An Investigation Into Several Factor Investment Models and its Practical Analysis——Modernization and Development of Factor Theory

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Abstract: The factor theory is an investing theory that has undergone continuous revisions in recent times. This paper focuses on the construction and derivation of various factor models, compares the APT, CAPM, and multi-factor models, and concludes that factor models can be used to study the real stock market using the real-time stock data capture method and Buffett's investment philosophy. Nonetheless, the A-share market has comparatively few successful factor model implementation instances. Since it is more often utilized in the United States, there is still a great deal of space for research in this field. This study is going to use the Python data interception method, investigate the factors behind China Moutai's market value increase, draw insights from Buffett's success philosophy, and offer some novel perspectives for further research on China's factor model application.

Keywords: Factor model , Stock market,Python data interception , Kweichow Moutai

1. Introduction

Scholars from several countries are committed to creating a reliable factor model that can explain securities' return and risk premium. The Capital Asset Pricing Model (CAPM) by Sharpe and Linmer , the Arbitrage Pricing Model (APT) by Ross, the Multi-Factor Pricing Model (FIF) by Fama and French, and other models are among its examples. While the CAPM model only consists of one market factor, the FF multi-factor model incorporates elements such as firm size and the ratio of the company's book value to its market value.

The aim of scholars from many different nations is to create a trustworthy factor model that can account for both the return on securities and their risk premium. Some of its examples are the Multi-Factor Pricing Model (F1F) by Fama and French,the Arbitrage Pricing Model (APT) by Ross , the Capital Asset Pricing Model (CAPM) by Sharpe and Linmer , and more models. The FF multi-factor model includes factors such as firm size and the ratio of business book value to market value, while the CAPM model only includes one market factor.

This study will analyse the underlying theories of each component model and perform the necessary theoretical derivations in order to investigate the viability of various factor models in the analysis and decision-making of real markets.

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2. Factor Model And Its Analysis

A.CAPM Capital Asset Pricing Model

$$E[R_i] - R_f = \beta_{i,MKT} \times \left(E\left[R_M - R_f\right]\right) \quad (1)$$

Where, $E[R_i]$ stands for the expected return rate of stock i, R_f for the risk-free return rate, and $E[R_m]$ for the expected return rate of market portfolio.

By assuming that investors own risky assets, including risk-free assets, and that every investor has the same expectations for the mean, variance, and covariance of the return on investment, the CML formula can be derived from portfolio theory.

$$\overline{r}_p = r_f + \frac{r_m - r_f}{\delta_m}\delta_p \quad (2)$$

The CML formula can be derived from portfolio theory by assuming that investors possess risky assets, including risk-free assets, and by assuming that each owner has the identical expectations for the mean, variance, and covariance of the return on investment.

$$\beta_i = \frac{\delta_{im}}{\delta_m{}^2} \quad (3)$$

Therefore, the CML formula will turn to such form:

$$\overline{r_i} = r_f + \beta_i\left(\overline{r}_m - \overline{r}_f\right) \quad (4)$$

This is how the capital asset pricing model works. In this formula, $\overline{r_i}$ stands for the expected return rate of the i asset, r_f for the risk-free interest rate, β_i for the β value of asset i, and $\overline{r}_m$ for the expected return rate of the market portfolio. The coefficient shows how sensitive the return on assets is to changes in the rate of return on the market portfolio, whereas the capital market line (CML), now known as the security market line (SML), is used to illustrate the relationship between an asset's risk and expected rate of return.

The CAPM has been the model paradigm for portfolio choice theory even before the multi-factor model was developed. However, since the 1970s, academics in related fields have begun to focus on new portfolio theory. For instance, Basu (1977) found that stocks with a low Price to Earnings Ratio (P/E Ratio) would have a superior value [1]; in 1983, it was found that stocks of companies with a low PE investment had greater return rates [2], even after properly accounting for the scale impact. In 1981, Banz examined and reached a conclusion regarding the Size Effect, often known as the little market value Effect.

Effects of book-to-market (BM) and debt-to-market (DM) are found following EP. Such a recently discovered anomaly, however, could not threaten the status of CAPM until Fama and French (1993) added a three-factor model and two elements of value (HML) and scale (SMB) on top of CAPM:

$$E[R_i] - R_f = \beta_{i,MKT} \times \left(E\left[R_M - R_f\right]\right) + \beta_{i,SMB} \times E[R_{SMB}] + \beta_{i,HML} \times E[R_{HML}] \quad (5)$$

Where $E[R_{SMB}]$ and $E[R_{HML}]$ stand for the scale factor (SMB) and value factor (HML) respectively.

Fama and French (1993) chose two indicators, BM and market value, and used them for 2X3 double-independent ranking in order to generate value and scale factors.(see Table. 1)

The equities are separated into two categories, **Small** and **Big**, using the median market value as the dividing line. The **H**, **M**, and **L** groups of equities are based on the 70% and 30% quantiles of **BM**. The cross-section stocks can be separated into six groups using the notation **SL**, **BL**, **SM**, **BM**, **BH**, and **SH** after the aforementioned division. Each group's market value is used to weigh the stock return rate, and the two elements of scale and market value are created as follows:

Table. 1. Value and Scale double independent ranking

		BM		
		High	**M**iddle	**L**ow
Market Value	**S**mall	SH	SM	SL
	Big	BH	BM	BL

Data source : youzuos, "FamaFrench Three-factor Notes and Reproduction", Zhihu column

$$SMB = \frac{1}{3}(SH + SM + SL) - \frac{1}{3}(BH + BM + BL)$$

$$HML = \frac{1}{2}(SH + BH) - \frac{1}{2}(SH + BH) - \frac{1}{2}(SL + BL) \quad (6)$$

Additionally, Liu et al. (2019) suggested utilizing EP (the inverse of P/E ratio PE) rather than BM for creating the value component for the A-share market.

As the Fama-French three-factor model has gradually replaced the role of the CAPM, the aforementioned double division and the multiple division factor construction method it produced have also started to be emulated in academics.

B. Linear Multi-Factor Arbitrage Pricing Model

$$E[R_i] = \beta_{1i}\lambda_1 + \beta_{2i}\lambda_2 + \cdots + \beta_{ki}\lambda_k \quad (7)$$

The left side of the equation in the CAPM theoretical model is the asset's excess return rate, and the right side is the product of the asset's exposure level and the market portfolio's excess return rate. In an attempt to create a linear multi-factor model, we extend this formula. The theoretical foundation of the APT model, which is a mathematical extension of the CAPM, is the assumption that the rate of return on securities is linearly related to a collection of unknown factors. This group of elements indicates some common basic characteristics determining the rate of return of securities, even though such an assumption may not be exact in practice.

$$E[R_i] = \beta_i\lambda \quad (8)$$

In this case, $E[R_i]$ stands for the excess return, and there is no need to subtract the risk-free return R_f .

In addition, by using long-short hedging in empirical asset pricing, we can construct a neutral portfolio. This excess return is the difference between the long return and the short return before deducting the risk-free return.

The APT arbitrage pricing theory states that the expected return of an asset $E[R_i]$ is defined by the expected return rate of a number of factors on the right side of the formula and the exposure relationship of the asset to these factors. This is similar to the CAPM capital asset pricing model.

Although we had anticipated a single linear link between the single market element and the return rate, there was actually no such relationship. Fama and French analyzed the variation in stock returns in 1992 and found that the "value" of the CAPM model was no longer able to account for the variation in stock returns.

$$E[R_i] - R_f = \beta_i\big(E\big[R_M - R_f\big]\big)$$

$$\beta_i = \frac{cov(R_i,R_M)}{var(R_M)} \tag{9}$$

As a result, the CAPM's single linear market factor fails, and the book-to-market ratio, price-to-earnings ratio, and market value of listed companies can all be used to effectively supplement variations in the variance of stock returns. These additional returns compensate for the risk factors that the CAPM model can capture, according to Fama and French. In their article, Fama and French created a three-factor model to explain the expected return on stocks.

The excess return rate of a portfolio can be explained by the exposure to market variables, size factors, and value factors. Writing the components into the APT formula yields the following formula:

$$E[R_i] = \beta_{i,MKT}\big(E[R_M] - R_f\big) + \beta_{i,SMB}(E[R_{SMB}]) \tag{10}$$

The predicted excess return is still on the left side of the equation. The market factor, SMB size factor, and HML value factor are the first three variables on the right side of the equation, and β_i is the exposure of specific stocks to each of these variables, based on the three-factor Fama French model. We mix the stock return rate with the values of these three variables to do regression. The point where the regression line and the Y-axis overlap is known as the alpha value in the calculation or the excess return. The size of this excess return will determine how large our portfolio should be.

3. Multi-assset With Time-series Multiple Regresssion Models And Factor Crowding

According to the Parsimony Principle, the factor model cannot have an excessive number of components, and the degree to which it is simple will determine its applicability. Investors often pay greater attention to whether factor variables can distinguish between stocks with high and low return rather than investigating model abnormalities.

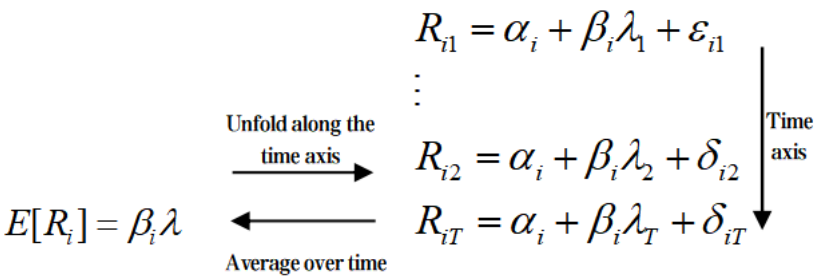

Fig. 1. Formula expands along the time axis
Data source : Cycle Studies, "The Detailed Explanation of Quantitative Arbitrage Pricing Theory"

In cross-section analysis, where the expected return is the average over time, factor timing is different. We add a temporal dimension to the formula.(see Fig. 1) For single asset i, the factor model should be $R_{iT} = \alpha_i + \beta_i\lambda_T + \varepsilon_{iT}$, where R_{iT} stands for the excess return of asset i at time T, λ_T for the factor return at time T, and ε_{iT} for the random disturbance at time T.

We can now express more asset further:

$$R_t\alpha + \beta\lambda_t + \varepsilon_t \tag{11}$$

Where, R_t stands for the N-dimensional excess return vector, α for the N-dimensional pricing error vector, β for the N × K factor exposure matrix, ε_t for the random disturbance vector at time T, and has:

$$E[\varepsilon_t] = 0$$

$$R_t\alpha cov(\lambda_t, \varepsilon_t) \tag{12}$$

Now we can determine the covariance on both sides of the formula:

$$\sum = \beta \sum_\lambda \beta^T + \sum_\varepsilon \tag{13}$$

The summation symbols represent N asset covariance matrices, K factor covariance matrices, and N disturbance covariance matrices.

Using the connection between assets and variables, the covariance matrix of asset return rate can be further constructed, and the risk control operation can be finished. The multi-factor model developed by Barra is quite well recognized.

Normally, investors use the market's inefficiency to their advantage in order to engage in arbitrage activities, but as the market grows more crowded, an excess of money may correct the market, lowering investors' anticipated return rates.

4. Buffet's Successful Investment Experience And Its Reference To The Chinese Stock Market

We need to talk further about specific circumstances in order to discuss how the theory applies in the real stock market following a thorough theoretical analysis. For the statistics of the exposure of factor on the rate of return, a rolling 252 trading time frame was utilized by using relative modelling.(see Table. 2)The approach makes use of Python's crawler interception function,and the following results are attained:

Table. 2. statistics on the impact of various factors on return rates

FACTOR	AVERAGE MONTHLY RETURN(%)	INFLUENCE COEFFICIENT(%)
Market	-0.17	-0.04
Scale	-0.52	-0.53
Value	1.88	0.45
Momentum	0.33	0.20
Profit	2.36	0.28
Investment	0.10	0.03
Stock Turnover	-1.33	-0.69

Data source : CSMAR database

As can be observed, the three factors of value, momentum, and profitability have the highest influence coefficients. In the Chinese A-share market, the influence of momentum often shows up in theme stocks, whereas the influence of value and profit typically shows up in consumer stocks. However, The information presented above is updating and should only be used as a general reference.

To illustrate and support the likelihood of applying factor theory in the Chinese market, we may now provide one typical case.

One of the greatest financial miracles ever occurred during Buffett's four decades at Berkshire, with annual excess returns of 18.6%. Buffett's record also outperformed 97% of equity mutual funds and 93% of stocks, respectively, when measured against all U.S. stocks or all equity mutual funds. Therefore, it is important to find out whether value and other traditional considerations can be used to explain and duplicate Buffett's renowned success over such a long period of time.

Using data on Berkshire's stock price, information on holdings of public market stock and private equity provided in periodic reports, and data on Berkshire's stock price, a complete analysis of Buffett's past success and management style is now conducted [3]:

The excellent success of Berkshire is due to three factors.

• the ability to add cost and leverage;

• Systematic exposure to value and quality factors;

• Buffett's superior ability to obtain alpha.

Academics used the six-factor framework developed by AQR to explain Buffett's investing track record, which expanded the traditional Fama-French three-factor model to include momentum, low risk, and quality factors:

• Buffett's portfolio has a notable effect on the value and quality factors

• Positive exposure (up to 0.40 and 0.47, respectively) :

• There is also a certain positive exposure to BAB

• There is a small but insignificant negative exposure to size and momentum.

Data source : Frazzini, Kabiller, and Pedersen (2018)

Table. 3. What Kinds of Companies Does Berkshire Hathaway Own ? (t-statistics in parentheses)

	Berkshire Stock, 10/1976-3/2017				13F Portfolio, 4/1980-3/2017 4/1980-3/2017							Private Holdings,
Alpha	**13.4%** (4.01)	**11.0%** (3.30)	**8.5 %** (2.55)	5.4% (1.55)	**5.8 %** (3.0 9)	**4.5 %** (2.4 6)	3.0% (1.62)	0.3 % (0.1 6)	**7.0**% (1.98)	4.9 % (1.4 0)	3.9% (1.10)	3.5% (0.91)
MKT	**0.69** (11.00)	**0.83** (12.74)	**0.83** (12.9 9)	**0.95** (12.7 7)	**0.77** (22. 06)	**0.85** (23. 81)	**0.86** (24.3 6)	**0.95** (23. 52)	**0.30** (4.46)	**0.39** (5.3 6)	**0.40** (5.72)	**0.42** (5.03)
SMB		**-0.29** -(3.11)	**-0.30** -(3.1 9)	-0.13 -(1.1 7)		**-0.1 9** -(3. 73)	**-0.19** -(3.7 9)	-0.0 5 -(0.9 5)		**-0.2 6** -(2.6 5)	**-0.25** -(2.5 6)	-0.23 -(1.95)
HML		**0.47** (4.68)	**0.31** (2.82)	**0.40** (3.55)		**0.28** (5.2 0)	**0.19** (3.25)	**0.25** (4.3 2)		**0.28** (2.6 3)	0.21 (1.80)	0.22 (1.85)
UMD		0.06 (1.00)	-0.02 -(0.2 5)	-0.05 -(0.8 0)		-0.0 1 -(0. 36)	-0.06 -(1.6 6)	**-0.0 9** -(2.5 8)		0.08 (1.2 4)	0.04 (0.62)	0.04 (0.51)
BAB			**0.33** (3.79)	**0.27** (3.04)			**0.19** (4.08)	**0.15** (3.1 8)			0.15 (1.61)	0.14 (1.53)
QMJ				**0.47** (3.06)				**0.37** (4.5 5)				0.07 (0.43)
$\overline{R}$^2	0.20	0.25	0.27	0.29	0.52	0.58	0.59	0.61	0.05	0.08	0.08	0.08
Obs.	486	486	486	486	444	444	444	444	399	399	399	399

The table displays the full sample series regression results provided by Frazzini, Kabiller, and Pedersen,(see Table. 3) which reveal that Buffett's investment has a very substantial Alpha of up to 13.4%. Under the three-factor dynamic paradigm, the value decreases but stays significant, and it is still significant even after the BAB component is added. Alpha is still beneficial after the QMJ quality factor is taken into account, but it is no longer significant.

Hu Yi, Gu Ming, and Yin, Libo, and Liao Huiyi's latest research on the Chinese stock market and the quality premium of the Chinese A-share market have all shed light on Buffett's investment beliefs in China.[4] To create quality indicators, four factors are considered: profitability, growth, security, and the ability to distribute dividends. According to Buffett, profitability is the most important factor.

5. The Case of Kweichow Moutai Stock Market Price Decline And Its Future Profitability Study

We have come to recognize the importance of quality and value investments and the need to deal with them with consideration.

Kweichow Moutai is a well-known brand that possesses powerful branding, an all-inclusive supply chain and a sales system, with advanced manufacturing technology. Kweichow Moutai's stock is regarded as the "King of the A-share market" and has always been a pioneer and leader in the Chinese A-share market.

Despite the widespread belief that high-quality companies have a significant premium over the long run, [5] Kweichow Moutai's unexpected fall by the daily limit in 2018 indicates that high-quality equities do not always perform well (as demonstrated, for instance, in the A-share market in 2017–2018).

We might take a look at how stock prices performed in the fourth quarters of 2017 and 2018 (see Table. 4):

Table. 4. Net profit growth rate of Kweichow Moutai within the year of 2016-2018

	2016	2017	2018
Net profit growth rate in the third quarter	9.11%	60.31%	23.77%

Data source: Kweichow Moutai Co. , LTD. 2016-2018 annual financial statement analysis report

There is no question that Kweichow Moutai's considerable decline in 2018 was not brought on by its poor profitability. Furthermore, while the gross profit margin ratio of 23.77% is still fairly high in the A-share market and significantly higher than that of Gree, the leading Chinese manufacturer, or the edible oil brand Arowana, it does not seem as good as it was in 2017 when it was 60.31%.

In addition ,We use Python to collect the four-factor return data of Kweichow Moutai stock from January 2018 to December 2020 and attribute its return, as well as obtain its risk exposure and t-statistics, in order to investigate the feasibility of applying the factor model in the Chinese stock market and whether Kweichow Moutai can survive within the period of the epidemic and how.（see Table. 5）

The results indicate that while Moutai's risk exposure and t-statistics are large, its exposure to SMB, VGM, and MOM variables is not. Among the four elements, it is obvious that Moutai's performance continued to be impacted by the market factor even during the epidemic time, demonstrating the company's significant potential for market growth.

Table. 5. Risk exposure and t-statistics of Kweichow Moutai analyzed by the four-factor model from 2018 to 2020

	Exposure	T-Statistics
SMB	-1.4055	-1.671
VGM	0.4702	0.817
MKT	0.9306	3.127
MOM	-0.9618	-1.189

Data source: Anonymous author, "Kweichow Moutai's Chinese version of four-factor attribution", CSDN column

Furthermore, Kweichow Moutai's stock returns have a track record of stability in post-epidemic periods and are predicted to rise over time.(see Table. 6)

Table. 6. Net profit growth rate of Kweichow Moutai within the year of 2020-2022

	2020	2021	2022
Net profit growth rate in the third quarter	51.26%	52.31%	51.48%

Data source: Kweichow Moutai Co. , LTD. 2020-2022 annual financial statement analysis report

Kweichow Moutai's attributes, like its clear equity structure and transparent, honest financial analysis, have produced a fantastic offering on the stock market. The basic principles of China's drinking culture remain unchanged, despite the country's recent decline in alcohol consumption. As the average person's disposable income increases along with the proportion of food, cigarettes, and alcohol consumed, Kweichow Moutai may continue to flourish.

Thus, we can draw the conclusion that market success or failure cannot be simply explained by quality.

Yin and Liao (2019) showed that:[6]

• High quality alone is not enough;

• Investors are also focused on quality growth;

• This may be even more important for big bulls:

• And its excess returns are mainly due to investors' lack of attention.

• At least think of it as a filter to avoid investing in stocks that have significantly declined in quality.

We now relate the stock market's Kweichow Moutai phenomenon to earnings instability. We may now go into a bit more detail in this paper about the necessity of looking into the profitability and instability of the A-share market in China.

Why we focus on the firm's profitability?

•When making investment selections, renowned investors like Charlie Munger, Warren Buffett, and Benjamin Graham put significant importance on a company's quality.

• Greenblatt, 2010; Frazzini et al., 2013; Lee, 2014

•Future stock returns are significantly influenced by a firm's profitability level.

•Businesses with higher profitability predict significantly higher future stock returns than those with lower profitability.

• Haugen and Baker, 1996;

• Fama and French, 2015;

• Novy-Marx, 2013;

• Ball, Gerakos, Linnainmaa et al., 2016;

• Hanauer and Huber, 2017;

• In order explore a number of well-documented anomalies, Fama and French (2015, 2018)[7] and Hou, Xue, and Zhang (2015, 2017) adopted the profitability element to new multi-factor asset pricing models.

•In emerging stock market, the positive effect of firm profitability on stock returns is also pervasive.

• Berggrun, Cardona and Lizarzaburu (2020) [8]document the profitability premium is also existent in the stock markets of Latin America.

• In Chinese stock market, Jiang, Qi and Tang (2018) [9]also find significant positive predictive power for the future cross-sectional stock returns.

Why we discuss profit instability?

• The entire marketplace in which businesses operate is dynamic.

• Firms' performance fluctuates all over time as a result of changes in both their own strength in competition and the general competitive environment.

• Investors ought to be more concerned with a company's current profitability trend. If firm profits suffer from cash flow shocks, they are likely to be permanent in the sense that rational investors have no reason to expect the stock price to rebound to previous levels [10]

•It is essential to note that although the size factor was found in the past century, there were several debates on it recently, for it barely matters in the US stock market. However, Yin and Liao(2021)[11] has evaluated profitability shocks across size deciles in a dynamic view:

•In the short term, there exists a U-shaped relationship between profitability shocks and size.

•However, when the holding period becomes longer, the profitability shogks in small firms drop sharply while profitability shocks in large firms remain high and stably positive.

6. Conclusions

This essay starts off exploring a number of factor models, gradually looks at their positive and negative aspects, and then discusses whether they can be used in the actual stock market.We

have found through the theoretical model's examination and discussed that the factor model has a certain reference relevance for the real stock market investigation.

Factor theory is normally to some extent applicable in the A-share market in China. However there is still a great deal of need for more research in this field, as the US stock market remains to be the most popular destination market.

This article offers a multi-factor model analysis method for the Chinese market, which presents investors and academic researchers with a rather new way of thinking. We can learn about Buffett's focus on profit growth by consulting his investment philosophy. Using Kweichow Moutai, a massive corporation in the field, as the case study, it is easy to see that while a number of elements contribute to market value growth, the market factor remains the most significant one.In addition, the two market factors—profitability and instability—can be extensively investigated by referring the perspectives of certain domestic academics.As a result, there is still plenty of rooms in this topic to be studied.

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