

An Application of Multi-Factor Model on Anomaly in China Stock Market

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Abstract

The traditional finance theories have been foundational in understanding financial markets. However, the discovery of anomalies has posed challenges to the established theories. These anomalies, including the equity premium puzzle, scale effect, overreaction, and reversal effect, have questioned classical finance theories. In response to these challenges, the field of behavioral finance emerged, offering insights into market behavior from the perspective of investor psychology and cognitive biases. Our paper contributes to this ongoing dialogue by examining 37 anomalies in the Chinese stock market. It seeks to understand the existence of these anomalies and evaluate the ability of asset pricing models to explain them. Our findings suggest that these models have substantial explanatory power, offering valuable insights for wealth management institutions in attributing investment performance. We underscore the importance of continuously refining financial theories to better capture the complexities of real-world markets and informs practical investment strategies in an ever-changing landscape.

Keywords: Multi-Factor Model, Asset Pricing Theory, Anomalies, Excess Returns

INTRODUCTION

Bloomberg (2021) reports that the Shanghai and Shenzhen stock markets are ranked third and seventh places respectively in terms of market capitalization. Sum of market capitalization in Shanghai and Shenzhen stock markets are the second largest securities markets in the world. If the Hong Kong market is added, the total market capitalization of the China stock market has already reached that of the U.S. Nasdaq. As a leading place in emerging markets, China has a broad range of influence in international trade, commodity manufacturing and geopolitics. However, its capital market is still relatively incomplete. For example, the turnover rate per capita in the China stock market is ten times higher than that of the U.S. stock market. There are more deep-seated reasons behind the high turnover rate. The current China stock market is undergoing rapid internationalization and capital expansion, which requires an objective and complete asset pricing mechanism for wealth managers to perform their decisions, which requires the employment of the asset pricing models. The China stock market has a relatively unique institutional structure and its market anomalies might be different from those of developed countries. Therefore, it is necessary and urgent for investment institutions, academics, and investors who are interested in expanding their business in China to study the factors of excess returns in Chinese stock market.

As it starts from the establishment of China stock market in November 1990, the security market in China has gone through many stages of development and generated many unique market phenomena, such as policy market, short bull and long bear, ownership discrimination, liquidity stratification, institutional grouping and shell resources. These terms are the traces of policies. Those have profoundly influenced the past and future in China stock market. At the same time, it also shapes the anomalies with China's characteristics. In the literature, the researchers have found no less than 400 anomalies. The performance of these anomalies in the China stock market is an issue of curiosity to the academic community in recent years. Therefore, there is a need to study a high growth, representative stock market both from the perspective of investment decision making and academic research. In the literature, most of the papers were on the application of asset pricing models in the China stock market or examined the returns of a few anomalies. Fewer paper has employed China's data to conduct a comprehensive and systematic factor examination.

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LITERATURE REVIEW

Since the 1960s, the relationship between risk and returns in the capital market was first clearly depicted with the Capital Asset Pricing Model (CAPM hereafter), a simple linear factor model that states that the expected excess return of an asset is determined by the expected return of the market and the exposure of the asset to the market risk, also known as the market factor. The CAPM kicked off a large number of subsequent studies on linear multi-factor pricing models. It was gradually discovered that the returns of different assets were not determined by a single market factor, but were influenced by other factors as well. Ross(1976) proposed Arbitrage Pricing Theory (APT), which is a further extension of the CAPM, to constitute a multi-factor pricing model. The multi-factor model assumes that the expected return of an asset portfolio is determined by the following multivariate linear model.

$$E(R_i^e) = \beta_i X \tag{1}$$

$E(R_i^e)$ denotes the expected excess returns of the asset portfolio. β_i is the exposure factor of the portfolio and X stands for the expected factor return, also known as factor risk premium. Like the CAPM model, the multi-factor model assumes that the expected return of the asset portfolio $E(R_i^e)$ is determined by the expected return of a series of factors on the right hand side of equation (1) and the portfolio's exposure to these factors (β_i). In other words, the expected return of a portfolio is determined by its exposure to these factors.

Equation (1) represents the expected return on the asset portfolio in market equilibrium, which allows one to include any factor on the right hand side that might have an impact on the expected return of the asset.

$$E(R_i^e) = \alpha_i + \beta_i X \tag{2}$$

If we further decompose equation (2), we could find that the equation (2) consists of three components. X includes multiple impact factors, each explanatory variable represents a factor. The expected returns of multiple factors and their asset exposures on them constitute a multi-factor model. For a given asset portfolio, if the difference (α_i) between its actual return and the expected return implied by the multi-factor model is significantly different from zero, then the returns of the asset is said to be an anomaly

Equation (2) is also stated as a matrix form (taking the Fama and French (1992) three-factor model as an example):

$$(1) E(R_i^e) = \alpha_i + [\beta_1 \ \beta_2 \ \beta_3] \begin{bmatrix} Rm - Rf \\ SMB \\ HML \end{bmatrix} + \varepsilon$$

$$(2) \beta = [\beta_1 \ \beta_2 \ \beta_3]$$

$$(3) X = \begin{bmatrix} Rm - Rf \\ SMB \\ HML \end{bmatrix}$$

Markowitz(1952) proposed the mean-variance model, which seeks the optimal value of the target function under constrains. Owing to the diversity and complexity of the capital market, conventional marginal planning is not sufficient to solve the asset pricing problem. Based on this idea, a series of classical model theories were born in the field of finance, among which the capital asset pricing model (Sharp, 1966) and the arbitrage pricing theory (Ross, 1976) have had a profound impact on the way assets are priced in the capital market.

In the present study, we divided the development of asset pricing models into three stages: the nascent period (1952-1965), the innovative period (from 1966 to 1992) and the development period (1993-present). In the first stage, Markowitz(1952) proposed the mean-variance model, which obtained the important conclusion that "the expected return of an asset is determined by its own risk. Namely, the price of an asset (individual asset and portfolio asset) is priced by its risk. The price of an individual asset is determined by its variance or standard deviation. The price of an asset portfolio is determined by its slope variance. Following Markowitz's model, the asset pricing entered the innovation period (1966-1992). The CAPM believes that the return of a portfolio is only related to the systematic risk. The portfolio already contains a basket of stocks, which could eliminate the

non-systematic risk of individual stocks. Ross(1976) proposed the arbitrage pricing theory APT (The APT model considered that the expected returns of a financial asset could be modeled as a linear function of various factors or theoretical market indices. The sensitivity of changes in each factor is expressed by a factor-specific beta coefficient (β). The rate of returns derived from this model is used to correctly price the asset. The asset price should be equal to the expected end-of-period price discounted at the interest rate implied by the model. The arbitrage should return it to normal if prices diverge.

After Fama and French(1992) proposed a three-factor model shocking the academic community, the asset pricing models entered a period of development (1993-present), and the viewpoint of the model influenced the direction of development in the next 30 years. Since then, the Fama and French (1992) three-factor model has become the mainstream asset pricing model and the basis of the entire multi-factor model building.

The emergence of the asset pricing anomaly(APA) was gradually discovered with the empirical examination of the efficient-market hypothesis and the asset pricing model(APM). By controlling for the beta of the CAPM, Basu(1977) found that the expected returns of stocks with high-earnings-ratio were higher than those of low-earnings-ratio firms. Stattman(1980) found the "anomaly of book-to-market ratio", that is, companies with higher book-to-market value ratios have higher expected returns on stocks. Bhandari (1988) pointed out the stocks with higher leverage have higher expected returns. Amihud and Mendelson(1989) showed the bid-ask spread of the stock is positively correlated with the expected rate of return, and the less liquid the stock, the higher the future rate of return.

Jegadeesh and Titman(1993) found a "momentum anomaly" whereby the stock portfolio with higher returns in the past 3-6 months would have higher returns in the future. Spiess and Affeck-Graves((1995) pointed out the IPO and SEO anomaly such as companies with initial public offerings(IPO) or seasoned equity offering(SEO) have lower expected stock returns over a longer period of time in the future. Piotroski(2000) found the "fundamental anomaly as companies with good fundamental quality have higher returns in the future. Ang(2006) found that volatility anomalies indicate that the more volatile a stock is, the lower its future returns are. Over the past thirty years, academic research on factor investment and anomalies has deepened our understanding of the market phenomenon. Many of the classic anomalies have persisted for many years, creating large rewards for investors (Jam, 2011). However, excessive factor mining has also brought negative effects to empirical asset pricing and factor investing, Cochrane used the term factor zoo to criticize the academic community's fervor for factor mining. Due to slow development of the Chinese securities market and the strong administrative overtones, the empirical studies on multi-factor models and anomalies are relatively lack.

RESEARCH METHODOLOGY

The research methodology is divided into two parts. In the first part, based on the abnormal phenomenon factors of excess returns in the financial literature, we screen out the abnormal phenomena factors with significant excess returns by independent sample t test. In the second part, a regression analysis of the above each of eight anomalies with excess returns is performed using the excess return from each of five asset pricing models as an independent variable. These models include Fama and French(1993) three-factor model, Carhart(1997) four-factor model. Novy and Marx(2013) four-factor model, and Hou, Xue and Zhang(2015) four-factor model and Stambaugh and Yuan(2017) four-factor model, and

The four models are stated as follows:

- (1) Fama and French(1993) added two factors of value (High-Minus-Low, HML) and scale (Small-Minus-Big) on the basis of CAPM, and proposed a three-factor model.

$$R_p - R_f = \alpha + \beta_1(R_m - R_f) + \beta_2SMB + \beta_3HML + \varepsilon \quad (3)$$

where $R_p - R_f$ denotes the difference the returns of the portfolio of firms and the risk free rate. $(R_m - R_f)$ is the difference the monthly valued-weighted return of all the sample and the risk free rate. SMB denotes the size factor. HML is the value factor.

- (2) Based on the three-factor model of Fama & French (1993), Carhart (1997) added the momentum

factor to the model. It is written as

$$R_p - R_f = \alpha + \beta_1(R_m - R_f) + \beta_2SMB + \beta_3HML + \beta_4MOM + \varepsilon \quad (4)$$

where MOM represents momentum factor.

(3) Novy-Marx(2013) pointed out that profitability is closely related to future expected rate of

return. They proposed a four-factor model based on this. They believed that gross profit (Gross Profit, GP) is more important than net profit (Net Profit, NP) It can measure the profitability of an enterprise, because gross profit includes expenses such as R&D investment and marketing and advertising, which are actually beneficial to the future profits of the enterprise. The model is

$$R_p - R_f = \alpha + \beta_1(R_m - R_f) + \beta_2HML + \beta_3R_{UMD} + \beta_4R_{PMU} + \varepsilon \quad (5)$$

where R_{UMD} and R_{PMU} are the expected returns of the profit factor and the momentum factor, respectively.

(4) Based on the research of Cochrane(1991), Hou et al.(2015) constructs a model including four factors of market, scale, investment and profit. In an empirical study, Hou et al.(2015) employed ROE and the rate of change of total assets as indicators representing profitability and investment.

$$R_p - R_f = \alpha + \beta_1(R_m - R_f) + \beta_2R_{ME} + \beta_3R_{I/A} + \beta_4R_{ROE} + \varepsilon \quad (6)$$

where R_{ME} , $R_{I/A}$, and R_{ROE} are the expected return of scale, investment factor and profit factor respectively

(5) Stambaugh and Yuan(2017) added management factor and performance factor on the basis of market factor and size factor. The four factor model of Stambaugh and Yuan(2017) is stated as

$$R_p - R_f = \alpha + \beta_1(R_m - R_f) + \beta_2SMB + \beta_3R_{MGMT} + \beta_4R_{PERF} + \varepsilon \quad (7)$$

where R_{MGMT} and R_{PERF} are the expected returns of the management factor and the performance factor, respectively.

EMPIRICAL RESULTS

Sample and Data Description

This study composes 56 quantitative factors based on the White Paper on Quantitative Factors of China A-shares. After eliminating data with different time calibers and difficulties in data acquisition. The first factor filtering is performed and 37 available anomalous variables remained. The research target is A-share stocks in China stock market (including traded and delisted stocks). The variables include daily closing price, highest and lowest price, daily yield, A-share outstanding capital, total A-share capital, trading volume, trading turnover, and trading turnover rate. The daily yield includes dividends. The company's financial statements are obtained from the RESSET database and include total assets, total liabilities, owner's equity, inventories, dividends payable, operating income, total profit, tax revenue, net income, and operating cash flow. Since financial data before 2003 were mostly semi-annual data with no quarterly information, the sample period starts from October 2003 to December 2017, totaling 171 months, a 14-year sample period covering important time points such as the 2008 global financial crisis and the 2015 China stock market crash. As of the end of 2017, there were 3,467 companies that were trading in the A-share market. This study multiplies the month-end closing price of each stock (without compounding) by the outstanding share capital at the end of each month to obtain the A-share market capitalization outstanding for each stock, and adds up all the market capitalizations outstanding in the A-share market to obtain the market capitalization outstanding for all A-shares in the market. We rank the stocks according to the size of each of their factors and divide the stocks into 10 groups. The stock with the smallest factor is the first group and the stock with the largest factor is in the tenth group. The weighted return of each group in the next period is calculated. The difference between the return of the tenth group and the first group is calculated.

Tests on Anomalies in Excess Returns

We perform independent samples t-Test on 37 variables with abnormal phenomena. 37 anomalous factors were employed to construct anomalous portfolios and calculated the investment return of the simulated portfolios. The significant abnormal excess of variables are firm size proposed by Banz(1981), trading value, volatility of turnover and volatility of volume discovered by Chordia (2001), zero trade as the standardized turnover factor defined by Liu(2006), change in momentum adopted by Gettleman and Marks(2006), the "momentum change factor" adopted by Jagadeesh and Titman(1993), lagged return on reversal as the short-term reversal factor proposed by Jagadeesh and Titman(1993), the ratio of cash to asset defined by Palazzo (2012).

Table 1. Anomalies in the excess returns of portfolio

Variable	Mean	t-statistic	p-value
Firm Size ¹	-0.017	-2.66	0.01
Trading Value ²	-0.017	-3.16	0.00
Volatility of Turnover ³	-0.014	-2.55	0.01
Volatility of Volume ⁴	-0.018	-3.00	0.00
Zero Trade ⁵	0.016	3.63	0.00
Change in Momentum ⁶	-0.011	-2.50	0.01
Lagged Return or Reversal ⁷	-0.013	-2.53	0.01
Cash to Asset Ratio ⁸	0.011	2.92	0.00

Note:

1. It is multiplied the closing price of the stock price on the last trading day at the end of each month by the share capital of A shares at the end of each month.
2. The trading value is equal to the daily closing price multiplied by the daily trading volume
3. According to Chordia (2011), the volatility of transaction turnover in month t is the standard deviation of daily turnover in month t.
4. According to Chordia (2001), the volatility of the transaction volume in month t is the standard deviation of the daily transaction volume in the whole month of month t

$$5. \left[\text{Number of zero daily trading volumes in prior month } t + \frac{1}{\text{Deflater}} \frac{\text{turnover}_t}{\text{NoTD}} \right] * \frac{21}{\text{NoTD}}$$

where *turnover* t is the sum of the daily trading turnover rate in month t. NoTD is the number of trading days in month t. The deflator for a month is 480,000. The daily turnover rate is equal to the trading volume divided by the outstanding A-share capital, and can be downloaded directly from Wind. Change in momentum in month t is equal to the momentum from the end of t-July to the end of t-1 minus the momentum from the end of t-December to the end of t-July

6. Lagged Return or Reversal: the short-term reversal is the monthly return of the previous month
7. The cash-to-asset ratio in month t is equal to the monetary funds in month t divided by the total average assets in month t-12 and month t.

As shown in Table 1, there are abnormal phenomenon factors of excess returns in the Chinese market, most of which are concentrated in transaction friction factors, while the growth factor and value factor, which have significant excess returns in Western capital markets, are not significant. If

company's operating conditions and financial growth do not represent the source of overall stock market excess returns, then what factors drive excess returns in the China stock market? This study draws on a wide range of literature and finds that the unworthiness of the China stock market is only an external effect, but there are many deep-rooted institutional reasons behind it, including single investor structure, excessive proportion of indirect financing, scarcity of investment varieties, low punishment for securities violations, strong awareness of regulatory intervention, "weak awareness of the rule of law, and "over-representation of industrial capital.

This is the result of a combination of factors such as the lack of investment varieties, the low level of punishment for securities violations, the strong awareness of regulatory intervention, the weak awareness of the rule of law and the high proportion of industrial capital. Although China is the second largest economy in the world and has great influence in international trade and geopolitical level, the development of its domestic capital market is still relatively backward, and the low penalty for securities violations and weak awareness of the rule of law have caused serious agency problems. This has resulted in a particularly non-valuable market in China, and market participants have learned from the evolution of the market that it is better to do market timing rather than value investing. This implies that the company's performance is highly cyclical and uncertain, and there are serious agency problems in corporate governance, lacking the consistency of stable growth over the years. If analyzed from the perspective of behavioral finance, retail investors tend to commit irrational behaviors including overconfidence, mental accounting, loss aversion, and regret aversion. These behaviors, combined with the existing institutional problems, are the reasons why the factors that work in Western markets do not work in Chinese stock markets.

RESULTS FROM REGRESSION MODELS

The 40 simple linear regressions are run, which is each of the 8 anomalies that passed the excess return test as a dependent variable and each of the estimated excess return from five asset pricing models as an independent variable. In this study, if α is significantly different from zero, it means that these anomalies cannot be explained by the model, which also means that the anomalies have excess payoff. If the α is not significant from zero, it means that the model could explain these anomalies well. Meanwhile, it also means that these anomalies are only a certain factor of β in the model. As shown in Table 2, Fama-French, Carhart, and Novy-Marx can fully explain all abnormal variables (α are all

Table 2. Results of regression estimation

	Fama-French ¹		Carhart ²		Novy-Marx ³		Hou-Xue-Zhang ⁴		Stambaugh-Yuan ⁵	
	α	t	α	t	α	t	α	t	α	t
A. Trading Friction Factor										
firm size	-0.013	-4.043	-0.011	-3.468	-0.023	-4.805	-0.008	-2.711	-0.006	-1.881
volatility of turnover	-0.025	-6.244	-0.019	-4.904	-0.013	-2.984	-0.022	-5.187	-0.021	-5.738
volume	-0.014	-4.474	-0.012	-4.010	-0.022	-5.401	-0.007	-2.077	-0.007	-2.368
volatility of volume	-0.019	-3.336	-0.017	-3.112	-0.022	-3.959	-0.011	-1.830	-0.010	-1.821
zero trade	0.026	6.502	0.021	5.293	0.016	3.604	0.020	4.713	0.020	5.059
B. Momentum factor										
change in momentum	-0.010	-2.217	-0.012	-2.851	-0.015	-3.518	-0.011	-2.318	-0.011	-2.537
lagged return or reversal	-0.019	-3.673	-0.013	-2.496	-0.017	-3.345	-0.011	-1.983	-0.010	-1.913
C. Financial Factor										
Cash to Asset Ratio	0.000	-2.451	0.015	4.633	-0.012	3.896	0.005	0.195	0.012	3.849

Notes:

- 1.Fama and French(1993) three-factor model is employed.
- 2.Carhart(1997) four-factor model is employed.
- 3.Novy-Marx(2013) four-factor model is employed.
- 4.Hou, Xue and Zhang(2015) four-factor mode is employed.
- 5.Stambaugh and Yuan(2017) four-factor model is employed.

significant), except that Hou-Xue-Zhang and Stambaugh-Yuan. We could find that most of the five asset pricing

models could explain the anomalies very well. Traditional financial theory suggests that a factor describes a certain systematic risk that is the driving force behind the rate of return, and the factor return is the risk premium or risk compensation for this systematic risk. The above-mentioned 8 anomalies, each with a specific risk premium, could all be employed as profit factors, but their excess returns disappear within the asset pricing model, in other words, these anomalies are probably just the exposure of a factor in the asset pricing model. This is important information for the wealth management manager. It enables institutional investors to conduct performance attribution and factor exposure more scientifically and improve investment efficiency.

CONCLUSIONS AND SUGGESTIONS

Conclusion

The present study constructs five categories of 37 anomalies in capital market based on literature. We conduct independent sample testing on them to screen out the anomalies with excess returns and observe whether the factors with excess returns in mature capital markets still exist in the China stock market through empirical study and literature review method. Furthermore we attempt to find the reasons for their existence. The present study shows that there is a deeper institutional contradiction in the China stock market. It is related to the strong regulatory intervention, single structured investors and asymmetric information in the China stock market. Those have led investors to believe that it is better to do market timing instead of doing value investment. Instead of focusing on corporate profitability, investors might as well use volatility to make profits. The same conclusion could be drawn from the classification of anomalies filtered out effectively in the present paper.

Traditional financial theory believes that a factor describes a certain systemic risk, which is the driving force behind the rate of returns, and the factor rate of return is the risk premium or risk compensation for this systematic risk. The above-mentioned 8 anomalies each have their own unique risk premiums, and they can all be used as profit factors in the Chinese market. However, in the asset pricing model, their excess returns disappear. In other words, these anomalies are just certain factors in the asset pricing model. The exposure or extension of a style factor. This study believes that this may be related to the factor composition of the model. Overall, the five mainstream asset pricing models can still explain these abnormal phenomena well.

Suggestions

1. For the supervision unit

The empirical results shows the evidence that most of the excess returns in the Chinese stock market are concentrated in the trading friction factor and the fundamentals-based financial-type factors are largely ineffective. We argue what China needs is a new set of rules, not a new exchange. Making adjustments and optimizations at the system level is a difficult but necessary solution.

For the Investor

The present study shows that most of the factors that generate excess returns are related to trading frictions. According to the perspective of behavioral finance, these factors generate excess returns precisely because of human irrationality. For institutional investors, taking full advantage of the mental defects of retail investors could be effective in obtaining excess returns. As for individual investors, a set of rules should be designed to prevent overconfidence and loss aversion to prevent damage to wealth accumulation.

For Subsequent Researchers

Chinese capital market is a fast-changing emerging market. Chinese government plays a dominant role in the formulation of the system. The subsequent researchers could build an asset pricing model for the China stock market on the basis of researches on the western capital market and existing theories. They could expand and deepen the theoretical applications for a socialist market economy with Chinese characteristics.

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