The Effectiveness of Fama-French 5 Factor Models Under COVID-19 Condition in the Gaming Industry

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Keywords: Fama-French 5 Factor, Gaming Industry, COVID-19.

Abstract: Contemporarily, it is crucial to investigate the effectiveness of assets valuation approaches in some special conditions. This article is aimed at assessing the effectiveness of the Fama and French 5 factor model under COVID-19 pandemic using data from the gaming industry. The empirical evidence has been presented in stable stock markets; its manifestations during the periods of increased volatility and instability of the markets remain poorly explored. This research intends to discover how Five-Factor model reacted to the impact from the pandemic in such a way that the market abnormalities can be analysed via data from the years 2019 and 2020. The R² value in five-factor model has shown more capability in explaining the excess returns during the pandemic with 0.8482+, compared to 0.6245, which was indicated before. In addition, all five predictors, which included factors related to profitability and investment strategy, proved to be significant in the pandemic period, as opposed to only three predictors in the period before the pandemic. Nevertheless, the predictive power of the model tends to deteriorate, which can be verified by the increase of RMSE. While this work establishes the strength of the model in a volatile environment, it should also be noted that forecasting inaccuracies are uncovered. These experiences, therefore, bring copious lessons for the investors and financial analysts as they analyse portfolios in such crisis scenarios as the one during the COVID-19.

1 INTRODUCTION

Asset portfolio has undergone several significant developments since the 1950s until now. Initially, Harry Markowitz introduced the Modern Portfolio Theory (MPT) in 1952, in which he mentioned diversifying a portfolio can effectively reduce unsystematic risk (Markowitz, 1952). Subsequently, in 1964, William Sharpe proposed the Capital Asset Pricing Model (CAPM), which was based on MPT. In CAPM, Sharpe measured the expected return of an asset by its volatility in the market, which was the Beta coefficient (Sharpe, 1964). He assumed that borrowing and lending can be done at a risk-free rate and that all investors have the same expectation of future returns (Elbannan, 2014). As the theory continued to evolve, more factors were considered to predict the asset return more accurately. Fama and French argued that there were limitations to the CAPM, where a single Beta coefficient was insufficient to represent the complexity of the market and explain the average returns it presented (Fama & French, 1992). For this reason, Fama and French

proposed a three-factor model (FF3), where they added market risk (RM-Rf), size risk (SMB) and book-to-market ratio risk (HML) to explain in more detail the variations in the excess returns of stocks (Eraslan, 2013). Following this, to improve FF3, Fama and French added two additional factors, profitability (robust minus weak, RMW) and investment (conservative minus aggressive, CMA) factors. RMW measures the excess returns of more profitable firms relative to less profitable firms, whereas CMA reflects the outperformance of firms with conservative investment strategies over firms with aggressive investment strategies (Fama & French, 2015).

CAPM, FF3 and FF5 are widely used in empirical asset pricing studies. Throughout the ages, many scholars have devoted themselves to studying the validity of these models in different economic situations or industries, and their studies have led to different results. Several scholars have studied some of the industries in the current pandemic: some of them believe that the limitations of the FF5 have led to a reduction in its validity. In contrast, others

believe that the validity of the model has not been affected.

The academics believe that there are several main reasons for the reduced validity of the model, firstly because the factors used in the model are based on normal market conditions and economic situations, so these factors are unable to capture the state of the market in a situation as volatile as an epidemic. According to Kostin et al., who studied the performance of selected companies in the energy sector as well as in emerging sectors during the COVID-19 pandemic through the FF3 and the FF5, the traditionally efficient as well as self-regulating market was severely disrupted so that the performance of the market was less dependent on conventional financial indicators and more influenced by short-term factors influence, and the traditional five factors do not capture such unusual market movements (Kostin et al., 2022). Secondly, scholars have also argued that the effectiveness of the model is reduced in emerging markets that are prone to anomalies and in markets that have been severely hit by the crisis. According to the study, the FF5 has a significantly lower R^2 value during the crisis, which measures the model's capacity to clarify the anomalies in the data, which represents the near-zero ability of the five-factors to explain stock returns in emerging and energy sectors (sectors severely affected by the pandemic), which are different from the normal market (Kostin et al., 2022). Third, regional differentiation in an epidemic can also lead to a reduction in the validity of the FF5. According to the research, countries like China and Russia, which have adopted both free markets orientated and economically planned policies, deviate from the efficient market assumption on which the multifactor model is based, and the inadequacy of the model is evident during the pandemic as it is unable to adapt to the external macroeconomic disruptions and governmental policies affecting these markets (Kostin et al., 2022). Finally, scholars argue that the complexity of the model also reduces its validity. In previous studies (Kostin et al., 2022; Zhou, 2024), they all argue that the FF5 is less effective than FF3 in the context of pandemics and that a multi-factor model would be more firm-focused and therefore of limited applicability. The RMW and CMA factors in the FF5 do not enhance the model's explanatory power. For example, the FF5 is unable to explain the market returns of the Chinese pharmaceutical industry during an epidemic (Zhou, 2024) because its rigid assumptions rely on traditional risk, which would limit the model's ability to capture market changes under high uncertainty.

Conversely, several academics contend that the reliability of the five-factor model remains robust in an epidemic scenario. Alqadhib et al., who incorporated the five-factor model in their research to measure the risk-managed performance of active mutual funds in Tehran, put forth compelling evidence that attests to the model's durability during the pandemic (Alqadhib et al., 2022). It was found to elucidate approximately 75% of the fluctuations in the returns of equity mutual funds. Regardless of the prevailing pandemic, enterprises with sizable profits and those pursuing conservative investment strategies were present. For such enterprises, the five-factor model capably accounted for the deviation, yielding an accurate depiction of returns investors garnered after risk adjustments. Substantially positive returns were accomplished in the study by adjusting for the recognized risks.

The study of other scholars also studies exhibit mixed results. According to Zhang et al. on the excess returns of real estate investment trusts (REITs), there conclusion indicates two of the factors in FF5, RM-Rf and SMB, show a relatively stable impact in explaining the returns and the model also demonstrates a certain level of validity after adding the momentum factor which explains the returns during the pandemic (Zhang et al., 2023). However, the applicability and validity of the model is limited by the fact that the skewness and kurtosis factors are not consistent across regions.

The research aims to investigate the effectiveness of the FF5 in the gaming industry before and during the pandemic. The pandemic provided this study with a market context of economic disruption and high volatility, which helped to test the robustness of the model. Although the FF5 has been widely validated in stable markets, it lacks performance in the gaming industry during a crisis. By exploring the gaming industry, this study aims to gain insights into how the five-factor model works when an unprecedented market crisis erupts and to assess the model's robustness. In the following, this will be done through an explanation of the methodology used in this study, presentation of the empirical results, analysis of the empirical results, conclusions, limitations of the model and outlook.

2 DATA AND METHOD

The data selected in this article are from daily data of the game industry in the United States. In this case, we have intercepted two time periods, the first starting from 2 January 2019 to 31 December, and the

second starting from 2 January 2020 to 31 December. The purpose of intercepting the data from the two time periods is that we want to divide the study into two segments: before the pandemic and during the pandemic, so that we can do a comparative study about testing the effectiveness of the model under the pandemic. Data comes from the Kenneth R. French's data librarys.

In this study, we use linear regression as the main statistical technique, which typically employs OLS as the main parameter estimation method. Specifically, we aim to model the excess returns of the portfolio through the risk-free rate and regress residual profits on a set of dependent variables. The non-dependent variables included in the regression represent various characteristics of the market and the portfolio.

The validity and interpretability of linear regression is why we chose it as our primary statistical technique, and by assuming a linear relationship between the independent and dependent variables, the impact of each factor on the portfolio's excess returns can be clearly inferred through the resulting coefficients. Specifically, the following models will be regressed:

$$Rp_t - Rf = \beta_0 + \beta_1(RM - Rf)_t + \beta_2(SMB)_t + \beta_3(HML)_t + \beta_4(CMA)_t + \beta_5(RMW)_t + \epsilon_t \quad (1)$$

Here, there are five explanatory variables, which are RM-Rf, SMB, HML, CMA and RMW. As described above, RM-Rf stands for market risk; SMB is size risk; HML is book-to-market ratio risk; RMW is excess return from profitability; and CMA is a comparison of the performance of companies with different investment strategies. The result of whether the validity of the five-factor model weakened during the pandemic was obtained by comparing the beta

coefficient significance, sign, and p-value of the five factors for the game industry under the two time periods.

3 EMPIRICAL ANALYSES

3.1 Correlation Analysis

Based on the regression results in Table 1 and Table 2, before COVID-19, the RM-Rf, SMB, and RMW factors are statistically significant, whereas the HML and CMA factors do not demonstrate significance. These suggest that the RM-Rf, SMB, and RMW factors have the greatest impact on the extra return. During COVID-19 pandemic, all five factors show significance. The following is a detailed correlation analysis for each factor.

The RM-RF factor shows how the stock has moved in relation to the market. The RM-RF coefficient is 0.698 before the pandemic and almost 1 during pandemic, demonstrating that the sensitivity of gaming industry is roughly same as the market movement during COVID-19 pandemic and less sensitive to market movements before that. The SMB factor shows how the stock has moved in relation to the size premium. In both periods, SMB factor and excess returns are strongly correlated. The positive correlation suggesting that small-cap stocks tend to have better performance than large-cap stocks have. Before COVID-19, the SMB coefficient of 0.765 indicates a moderate positive exposure to small market value stocks, while during the COVID-19 outbreak, the SMB coefficient increases to 1.301, reflecting a much better performance of smaller firms

Table 1: Coefficient of FF5 of gaming industry before COVID-19.

	Coefficient	Std. err.	t-Stat	P-value
RMW	0.300	0.139	2.16	0.032
SMB	0.765	0.098	7.81	0.000
RM-RF	0.698	0.056	12.49	0.000
HML	-0.137	0.110	-1.25	0.213
CMA	-0.233	0.205	-1.14	0.257

Table 2: Coefficient of FF5 of gaming industry during COVID-19.

	Coefficient	Std. err.	t-Stat	P-value
RMW	0.657	0.202	3.26	0.001
SMB	1.301	0.117	11.14	0.000
RM-Rf	0.985	0.392	25.12	0.000
HML	0.536	0.243	4.44	0.000
CMA	-1.550	0.079	-6.37	0.000

over larger ones. The RMW factor shows how the stock has moved in relation to the profitability premium. The coefficient of RMW factor doubles from 0.300 to 0.657 as affected by the pandemic. This suggests that firms with higher profitability continuously increase returns, but due to the pandemic their influence doubles. The HML factor shows how the stock has moved in relation to the book-to-market ratio premium. It is not significant to explain the stock price changes in the game industry before COVID-19, but after the outbreak, the HML factor becomes significant, the coefficient of which is 0.536. This shift suggests that firms with a high book-to-market ratio typically have higher returns. The CMA factor shows how the stock has moved in relation to the investment premium. Based on the result, CMA also changed from a redundant variable of FF5 before COVID-19 to a valid factor after the outbreak, with a coefficient of -1.550. This negative coefficient smaller than -1 reveals that during this period, firms that pursued more aggressive expansion strategies generates higher returns than those pursuing conservative expansion strategies.

3.2 Model Performances

To assess how well the FF5 performed in the gaming sector prior to and following the COVID-19 outbreak, Coefficient of determination (R^2 and Adjusted R^2), and Root Mean Squared Error (RMSE) are the key measurement statistics. R^2 measures the proportion of the excess return's overall anomalies explained by the five factors. Adjusted R^2 accounts for the number of predictors and sample size in the regression model, serving as a more accurate measure to explain the variation. RMSE measures the average magnitude of the errors in predictions made by a regression model.

Table 3: Comparison between R^2, Adjusted R^2, and RMSE statistics before and during COVID-19.

	Before COVID-19	During COVID-19
F-Stat	81.84	276.03
P-value	0.0000	0.0000
R^2	0.6245	0.8482
Adjusted R^2	0.6169	0.8451
RMSE	0.5937	1.2458

According to Table 3, the regression results had an R^2 value of 0.6245 before COVID-19 pandemic. This means that the model can explains 62.42 percent of the variation in excess return. Comparatively, the second sample shows a marked increase in the value of R^2 of 0.8482, which indicates a marked improvement in the model's ability to explain variation of excess return during the pandemic. As

adjusted R^2 varied little from R^2 in both periods, this indicates that the model is a good fit for data before and during COVID-19 pandemic. However, RMSE rose from 0. 594 to 1246 during the COVID-19 pandemic, which means that the predicted values were further away from the actual values. The increase shows that the model was less reliable during the pandemic.

3.3 Discussion

The results of this study show important information about how the stock prices of the gaming industry changed before and during the COVID-19 pandemic. Before the pandemic, the model shows that RM-RF, SMB, and RMW are significant for understanding excess returns. This model explains 62.45 percent of the differences in returns. The sensitivity of the gaming industry to market movements is relatively lower, and smaller, profitable firms shows a positive impact on returns. During the pandemic, all five factors, including the HML (value premium) and CMA (investment premium), are statistically significant. The rise in R^2 to 84.82 percent during the pandemic indicates that the model acquired greater efficacy in capturing the determinants of surplus returns in the gaming sector.

From the investment perspective, these results show that during crises like the COVID-19 pandemic, smaller gaming firms do better than larger ones, and firms that make more profit continue to offer significant returns. Additionally, the HML and CMA factors that show significance during the pandemic suggests that firms having higher book-to-market ratio and invest aggressively may generate better returns during economic condition like COVID-19. However, even though the regression model had a better performance during the pandemic, the results became less reliable. Therefore, investors should take the model performance into consideration when making portfolio decisions based on the five factors.

4 CONCLUSIONS

To sum up, the purpose of this study is to assess the efficacy of FF5 under the under the COVID-19 through analysis of data selected from the gaming industry. The analysis revealed that FF5 is able to explain more of the anomalies in returns at this time during the pandemic, as seen by a significant increase in both the R^2 and Adjusted R^2 values. As RMSE also increased during the pandemic, prediction accuracy of the model decreased during the pandemic. Factors

valid to explain excess return changed from RM-RF, SMB, RMW to all five factors across Pre-COVID and COVID periods. The results suggests that firms that are smaller, more profitable, high book-to-market ratio, and invest aggressively are likely to have higher returns. Nonetheless, this study is limited due to the unrepresentative data selected from single industry and single time. Future research could analyse more samples from different industries and under different conditions for more precise and representative results. The finding of this paper help to better understand how the FF5 works during COVID-19, providing useful information for investors and financial analysts. There exists some limitation to the study. First, a key issue of this study is that data selected only come from the gaming industry that may not be representative to the entire market as different industry may react differently to the COVID-19 outbreak. Evaluating effectiveness of FF5 based on regression results using unrepresentative data can be inaccurate. Second, the study period is constrained to the time before and during the COVID-19 pandemic. This limits the applicability of the results to time after the recovery from pandemic and other economic conditions. Third, unreliability of the model during the pandemic creates large difficulty to make accurate conclusion. Considering these limitations, future research could examine data from a wider range of industries and see how well the Farmer-French 5-Factor model works in different economic periods or crises. Adding more factors or trying different models could make predictions more accurate in unstable markets. The result of this study helps to understand factors affect stock returns in the gaming industry. It also gives important information for investors during economic condition like COVID-19 pandemic.

AUTHOR CONTRIBUTION

All the authors contributed equally and their names were listed in alphabetical order.

REFERENCES

Alqadhib, H., Kulendran, N., Seelanatha, L., 2022. *Impact of COVID-19 on mutual fund performance in Saudi Arabia.* Cogent Economics Finance, 10, 1.

Elbannan, M. A., 2014. *The Capital Asset Pricing Model: An overview of the theory.* International Journal of Economics and Finance, 7, 1.

Eraslan, V., 2013. *Fama and French Three-Factor Model: Evidence from Istanbul Stock Exchange.* Business and Economics Research Journal, 4(2), 11-19.

Fama, E. F., French, K. R., 1992. *The Cross-Section of Expected Stock Returns.* The Journal of Finance (New York, 47(2), 427–465.

Fama, E. F., French, K. R., 2015. *A five-factor asset pricing model.* Journal of Financial Economics, 116(1), 1–22.

Kostin, K. B., Runge, P., Charifzadeh, M., 2022. *An Analysis and Comparison of Multi-Factor Asset Pricing Model Performance during Pandemic Situations in Developed and Emerging Markets.* Mathematics Basel, 10(1), 142.

Kostin, K. B., Runge, P., Mamedova, L. E., 2023. Validity of the Fama-French Three- and Five-Factor Models in Crisis Settings at the Example of Select Energy-Sector Companies during the COVID-19 Pandemic. Mathematics Basel, 11(1), 49-53.

Markowitz, H., 1952. *Portfolio selection.* The Journal of Finance New York, 7(1), 77–91.

Sharpe, W., 1964. *Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk.* The Journal of Finance, 19(3), 425-442.

Zhang, W., Li, B., Roca, E., 2023. *Moments and momentum in the returns of securitized real estate: A cross-country study of risk factors driving real estate investment trusts before and during COVID-19.* Heliyon, 98, pp 18476–18476.

Zhou, Y., 2024. *An Empirical Analysis on the China's Medical Industry under COVID-19 Based on Fama-French model.* SHS Web of Conferences, 181, 1002-.