 to 2022/4/15 as the sample. The selected data includes the B/M ratio, market value of shares outstanding, operating profit, shareholders' equity, and total equity. Consistent with much of the academic literature, we choose the latest 3-month deposit rate published by the People's Bank of China as the risk-free interest rate[15].

#### 3.2 Model and data processing

The F-F Five-Factor Model is as follows,

$$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_iSMB_t + h_iHML_t + r_iRMW_t + c_iCMA_t + e_{it} \quad (1)$$

In this equation,  $t$  is the period,  $R_{it}$  is the portfolio  $i$  return,  $R_{Ft}$  is the risk-free return,  $R_{Mt}$  is the return of the value-weight market portfolio,  $SMB_t$  is the difference of the portfolio return between small and large size,  $HML_t$  is the difference of the returns between high and low B/M ratios,  $RMW_t$  is the difference of the returns between robust and weak profitability,  $CMA_t$  is the difference of the returns between conservative and aggressive investment firms, and  $e_{it}$  is the zero-mean residual.  $b_i$ ,  $s_i$ ,  $h_i$ ,  $r_i$ , and  $c_i$  are responsible for seizing alternation expected returns, and  $a_i$  is used to be determined the intercept [18].

Since the STAR Market has been set up for a relatively short period, we modified the monthly grouping method in F-F's studies to the weekly grouping method [14]. For portfolio  $i$ , both its market value ( $Size_{it}$ ) and book-to-market ratio ( $B/M_{i,t}$ ) adopt the data from the latest disclosures. Given the differences between Chinese and American accounting standards [14], we directly use the operating profit divided by stockholders' equity to indicate the profitability index of the A-share market. Investment ( $Inv_{it}$ ) is calculated by dividing the latest quarterly disclosures by the previous quarterly disclosures.

This paper adopts the 2\*3 grouping method put forward by Fama and French to test the conclusions [18]. First, all data are segmented into small (S) and large size (B) groups on the basis of the median value. And all data were segmented into high (H), medium (N), and low (L) groups based on the 30% and 70% percentile. Secondly, all data were segmented into six portfolios by size and book-to-market ratio: SH, SN, SL, BH, BN, and BL. Thirdly, profitability and investment are used to substitute the B/M ratio. Then, the 12 portfolios came out as SR, SN, SW, BR, BN, SC, SN, SA, BC, BN, and BA. Then calculate the weighted equal-average returns of each period of the portfolios. The risk factors' calculation methods are shown in Table 1.

Table.1. Calculation Methods for Risk Factors.

Breakpoints	Calculation Methods for Risk Factors
Size: STAR median	$SMB_{B/M} = \frac{SH + SN + SL}{3} - \frac{BH + BN + BL}{3}$
	$SMB_{OP} = \frac{SR + SN + SW}{3} - \frac{BR + BN + BW}{3}$
	$SMB_{Inv} = \frac{SC + SN + SA}{3} - \frac{BC + BN + BA}{3}$
	$SMB = \frac{SMB_{B/M} + SMB_{OP} + SMB_{Inv}}{3}$
B/M: 30th and 70th STAR percentiles	$HML = \frac{SH + BH}{2} - \frac{SL + BL}{2}$
OP: 30th and 70th STAR percentiles	$RMW = \frac{SR + BR}{2} - \frac{SW + BW}{2}$
Inv: 30th and 70th STAR percentiles	$CMA = \frac{SC + BC}{2} - \frac{SA + BA}{2}$

In addition, this paper also explores the applicability of the Carhart four-factor model in the STAR Market [4]. The approach to calculating the MOM is the same as the 2 \* 3 method above.

## 4. Results analysis

### 4.1 Preliminary descriptive statistics

We investigated weekly data of the STAR Market from 2020/6/5 to 2022/4/15. The empirical results of the multi-factor models on the STAR Market are reported below.

Table.2. Descriptive statistics of factors in the STAR Market (2 \* 3)

	$R_M - R_f$	SMB	HML	RMW	CMA	MOM
<b>Mean</b>	-0.29	-0.32	0.64**	0.76***	0.46**	-0.11
<b>t - Statistic</b>	-0.75	-1.13	2.12	3.21	-2.43	-0.39

Notes: The unit is “%”; \*\*/\*\*\* indicate that the value is significant at 5% / 1% level.

Table 2 is the descriptive statistics of the five factors. It reveals that the average value of the profitability factor is salient at the 1% level; the mean of the B/M ratio factor and investment factor is salient at the 5% level. However, the mean of the factor returns is an elementary descriptive statistic, which is inadequate to judge the significance of the factor in the STAR Market. Since the return can be affected by variations of other relevant factors, a test for redundancy might be more accurate and appropriate [14].

Table.3. Test for market characteristics' effect &amp; Test for redundancy

	Test for Market Characteristics' Effect			Test for Redundancy				
	RMW	CMA	MOM	$R_m - R_f$	SMB	HML	RMW	CMA
<b>2*3 alpha</b>	0.92***	-0.62***	0.03	0.68*	-0.04	1.08**	0.78**	-
<b>t- statistics</b>	4.22	-3.76	0.4	1.695	-	4.31	3.35	0.50***
					0.133	4.31	3.35	-2.79

Notes: The unit of “ $\alpha$ ” is “%”; \*\*/\*\*\* indicate that the value is significant at 5% / 1% level.

We conduct regressions about the profitability, investment, and momentum returns for the market characteristics' effect. We used two factors to seize the average return of the third. The alpha value is the intercept term, representing the value premium. It can be seen in Table 3 that both effects of profitability and investment are still significant. Therefore, it seems feasible to consider profitability and investment factors. Otherwise, the effect of momentum is relatively weak.

Then, we further conduct regressions to examine the effects of all the five factors. We determined the average returns of the fifth by the other four factors. The test for redundancy in table 3 shows that the effects of risk, book-to-market ratio, profitability, and investment are significant, while the effect of the market size is insignificant. Thus, for the data in the STAR Market from 2020 to 2022, SMB is redundant to capture describing average returns. Nonetheless, this result does not meet the theory of the three-factor model. Considering that the period of the STAR Market is relatively short and the difference in the market value of most companies is not evident, the redundancy of the SMB factor in the sample is intelligible.

#### 4.2 Regression analysis

This paper adopts the 2 \* 3 method for regression. And we present intercepts and slopes of regression from equation (1) for the 25 Size-OP shown in Table 4. According to the discussion before, after the three-factor model's adjustment, the momentum factor does not have a remarkable risk premium. Adding it will not conspicuously ameliorate the model's performance, so we will not report the regression coefficient of the four-factor model here.

Panel A states the intercept for the three-factor model. It demonstrates that only a few intercepts are distinctly different from 0, indicating a sufficient three-factor model explanation for average returns. As shown in Panel B, the five-factor model has a better expression. The intercepts for many groups tend to be closer to zero, meaning that the added two factors absorb additional excess return. The most extreme five-factor intercept of - 0.52 ( $t = - 2.25$ ) is moderate compared to the most extreme intercepts of the other categories.

Panel B also shows the factors' slopes for HML, RMW, and CMA. This paper does not present the market and SMB slopes. The market slopes tend to be approximate to one. Although the redundancy

test reveals that SMB is redundant, the regression results show that most SMB slopes are significantly positive at the 10% level, proving that SMB has a robust explanatory ability to the STAR Market. Moreover, the market slope and SMB slope are similar across models, not altering the intercepts when adding factors. Hence, we will pay more attention to HML, RMW, and CMA.

Furthermore, Panel B reveals that the HML slopes significantly positively impact microcap portfolios when controlling for other factors. In contrast, HML slopes tend to impact mega-cap portfolios negatively. These indicate that it exists an apparent size effect in the STAR Market. We also find a book-to-market ratio effect since the lowest OP quintile portfolios always have a higher slope than those in the highest. The same pattern happens to the CMA slopes with weaker features, revealing a weak investment effect. In addition, the RMW slopes significantly negatively impact the portfolios in the lowest OP quintile, while most of the highest OP quintile portfolios have significantly positive RMW slopes. Therefore, we can observe a significant profitability effect.

Table.4. Regressions for Size-OP portfolios

Panel A: Three-factor model										
Inv	Low	2	3	4	High	Low	2	3	4	High
a					t(a)					
<b>Smal</b>	-0.5**	-0.20	0.21	0.72**	1.12***	-	-	0.71	2.21	2.67
<b>1</b>						2.61	1.07			
<b>2</b>	-0.24	0.01	-0.26	0.39	0.51	-	0.05	-	1.63	1.33
<b>3</b>	-	-0.13	-0.02	0.00	1.00***	-	-	-	0.02	2.84
<b>4</b>	0.69***					2.66	0.47	0.09		
<b>Big</b>	0.21	0.48	-0.10	0.34	0.98***	0.58	1.57	-	0.97	2.89
	-0.29	-0.43	-0.23	0.49*	0.30	-	-	-	1.82	1.03
						0.79	1.20	0.69		
Panel B: Five-factor model										
Inv	Low	2	3	4	High	Low	2	3	4	High
a					t(a)					
<b>Smal</b>	-0.20	0.05	-0.11	0.78**	0.78	-	0.25	-	2.09	1.63
<b>1</b>						0.97		0.34		
<b>2</b>	0.34	0.11	-0.52**	0.08	-0.32	1.01	0.42	-	0.30	-0.83
<b>3</b>	-0.40	-0.01	0.01	-0.21	0.70*	-	-	0.04	-	1.74
<b>4</b>	-					1.38	0.04	0.04	0.77	
<b>Big</b>	0.46	0.48	-0.47	0.51	0.44	1.13	1.36	-	1.27	1.22
	0.39	0.08	-0.06	0.21	-0.31	1.11	0.19	-	0.71	-1.10
								0.17		
h					t(h)					
<b>Smal</b>	0.42***	0.29***	0.42**	0.25*	0.32*	5.24	3.62	3.38	1.74	1.78
<b>1</b>			*							
<b>2</b>	0.11	0.34***	0.36**	0.27***	0.27*	0.82	3.48	4.09	2.73	1.85
<b>3</b>	-0.03	0.22*	*							
<b>4</b>	-0.03	0.22*	-0.05	0.15	0.08	-	1.91	-	1.46	0.53
	-0.02	0.06	-0.15	-0.3*	0.00	0.29	0.45	0.53		
						0.10		-	1.96	-0.02
								0.83		

<b>Big</b>	0.41***	0.52***	-0.31**	-0.2*	0.31***	3.06	3.37	2.15	1.74	-2.86
	<b>r</b>					<b>t(r)</b>				
<b>Small</b>										
<b>1</b>	0.25***	-0.21**	0.13	-0.19	0.33	2.81	2.28	0.96	1.19	1.61
<b>2</b>	-0.27*	-0.09	0.14	0.04	0.77***	1.85	0.77	1.40	0.37	4.66
<b>3</b>	-0.30**	-0.28**	-0.05	0.15	0.16	2.41	2.11	0.48	1.27	0.92
<b>4</b>	-0.4**	-0.04	0.05	0.17	0.54***	2.30	0.28	0.24	0.97	3.48
<b>Big</b>	0.97***	-0.32*	0.10	0.3**	0.70***	6.49	1.88	0.60	2.27	5.69
	<b>c</b>					<b>t(c)</b>				
<b>Small</b>										
<b>1</b>	0.11	0.11	-0.31*	-0.19	-0.06	0.90	0.90	1.69	0.91	-0.23
<b>2</b>	0.53***	0.03	-0.21	0.44***	-0.18	2.81	0.21	1.60	2.96	-0.84
<b>3</b>	0.03	-0.23	-0.03	-0.12	-0.26	0.18	1.30	0.22	0.81	-1.13
<b>4</b>	-0.19	-0.06	-0.53**	0.51**	-0.05	0.85	0.33	2.06	2.25	-0.26
<b>Big</b>	-0.34*	0.34	0.41*	-0.01	0.04	1.74	1.52	1.93	0.05	0.28

Notes: \*/\*\*/\*\* indicate that the value is significant at 10% / 5% / 1% level.

### 4.3 Model performance evaluation

Next, we turn to testing the performance of multi-factor models. The summary statistics for multi-factor tests are shown in table 5, which obtain the extra weekly returns on 25 Size-Inv and 25 Size-OP portfolios. These summary statistics include GRS statistics,  $A|a|$ ,  $A|a|/A|r|$ , and  $A|a|^2/A|r|^2$  [18].

For size-Inv portfolio returns, the four-factor model lowers GRS statistic from 2.73 ( $p=0.0006$ ) to 2.69 ( $p=0.0007$ ). Though the four-factor model amonites the performance of the three-factor model slightly, the five-factor model lowers the GRS statistic obviously from 2.69 to 1.52 ( $p=0.0913$ ). Most importantly, the three- and four-factor models are not rejected by GRS statistics at a 1% confidence interval and the five-factor model at a 10% confidence interval, which is a remarkable finding for the Chinese market. Meanwhile, the four-factor model don't significantly reduce other four statistics, but the five-factor model lower  $A|a|$  from 0.40 to 0.32, decrease  $A|a|/A|r|$  from 0.18 to 0.15, and reduce  $A|a|^2/A|r|^2$  from 0.05 to 0.04.

For size-OP portfolio returns, the same pattern is observed. The four-factor model lowers GRS statistic from 1.89 ( $p=0.0209$ ) to 1.87 ( $p=0.0228$ ) and the five-factor model lowers GRS from 1.87 to 1.30 ( $p=0.1970$ ). Unfortunately, though the three- and four-factor models are not rejected by GRS statistics at a 5% confidence interval, the five-factor model is rejected at a 5% confidence interval. And similar improvement pattern is observed in the other three statistics.

Table.5. Test statistics for models

	GRS	$A a $	$\frac{A a }{A r }$	$\frac{A a ^2}{A r ^2}$
<b>Panel A: 25 Size-Inv portfolios</b>				
<b>Three-factor model</b>	2.73	0.40	0.18	0.05
<b>Four-factor model</b>	2.69	0.39	0.18	0.05
<b>Five-factor model</b>	1.52	0.32	0.15	0.04
<b>Panel B: 25 Size-OP portfolios</b>				
<b>Three-factor model</b>	1.89	0.39	0.18	0.05
<b>Four-factor model</b>	1.87	0.40	0.19	0.05
<b>Five-factor model</b>	1.30	0.32	0.15	0.03

## 5. Conclusions

The paper selects the data of all listed companies on the STAR Market from 2020 to 2022 as samples. And it tests the rate of return on the STAR Market on account of the F-F multi-factor models. It is worth noting that, unlike F-F's method of obtaining data values monthly, due to the short time to market on the STAR Market, this paper mainly uses weekly data to increase the sample size and empirically obtain positive results. The feasibility of using weekly data is also demonstrated. Finally, the main results obtained are as follows: first, the three-factor model is very significant in all aspects; second, the five-factor model is more significant in some groups, and there is a significant difference after adjustment by the five-factor model—the book-to-market effect and profitability effect.

This paper aims to explore a pricing model that is more pragmatic for the Chinese capital market. To a certain extent, it provides a reference for further revealing the law of asset pricing in the Chinese capital market. In the past, most scholars believed that the five-factor model was not applicable to the A-share market. However, this paper verifies the practicality of the five-factor model in the STAR Market. The difference in this conclusion may be because: the A-share market is mainly dominated by retail investors, most of whom have no professional investment experience. In contrast, in the STAR Market, the proportion of retail investors is small due to investment thresholds and other reasons. The proportion of professional, institutional investors is high, so the role of pricing factors will be more significant.

However, due to the short time of listing on the STAR Market and the fact that many systems in the Chinese capital market are still immature, the current data may not comprehensively analyze the laws of the market. Therefore, exploring and verifying various factors to find a pricing model suitable for China's capital market is still the main research direction in this field in the future.

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