Comparisons of performances for different financial models: evidence from CAPM and Fama French

Ce Chen[1, †], Zichen Wang[2, †], Tianyi Xia[3, †], Ruoxuan Yu[4, *, †]

[1]School of business, University of Sydney, Sydney, Australia

[2]School of mathematics and statistics, Northwestern Polytechnical University, Xi'an, China

[3]School of Mathematics, Xi'an-JiaoTong Liverpool University, Suzhou, China

[4]School of international education, Wuhan University of Technology, Wuhan, China

*Corresponding author: xunyr@whut.edu.cn

†These authors contributed equally.

Keywords: CAPM, Fama-French Three-Factor, Fama French Five-Factor, Empirical analysis.

Abstract: Contemporarily, there are plenty of quantitative financial models for assessing investment risk and return. Based on existing research and experiences, we will introduce the Capital Asset Pricing Model (CAPM) and the Fama-French Models, as well make comparison on their benefits and drawbacks. To be more explicit, construction principles, definitions of each model will be demonstrated, and its application, strengths, and weaknesses will be verified for future promotion using particular instances. According to the analysis, all three models show plausible explanatory power to varying degrees in various research. Specifically, Fama-French three-factor model adds the components SMB and HML to the original CAPM framework while the Fama-French five-factor model enriches the framework by considering additional risk factors that may possibly affect the portfolios' returns ignored by the previous one, i.e., continuously improves both accuracy and applicability. Overall, these results shed light on pricing model usage for investors and scholars.

1. Introduction

In general, there are mainly three methods to evaluate investment risk and return in the field of finance, including the (CAPM), the Fama and French Three-Factor Model (FFTFM) and Five-Factor Model (FFFFM). In short, scholars mainly investigated the link between the expected return from assets and the risk of them in the market. Meanwhile, they supposed to use that relationship to explore the mechanisms of equilibrium price in terms of CAPM. Moreover, FFTFM is recognized as an extension of CAPM that adds the risk factors that may be brought by the market. Similarly, FFFFM is also an extension of FFTFM that it considers additional risk factors that will potentially affect the return of a portfolio.

As a matter of fact, these models mainly analyze the sensitivity of securities returns and market portfolio returns, and offer a guideline for investment decisions (e.g., whether the investors can gain additional return that matches the risk) [1]. As a result, choosing the model with the smallest result error will bring competitive advantage to investors.

In this paper, we will analyze from the following aspects. Primarily, a brief introduction of the background of each method and their specific applications will be presented, as well as the interpretation of each element in the formula they involve. In the meantime, the advantages and disadvantages of each method will be described in order to make a comparation. Afterwards, this review is capable of analyzing which method is the best choice.

The rest part of the paper is organized as follows. The Sec. 2 will analyze different aspects of the CAPM. The Sec. 3 will illustrate the FFTFM. The Sec. 4 will analyze the extended model of Sec.3, which is the FFFFM. The Sec. 5 will make a comparison among those 3 models above. The Sec. 6

will elaborate the gap and outlook of those models. Eventually, a brief summary will be given in Sec. 7.

2. CAPM

2.1 Background

In retrospect, it was created by 4 researchers in terms of the conventional and basic financial theory in 1964 [2], which can be recognized as the foundation of modern financial market price theory. Moreover, CAPM is also widely used when the investors are making an investment decision or dealing with the corporate finance [1].

2.2 Definition and the method of computation

The aim of CAPM is to explore the quantitative connection between the return on risky assets and their risk, which is basically about the level of return that investors need to get for a certain level of risk [1]. Besides, once a capital market hits its equilibrium, the marginal price of risk remains unchanged. Therefore, under the capital market condition of substitution equilibrium, the formular of CAPM will be

$$E(R) = R_f + \beta\left[E(R_m) - R_f\right] \tag{1}$$

Where $E(R)$ represents the expected rate of return of asset, R_f refers to the risk-free interest rate, β refers to the systemic risk of asset, R_m refers to the expected market return of market. To be noticed, $E(R)$ - R_f can be concluded as the market risk premium.

3. Limitation

There are four limitations in CAPM. Firstly, the assumptions of CAPM cannot reflect the condition in reality. Secondly, CAPM can only be applicable to capital assets, and assets that highly related to human can hardly be tradable either. Furthermore, the β coefficient reflects the fluctuation extent in previous period. Nevertheless, both scholars and investors in the markets focus more on the forecasting of the price or volatility of the securities. Moreover, it should be noted that both the underlying assets and portfolios are unlikely to be risk-free.

4. Empirical investigation of the CAPM

Based on the research by the 3 main founders in 1960s, CAPM model is a theoretical analysis model under strict assumptions. In details, these assumptions mainly include mean variance hypothesis, investor consensus hypothesis and complete market hypothesis. Therefore, the conclusion of CAPM under these assumptions is that the risk level of an products will be able to be evaluated according to the augment of the risks to the whole constructed portfolio. Meanwhile, that part of risk is measured by estimating the covariance among the two. Furthermore, once the market reaches its equilibrium, the pricing relationship between risk and return for the whole underlying assets ought to be laid on the SML, which is schematically shown in Fig. 1 [2].

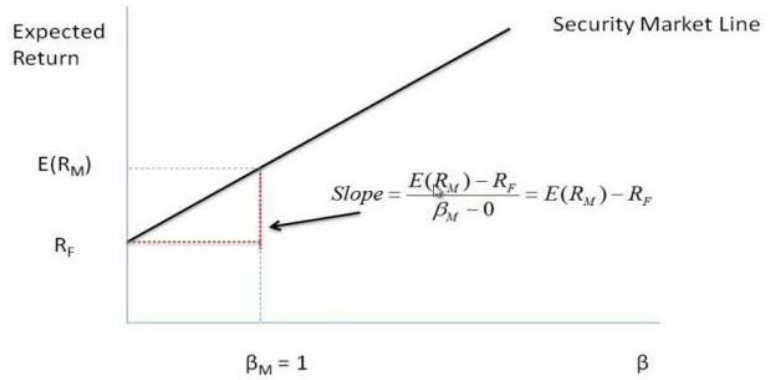

Figure. 1 The CAPM and SML make a connection between β and E(r) [2]

After a decade, a new zero β Model was proposed by Black as following [1]:

$$E(R_i) = E(R_z) + \beta[E(R_m) - E(R_z)] \tag{2}$$

In addition, it should be noted that investors only focus on a single investment in a certain period, which serves a strict hypothesis of conventional CAPM, while the transactions of the underlying assets are a dynamic process. As a result, Merton built a theoretical framework of continuous time portfolio and improve the model to an inter-temporal one [3]. In this case, investors are able to hedge the risks that may be created by the future changes of the opportunities in investment [3]. Furthermore, there is a need for investors to gain excess investment return.

Another major research is that CAPM is static. Simultaneously, it recognizes the return of risk-free asset and market portfolio return as exogenous variables. Hence, Consumption based asset pricing models have proposed by Lucas and Breeden (CCAPM). In addition, the feature of CCAPM is that it uses the covariance between the return from asset and the consumption of growth rate to describe risk, which is the β [4]. In short, the higher the coefficient, the higher its expected equilibrium return.

5. Fama–French three-factor model

Fama and French found that the beta value in CAPM fail to explain the varying excess return, and factors describing size and value contribute the most to the excess return's fluctuating. Therefore, they proposed a three-factor model with two newly added factors: SMB to address size risk, and HML to address value risk, to improve the model's explanatory power of excess return. The model can be described as the following:

$$r_A = r_f + \beta_A(r_M - r_f) + s_A SMB + h_A HML \tag{3}$$

Where β measures how risky an asset is. Fama and French investigated stock returns and price determinants in many nations and concluded that FFTFM may give a more exact explanation of the stock premium phenomena than CAPM while having broader application. In later studies, the coefficients of the model varied greatly by countries and regions, and the regional factors show a more pronounced effect than the global economic factors [4]. For example, in a regional test by Abhakorn's team in US, the HML factor had a pivotal effect on the risk premium, while the SMB factor had no effect [5]. Wang's team utilized the original and updated it in different industries of Shanghai Stock Exchange to test if the FF3 model is equally applicable to current 's stock market. The modified Three-Factor Model is optimized by adding cross and quadratic terms to previous configuration, expressed as following:

$$E[r] - R_f = \beta_3(K_m - R_f) + \beta_s SMB + \beta_r HML + \alpha \tag{4}$$

Where $E[r], R_f, K_m$ refer to the expected return of all stocks, the risk-free return on daily basis, the market performance separately. According to the analysis, the modified model may offer a wider

explanation of the risk premium and offer a new insight, which can be also used to classify funds into Style Buckets (e.g., Morningstar is the most comprehensive resource for its categorization). A B/M ranking divides funds horizontally into three nearly equal categories. In addition, it is usually sorted them vertically in terms of the rating of market capitalization, with buckets depending on percentages, shown as Fig. 2.

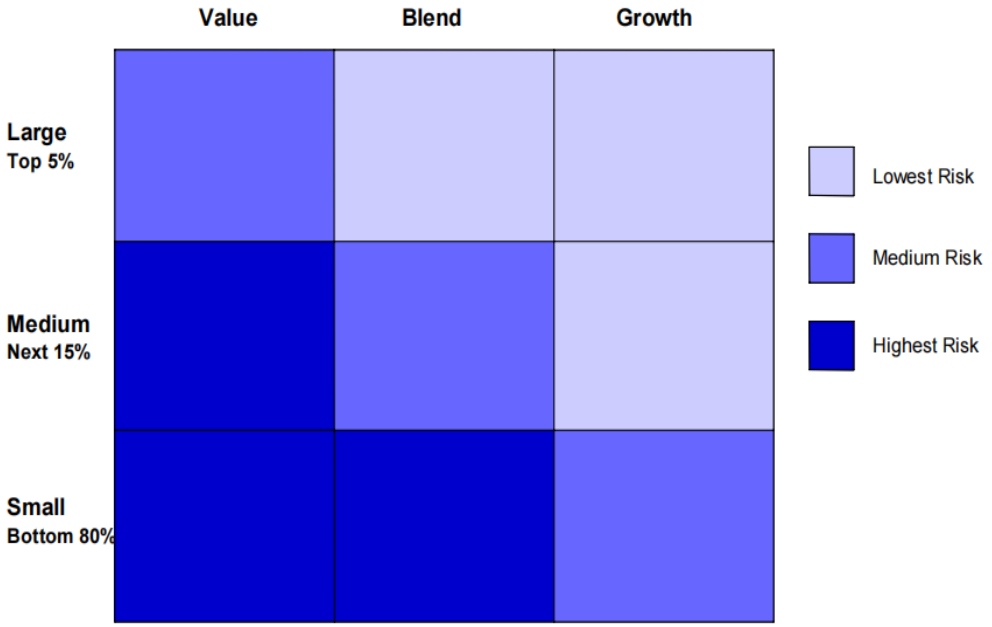

Figure. 2 Morningstar investing Style Box

The FF3 model also provides researchers with new ideas, i.e., to construct new independent variables for the factors that have obvious influence, and to modify the existing FF3 model to enhance its applicability. Blockchain technology has piqued the interest of many investors as an emerging business in the realm of financial technology. In order to properly define the influence of investor interest on stock yields connected to blockchain firms in the China, author mined and quantified the network information that directly reflects investor sentiment, constructed and introduced sentiment factor into the original FF3 model framework, and proposed the FFTFNM.

The comparison found that investor sentiment can be adopted as a new factor independent from the existing factors, to more precise explanation of the varying excess return and the risk premium. Two aspects were mainly analyzed: the market risk factor and the scale factor. For the market risk factor, compared with the CAMP model, the FFTFM model better describes the excessive impact of the combined S/L and B/L excess markets during the period from 2018.2 to 2018.4, as shown in Figure 3, due to added factors. For the scale factor, following February 2019, the average return rate on stocks per month of small-cap listed businesses exceed that of large-cap listed companies' portfolios greatly, which is for the reason that there were more than 50 businesses involved in the region's blockchain sector and the industry scale has expanded greatly, providing a powerful illustration of the size and investor mood’s reflection on the return rate (seen from Fig, 3).

Therefore, the FFTFM may performance better and exhibit better explanation for the overall features of portfolio returns. As a combination of blockchain technology and traditional financial models. Besides, it may also serve as a model worthy of reference, for organizations employing blockchain as a FinTech tool.

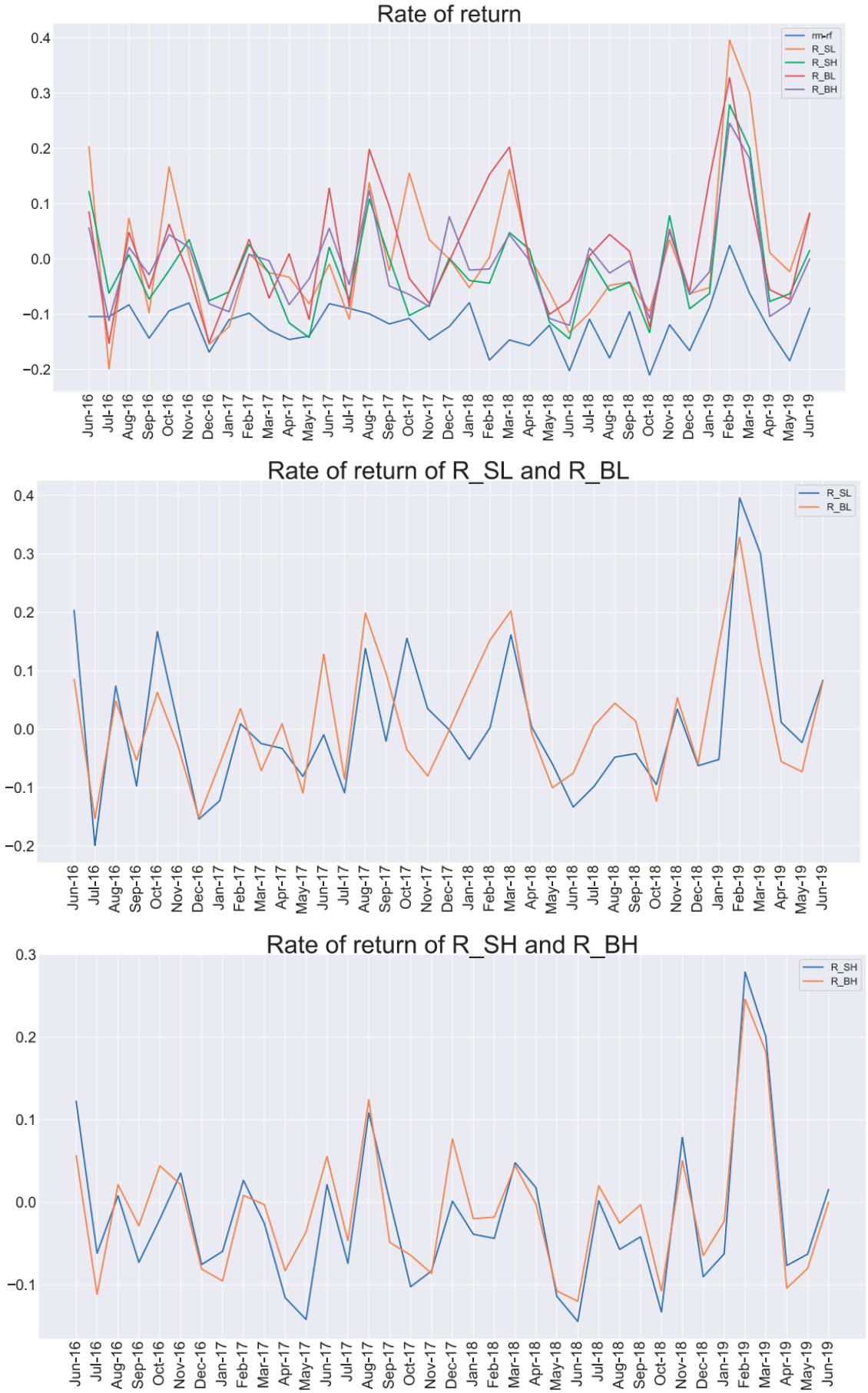

Figure. 3 The return ratio of different portfolios.

6. Fama–French five-factor model

In 2015, Fama and French add profitability factor and investment factor into the asset pricing model, which is called the five-factor model [6]:

$$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + e_{it} \quad (5)$$

Here, RMW_t is the profitability factor and CMA_t is the investment factor. $RMW_t$is the spread between the returns of firms whose profitability is robust and weak. CMA_t is the spread between the returns of firms whose investment strategy is conservative and aggressive. In order to test the capability of the five-factor model, Fama and French used US portfolios to evaluate the model in 2015 as they did in 1993 [7]. The only difference is the period, which is from 1963 to 2013. They find that when they put profitability factor and investment factor into the model. If they dropped the value factor, the description of average return would not deteriorate in the stocks market in the USA.

We take Fama and French's result which uses 2×3 factors as an example. In the regressions to explain $R_M - R_F$, SMB, RMW, and CMA, the t-statistic is very large which shows significance. In the HML regressions, however, the intercept is 0.04 and the t-statistic is -0.47, which means whether this factor is added into regression will not affect the result of regression. This result was also shown in the regression when they use 2×2 factors and 2×2×2×2 factors. The test of the five-factor model in the international market shows a different result. In the international tests from Ref. [6], HML is significant in describing average returns in the period 1990-2015 across all areas including American stocks markets. This is reasonable since if the explanatory ability of a certain factor can be illustrated by the other factors in the five-factor model, that factor will have no power of explanation and seems redundant.

Moreover, at least for the period 1990-2015, the size factor SMB seems redundant in every other region except in North America. In the SMB regressions of Europe, Japan and the Asia Pacific, however, the intercepts are 0.16, 0.05 and 0.14, and the t-statistics are 1.2, 0.29 and 0.77, which means whether this factor is added into regression will not affect the result of regression. In the CMA regressions of Europe and Japan, the t-statistics are 1.08 and 0.60, which are also not significant. As mention in one test of US returns [8], the models will be inefficient. Moreover, it is also found that the problem is more serious in the Asia Pacific and Europe. This could cause challenge to future exploration. In the empirical test made by Chiah et al. [9]. They find the five-factor model has the best explanatory power of returns in Australian stocks market among several effective asset pricing models. Kubota and Takehara use stock returns and the market value of equity in Japan from 1978 to 2014 to see if the five-factor model works well in Japan [10]. They confirm that a strong 'value effect 'exists in Japan. Moreover, as for firms' investment (INV), they show a negative relationship to stock market returns, which is as same as how Fama and French consider. However, the effect of the five-factor model is limited in Japan since the spreads of returns only show significance in large capitals. The result of Generalized Method of Moments they conduct also indicates that the two new factors are not statistically significant. As a result, whether the inclusion of investment factor and profitability factor in the five-factor model is practical in the Japanese market is questionable.

In Fama &French's traditional theory [7], stocks with large size and stocks with high value are expected to exceed the performance of stocks with small size and growth stocks separately. However, Mosoeu and Kodongo's applies the Fama-French five-factor model in the equity returns of emerging markets [11]. They find Robust firms generate higher average returns than weak firms. Furthermore, aggressive firms' average returns on stocks perform better than conservative firms' returns. Mosoeu and Kodongo's explanation is that in emerging markets, investors would prefer companies that make efforts to build and increase value rather than companies that are afraid of increasing risk, which means investing conservatively. They take six emerging markets and two developed markets as examples, utilizing weekly stock price data between 2010 and 2015. In these sampled countries, a GRS test was used to see if the five-factor model works in the emerging markets.

Table 1. Fama French five-factor regressions for country indices—developed and emerging.

Country data	α	t(α)	β	SMB	HML	RMW	CMA	R^2(Adjusted)
US	0.01*	4.53	0.96*	0.12	-0.76*	-0.99*	-0.15	0.86
UK	-0.003*	-2.48	0.74*	-0.21*	0.07	0.00	0.03	0.70
Japan	-0.002	-0.94	0.81*	0.44*	0.26	0.03	-0.36	0.53
Germany	0.01	0.62	1.01	-0.24	-0.14	-0.50*	0.06	0.65
Russia	0.01*	2.00	-0.02	1.25*	0.93*	-0.02	-1.24*	0.10
China	-0.001	-0.15	0.56*	0.38	0.27	0.18	0.10	0.18
Brazil	0.001	0.61	0.89*	-0.71*	0.24	-0.27	0.27	0.65
Mexico	0.003	1.27	0.67	-0.09	-0.16	0.15	0.21	0.53
MAVA DEV: 0.003		Average R^2DEV: 0.68						MAVA EM: 0.003
				Average R^2EM: 0.36				

* $p < 0.05$

7. Comparison

In Chinese stock market, multiple capital asset pricing models have been used. When Fama and French revised three-factor model and raised five-factor model in 2015 [5], the model's explanatory power on stock market returns has been strengthened by the newly-added profitability and investment factors. The original idea of this model is to explain asset returns in international markets and financial anomalies more accurately. The tests have all been done in international markets, which are largely dominated by Western market structures. However, Chinese market, unlike any other markets, has its own charismatics in terms of regulations, market structure and investor preferences. In this section, the interpretability of CAPM, Fama-French three and five factor models in Chinese stock market will be discussed.

Table 1 shows premium returns sorted by different factors under different financial models [12], with (3) refers to the Carhart four-factor model [13], which takes momentum factor into account based on traditional CAPM model. (5) is the augmented version with all factors taken into consideration. The revised model added size SMB_t and value HML_t factors to the original CAPM model, with these two newly added dimensions, the Fama-French three factor model outperforms CAPM model in terms of adjusted coefficient of determination (R-squared) in Chinese stock market with a significant increase, showing the two added factors offer some explanatory power over the asset returns in China. Compared with Fama-French three model, the Fama-French five-factor model has a slightly higher R-squared value, indicating more explanatory power over asset prices. Moreover, the HML_t is not significantly changed, meaning the value factor cannot not be completely explained by the profitability and investment, thus proven the factor is not redundant. According to the results, one can expect a higher explanatory power of the Fama-French three-factor model for the Chinese stock market returns than CAPM. The explainability would be slightly enhanced once RMW and CMA introduced. However, the intercepts of all models are still remained quite noticeable, indicating there might be other factors exist.

In the past years economic crises have shaken global financial market many times, but rare have had the impact like COVID-19 pandemic had on the economic world. The results of Fama-French five-factor model applied for developed and emerging countries during the pandemic are from Kostin,

Runge, and Charkifzadeh [14], and Fama-French three-factor model's statistics made by Kostin, Runge, and Adams [15]. MAVA stands for mean average value of alphas.

One notices that the adjusted R-squared value obtained by both two models are profoundly statistically similar with the average value for both markets almost unchanged while the values for emerging markets are generally lower than developed markets, especially in China and Russia, this indicating both models have a strong advantage in developed markets over emerging ones. Besides, the newly-added *RMW* and *CMA* factors cannot cover the stock exchange to a further dimension. The Fama-French five-factor model fails to increase the value, indicating other factors may influence the market returns as well. Interestingly though, as market located in Asia Pacific, the result gained from Japan market is noticeably lower than Western countries as a developed market. It should be noted that all betas collected from three factor models were statistically significant while only five out of eight betas generated from five-factor model were statistically significant. Overall, based on the data, the performance of Fama-French five-factor model on the developed and emerging markets during pandemic compared to the three-factor model is not as satisfactory as expected.

8. Gaps and outlooks

Compared with the CAPM model and the three-factor model, the five-factor model has better explanations for the returns of stocks in international markets. Nevertheless, not only Fama and French indicate that the five-factors model is not capable to seize the patterns of returns of small stocks which invest like aggressive firms with low profitability [5], many other empirical tests also verify the same conclusion. Meanwhile, according to Mosoeu and Kodongo's research results, Fama & French's five-factor model seems disabled for the emerging markets. For some special markets like Japan, whether this model is the best model is still questionable.

Nowadays, many researchers are dedicated to find a better asset pricing model. Fama and French have tried to use new factors to build a six-factor model [16]. Harvey and Liu also use their specific method to construct new multi-factor model [17]. By testing more than a hundred factors, they find there are many factors may seem significant only by chance. However, their way of testing model is worth using for reference. We believe a better asset pricing model will appear soon.

9. Conclusions

In conclusion, this paper discusses and compares the applications and interpretability of CAPM and Fama-French three- and five-factor model based on theories. Specifically, the construction ideas and basic definition, as well as both advantages and disadvantages. According to previous studies and literatures, solid evidences are shown that CAPM and Fama-French three-factor model explain well in Western developed markets, with increased explanatory power since revised in 2015 with two newly-added factors *RMW* and *CMA*. However, there lacks concern from emerging markets and post-pandemic perspectives. In the future, more researches focused on emerging markets are expected. Overall, with experiments and comparisons conducted, even though the slight superiority of the revised Fama-French five-factor model can be noticed under Chinese stock market, we believe the current five-factor model still lacks the general interpretability over emerging markets (especially under a pandemic perspective). The reason is that all three models failed to explain stock market returns satisfactory, indicating and other factors may exist. These results offer a guideline for further studying focusing on financial models.

References

[1] Jensen, Michael C. and Black, Fischer and Scholes, Myron S. and Scholes, Myron S. The Capital Asset Pricing Model: Some Empirical Tests [J], 1972.

[2] Sharpe W F. Capital asset prices: A theory of market equilibrium under conditions of risk[J]. The journal of finance, 1964, 19(3): 425-442.

[3] Merton, R. C. An Intertemporal Capital Asset Pricing Model [J]. Econometrica,1973, *41*(5), 867–887

[4] Duffie, D., Zame, W. The Consumption-Based Capital Asset Pricing Model [J]. Econometrica, 1989, *57*(6), 1279–1297.

[5] Fama E F, French K R. A five-factor asset pricing model [J]. Journal of financial economics, 2015, 116(1): 1-22.

[6] Fama E F, French K R. International tests of a five-factor asset pricing model [J]. Journal of financial Economics, 2017, 123(3): 441-463.

[7] Fama, E. F., French, K. R. Common risk factors in the returns on stocks and bonds [J]. Journal of Financial Economics, 1993, 33(1), 3e56.

[8] Abhakorn P, Smith P N, Wickens M R. What do the Fama–French factors add to C-CAPM? [J]. Journal of Empirical Finance, 2013, 22: 113-127.

[9] Chiah M, Chai D, Zhong A, et al. A Better Model? An empirical investigation of the Fama–French five‐factor model in Australia [J]. International Review of Finance, 2016, 16(4): 595-638.

[10] Kubota K, Takehara H. Does the Fama and French five‐factor model work well in Japan?[J]. International Review of Finance, 2018, 18(1): 137-146.

[11] Mosoeu S, Kodongo O. The Fama-French five-factor model and emerging market equity returns[J]. The Quarterly Review of Economics and Finance, 2020.

[12] Huang T L. Is the Fama and French five-factor model robust in the Chinese stock market?[J]. Asia Pacific Management Review, 2019, 24(3): 278-289.

[13] Carhart M M. On persistence in mutual fund performance[J]. The Journal of finance, 1997, 52(1): 57-82.

[14] Kostin K B, Runge P, Charifzadeh M. An analysis and comparison of multi-factor asset pricing model performance during pandemic situations in developed and emerging markets[J]. Mathematics, 2022, 10(1): 142.

[15] Kostin K B, Runge P, Adams R. Investment strategies in pandemic situations: An analysis and comparison of prospective returns between developed and emerging markets[J]. Strategic Management, 2021, 26(1): 34-52.

[16] Fama E F, French K R. Choosing factors[J]. Journal of financial economics, 2018, 128(2): 234-252.

[17] Harvey C R, Liu Y. Lucky factors[J]. Journal of Financial Economics, 2021, 141(2): 413-435.