Metaverse and Stock Market—A Study Based on Fama-French Model

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Abstract. Stock prices reflect the value of anticipated future profits of companies. Since business cycle conditions affect the future profitability of firms, expectations about the business cycle will impact the stock value of firms. Recently, the popularity of Metaverse in the global financial market has been increasing. One of the novel features of this paper is to incorporate a link between stock price movements and Metaverse. By implementing the three-factor and five-factor Fama-French model, the author selects different industries to better study the impact of the Metaverse in different industries in the U.S. stock market. The data is derived from the New York Stock Exchange, the American Stock Exchange, and the Nasdaq Stock Market. The results indicate that Metaverse has affected the stock price of technology companies, especially the monopolies of the technology related companies. Moreover, the emergence of Metaverse has influenced the stock price of the real estate industry. Not only the worldwide Internet giants such as Meta, Tencent, NetEase, ByteDance, etc. are taking actions to seize the great opportunities of Metaverse, but more small and medium-sized enterprises are following the trend. Undoubtedly, Metaverse has brought an innovative business model to the financial market and the world. It hopes that the results of this paper would help investors better understand the stock market of both technology and Meta related companies with the storm of the Metaverse.

Keywords: Asset pricing · Metaverse · Stock price · Fama and French five factor model · Financial market · Technology companies

1 Introduction

Technology has been considered as one of the main drivers of companies' development. It also serves as an important predictor of stock performance. Stock prices reflect the value of anticipated future profits of companies. Since business cycle conditions affect the future profitability of firms, expectations about the business cycle will impact the current value of firms. Previous research indicates that what seems to be overvaluation in one sector of the economy may lead to positive externalities for other sectors [4].

The term Metaverse was put forward in 1992 by the American science fiction writer Neal Stephenson's novel Snow Crash, which describes a virtual world parallel to the real space. With the maturity of cloud computing, 5G, AR, VR and other technologies, Metaverse is expected to gradually transfer from a concept to reality. Recently, the

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popularity of Metaverse in the global financial market has been increasing. On March 10, 2021, regarded as the "first share of the Metaverse", Roblox was successfully listed on the New York Stock Exchange. The success of Roblox demonstrated that humans had entered the world of Metaverse. The listing of Roblox on NYSE not only declared the success of Metaverse as a business concept, but also illustrated its potential effect on stock performance. Subsequently, the Facebook CEO Mark Zuckerberg initiated the idea of Metaverse, announcing that Facebook had begun to enter the world of Metaverse. On October 28, 2021, the company name was changed from "Facebook" to "META". The emergence of the Metaverse not only brought great impacts on the worldwide internet giants, but also predicted the reform of existing industries. Virtualized space promotes the construction of virtualized production scenarios, stimulating the development of a number of emerging industries. The development of related high-tech industry has also led to an unprecedented industrial technology storm [5]. The emergence of Metaverse has provided capital with a new direction for industrial investment. A large amount of capital has been invested in related industries, which not only promotes the development of high and new technology, but also optimizes the industrial layout of capital to some extent.

According to the "2020–2021 Metaverse Development Research Report" released by Tsinghua University, the Bloomberg industry research report predicts that Metaverse will reach a market size of 800 billion US dollars in 2024, which illustrates its comparable scale. In other words, experts predict that in the next three years, the Metaverse industry will be able to make the accomplishments that the mobile phone industry has achieved in the past 40 years. At the same time, the Internet has also become popular on how to quickly use the Metaverse to make profits. Therefore, the emergence of Metaverse has significantly influenced the financial market including the stock market. However, what the impact that Metaverse brings to the stock market is and how it will develop has not been widely discussed.

In this paper, the author will implement three-factor Fama–French model and the five-factor Fama–French model to analyze the effect of Metaverse on the stock market. It hopes that the results of this paper would help investors better understand the stock market of both technology and Meta related companies with the storm of the Metaverse.

2 Literature Review

2.1 Asset Pricing

Asset pricing has always been a popular research topic in modern finance field. Its theoretical model has experienced many evolutions. Markowitz (1952) first proposes the asset portfolio theory, using the mean variance analysis method to determine the optimal investment portfolio [9]. Subsequently, Sharpe (1964) puts forward a capital asset pricing model (CAPM) on the basis of asset portfolio theory and capital market theory [11]. As a single-factor model, CAPM mainly studies the assets in the stock market, the relationship between expected rate of return and risky assets, and how the equilibrium price is formed. CAPM believes that it is unsystematic risk that affects the rate of return of stocks. After the 1980s, studies illustrate that CAPM is not rigorous enough to explain stock returns and cannot explain some abnormal phenomena outside of

system factors. Under such circumstances, the arbitrage pricing theory (APT) becomes an extension of CAMP. Based on a multi-factor model, APT considers arbitrage as a decisive factor in the formation of the modern efficient market (that is, the average market price). Based on APT, Fama and French propose the Fama-French two-factor model, adding the scale factor and the book-to-market value ratio factor [6]. In this way, the expected return of the investment group is more accurately predicted. Afterwards, researchers discover that although the three-factor model successfully resolve various shortcomings in the CAPM, it gave rise to new disadvantages, such as the anomaly of accrued earnings and the anomaly of net stocks. It fails to explain some anomalies or the cross-sectional variation in expected returns that are related to profitability and investment. Therefore, Fama and French (2015) develop a five-factor model based on the discussion framework of the Dividend Discount Model (DDM) [7], which adds profit factors and investment style factors to better describe average returns on portfolios formed to produce large spreads in size, book-to-market equity (B/M), profitability and investment. In the international capital market, the empirical test results of the five-factor model are generally better than the three-factor model and have been widely used. When it comes to the emergence of Metaverse, the applicability of the three-factor model and the five-factor model to specific industries needs to be further explored.

2.2 Financial Technology

The concept of financial technology (Fintech) first appeared in the 1990s. It is considered to be a number of emerging information technologies and collections. There is no unified definition in subsequent developments. The idea of Fintech is widely recognized and was defined as "technology-driven financial innovation" at the G20 meeting, which allows Fintech to become well-known in the worldwide. Anand and Mantrala (2019) believe that Fintech is a new business model with new technology applications, new products and services that act on the financial industry, as well as innovations from front-end products to back-end technology [1]. With the deep integration of technology and finance and the support from the regulatory authorities for Fintech, traditional commercial banks, securities companies and other institutions have established their own financial technology departments. At the same time, many internet companies such as Alibaba, Tencent and Baidu have gradually established their own financial technology departments. As increasing number of companies started to get involved in financial business, the financial technology industry developed rapidly. Tufano (1989) explains that due to the application of various emerging technologies, financial technology innovation has produced new financial products that intersect with each other [13]. Arner et al. (2015) argue that financial technology has reshaped the existing financial industry and forms a positive feedback loop [2]. Information technology continuously brings new financial innovation products, which in turn will deepen the integration of finance and technology.

According to the previous literature, financial technology is based on basic innovation activities that are triggered by information technology and Internet technology. This alters the operation mode of traditional finance and gives rise to new changes in financial products, business processes, and basic technologies. The development of Fintech in recent years is derived from the development of Internet finance, which most

of the previous research has widely discussed. While financial innovation activities are spread across all aspects of the financial system and brings a profound impact, Fintech has attracted numerous scholars' attention. However, by changing the function of the traditional financial system, while the Fintech is developing rapidly, the application of financial technology may also lead to certain traditional financial risks. Therefore, it is believed that financial technology can affect the stock market essentially.

When it comes to the market risk of financial technology, Ofek (2002) studies stock prices and volatility based on the structure of social networks, improving the risk asset pricing model based on social network analysis, and made improvements to Internet finance [10]. The social networks in the market are defined and measured. Studies have shown that in the Internet finance environment, due to the more advanced information transmission, the measurement of financial risks requires more consideration of the social network structure, and the investment risk caused by the social network structure may be greater [8].

Research on financial technology demonstrates that financial technology has the effect of lowering the threshold of financial services and strengthening financial functions [12], which may cause bad money to drive out good money and strengthen the procyclicality of the financial market. At the same time, the uncertainty brought about by technology makes traditional financial risks more difficult to detect, and financial risks caused by technical defects and operational errors will spread more quickly to the entire financial market. Compared with traditional finance, the scale of Fintech is still small. However, the development of financial technology has shown its promising future. Firstly, the speed of financial technology innovation has been greatly increased, and products can be formed more quickly and are allocated into the market faster. Secondly, financial products are more inclusive and innovative ideas always come out rapidly.

Regarding the technical risks of financial technology, research on financial technology believes that the openness of fintech greatly enhances the risk in the stock market [3]. Herd behavior will occur more easily in this context, and the market panic will further affect the entire market.

Metaverse is a new context in the fintech field. Inspired by the previous study, whether it has significant impact on the stock price and volatility remains a question to be discussed. Considering the heterogeneity of the industry, the effect and degree of the impact on different industries are different. In this paper, the author chooses the data from technology industry, real estate industry, internet entertainment industry, and traditional manufacturing industry to study.

3 Fama-French Model

Many researchers found in analyzing asset pricing models that a single factor cannot well explain the excess return of the investment portfolio. In order to analyze and explain more comprehensively, Fama and French proposed a three-factor model in 1992. The Fama-French three-factor model explains the difference in stock returns. The three-factor model believes that the excess return rate $E(R_{it}) - R_{ft}$ of the investment portfolio will be affected by the market's excess return rate $E(R_{mt}) - R_{ft}$, the company's market value

and the book-to-market value ratio. Among them, Fama-French takes the company's market value as the size factor SMB, the book-to-market value ratio factor as HML and puts these two factors into the capital asset pricing model CAPM to improve it.

The three-factor model is expressed as:

The basic form of the model is:

$$E(R_{it}) - R_{ft} = \alpha + \beta MKT[E(R_{mt}) - R_{ft}] + \beta SMB$$
$$E(R_{it}) - R_{ft} = \alpha + \beta MKT[E(R_{mt}) - R_{ft}] + \beta SMBSMB_t + \beta HMLHML_t + e_{it} \quad (1)$$

Where R_{it} is the rate of return of the portfolio, R_{ft} is the risk-free rate of return, α is the intercept term, R_{mt} is the market rate of return, $E(R_{it}) - R_{ft}$ is the excess rate of return of the portfolio, and $E(R_{mt}) - R_{ft}$ is the return spread between the capitalization-weighted stock market and cash. SMB_t represents the return spread of small minus large stocks (i.e. the size effect). The book-to-market value ratio factor HML_t represents the return spread of cheap minus expensive stocks (i.e. the value effect). And e_{it} is the residual item. If the market factor, market value factor, and book-to-market value ratio factor can fully explain the abnormal return of the asset, then the intercept α in the model should tend to zero. However, some scholars later found that in some investment portfolios, α is significantly rather than zero, indicating that the three factors model has limitations, such as the existence of an anomaly of bearable earnings, an anomaly of net stock issuance, and an anomaly of momentum.

In 2015, Fama and French further propose a five-factor model, adding profitability and investment style factors to the three-factor model to better describe the excess return rate of the investment portfolio. The five-factor model is based on the dividend discount model, and the company's profitability and investment style factors are added to the three-factor model. Among them, Fama-French regards company earnings as the profit factor RWM and investment style as the investment factor CMA.

The five-factor model is as follows:

$$E(R_f) = \beta_{M_{kt}}[E(R_m - R_f)] + \beta_{SMB}SMB + \beta_{HML}HML + \beta_{RMW}RMW + \beta_{CMA}CMA + e_i \quad (2)$$

RMW represents the profitability factor, which reflects the return spread of the most profitable firms minus the least profitable. Profit is defined as the annual operating income minus operating costs, interest expenses, sales expenses and management expenses and then dividing the book equity at the end of the previous fiscal year. CMA represents the investment style factor, which reflects the difference between the stock portfolio returns of conservative and aggressive investment styles.

4 Data and Results

This paper uses stock samples of listed companies' data derived from the New York Stock Exchange, the American Stock Exchange and the Nasdaq Stock Market. In order to better study the impact of the Metaverse in different industries in the U.S. stock market, the author selects 8 companies from each different industry, including technology industry, internet entertainment media industry, real estate industry, and traditional manufacturing

industry. Due to the popularity of Metaverse in the United States in 2021, a total of 12 months of daily value from January to December was selected. Theoretically, the data of the same length of time was selected as the comparison reference before the event (January 2020 to December 2020).

The rules of Fama-French three-factor model grouping are: according to the market value, listed companies are divided into small market capitalization stocks and large market capitalization stocks (each accounting for 50%). According to book-to-market ratio, the listed companies are further divided into H (high book-to-market ratio), M (medium book-to-market ratio), L (low book-to-market ratio), each accounted for 33%. Thus, there are six combinations of stocks: SL, SM, SH, BL, BM, and BH. The factor construction of the five-factor model is based on the three-factor model. The profit factor RMW and the investment factor CMA are sorted and grouped to obtain W (poor profit), O (medium profit), R (good profit), C (Investment style is conservative), N (Investment style is neutral), A (Investment style is radical). In total, there are 18 groups.

The multiple linear regression method was implemented to process the data of technology companies in the US stock market, and the coefficients of the three-factor and five-factor models before and after the Metaverse event. The significance test was performed to verify the matching effect of the model, the significance of the factor, and the trend of change. Considering the convenience of comparison, the factor coefficients are all evaluated at 5% significance, as shown in Fig. 1. There is only a slight improvement of the five-factor model compared to the three-factor model. This indicates that the fitting effect of the five-factor model on the selected data segment before and after the event has not been significantly enhanced. After the model is adjusted, the average value of R square has increased significantly, suggesting that the three-factor model after the Metaverse event fits the market better. Therefore, it can be inferred that the accuracy of the Fama-French model for industry pricing after the Metaverse event is higher.

By comparing the significance of each factor before and after the Metaverse event, the author further investigates the effect of the multi-factor model on the data, as shown in Fig. 2. The intercept term α of selected industries after the event in the three-factor model is significant. After the Metaverse event, the significance ratio of the scale factor SMB and the book-to-market value ratio factor HML has increased.

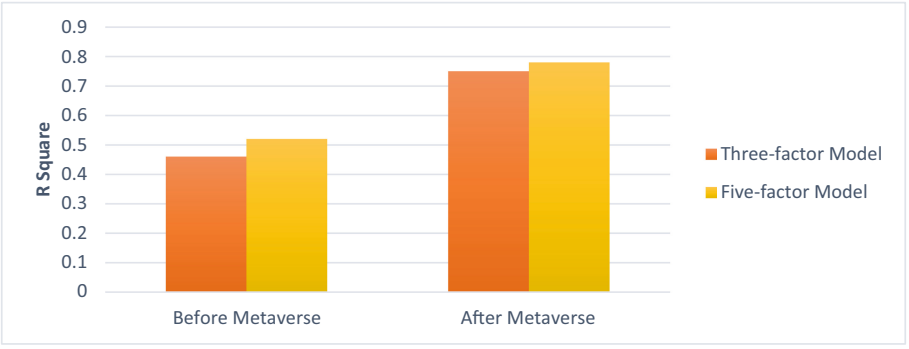

Fig. 1. Adjusted R Square average value of three-factor model and five-factor model of technology industry before and after the Metaverse event.

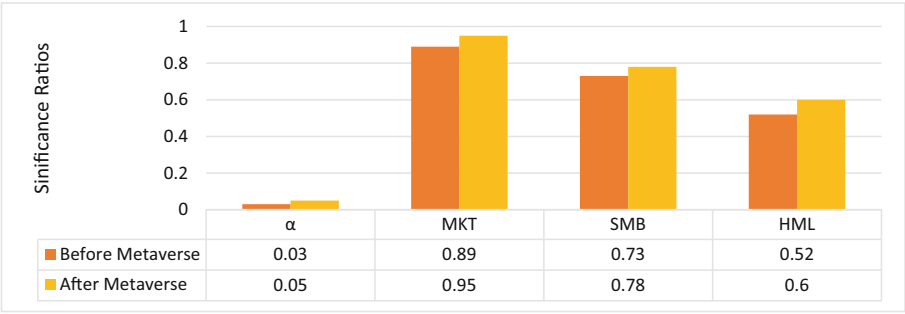

Fig. 2. Significance ratios of each factor in the three-factor model of selected industries before and after the Metaverse event.

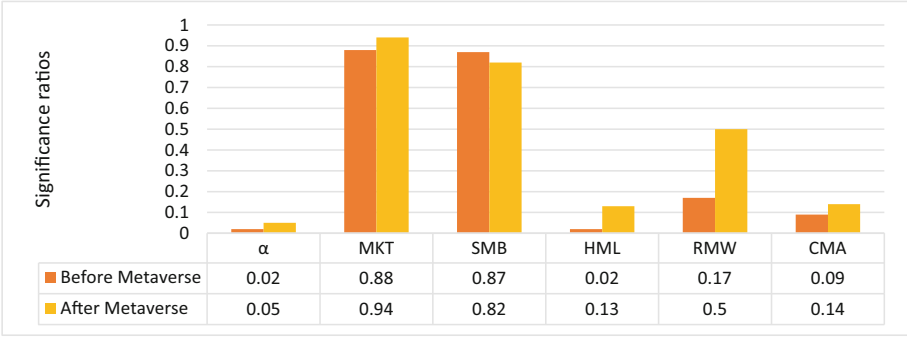

Fig. 3. Significance ratios of each factor in the five-factor model of selected industries before and after the Metaverse event.

With the addition of the profit factor RMW and the investment style factor CMA, the book-to-market value ratio factor HML will be redundant. As shown in Fig. 3, the overall significance ratio of the pre-Metaverse profit factor RMW to the investment style factor CMA is not high, while the book-to-market value ratio has increased. However, based on the results of Figs. 2 and 3, before the Metaverse event, stock performance in technology industry is more related to market and market value factors. It is noteworthy that during 2020, in addition to the impact of the COVID-19 pandemic, US stocks were also affected by such factors as the Federal Reserve's quantitative easing policies, the impact of many important events has caused anomalies in many industries, such as Brexit, black riots, and the US presidential election.

After U.S. stocks fell to lows at the end of March 2020, technology stocks led the Nasdaq Index to rebound sharply, and most of the funds flowed to technology stocks. The possible reason is that the COVID-19 pandemic accelerated the shift of the consumer side from traditional industries to the new economy on a global scale. During 2021, the Nasdaq Index has been also increasing, especially after November 2021, when the Metaverse event occurred.

As shown in Table 1, the market factor MKT has an increasing trend under the influence of the metaverse. This demonstrates that asset price changes in technology

Table 1. Descriptive statistics of technology industry factor returns before and after the Metaverse event.

Time	Indicators	Three-factor Model			Five-factor Model				
		MKT	SMB	HML	MKT	SMB	HML	RMW	CMA
Before Metaverse	coefficient	0.92*	1.84*	−0.52*	0.87*	0.84*	0.22*	−0.23	0.06
	T-value	19.23	11.45	−0.28	22.68	15.42	0.47	−1.56	0.29
After Metaverse	coefficient	3.46*	1.97*	−0.75*	3.70*	0.41*	0.67*	−0.04	−0.95
	T-value	26.59	8.21	−0.83	28.90	13.03	0.96	−0.83	−0.11

industry are sensitive. After the emergence of the metaverse, the overall performance of the market is closely related to people's rising attention to technology companies, which also directly affects the stock price of the technology industry. Additionally, both the small and mid-cap stocks in the tech sector have significantly higher yields. Companies with smaller market capitalizations are usually smaller in scale, and the companies are relatively less stable, so they are riskier and need to obtain higher returns to compensate. The results show that the book-to-market ratio and investment style factors are redundant for describing stock returns. The HML remains significant and negative before and after the Metaverse event, indicating that the market prefers growth stocks. The RMW increases significantly, which shows that the technology industry is speculative. Despite being only recently popularized, the metaverse industry has greatly affected the tech industry. Due to its optimistic projections as well as nascent nature, large and small companies in the technology sector have their eyes set on the metaverse industry. Some of them seek to develop products, aiming to provide users with metaverse experience. Others create metaverse products that enable professionals in various industries to create the virtual extension of physical reality.

From Table 2, the real estate industry is less sensitive to the market. However, with the rise of Metaverse, the coefficients also increase in the Fama-French three-factor and five-factor model. The idea of owning metaverse real estate for profit attracts investors, which further influences their preferences for the real estate industry. Recently, a virtual real estate on the virtual reality platform called "Decentraland" was sold for a record-breaking amount $2.4 million worth of cryptocurrency. This sparked attention from real estate speculation in the Metaverse industry. With the popularity of the metaverse concept, buying and selling real estate in the virtual world has become more and more common.

The Metaverse has aroused market's attention towards the great value of technology related companies, especially the giants and monopolies of the technology companies. In addition, many industries are not significantly affected by the Metaverse event. Taking the traditional manufactory industry as an example, its stock prices have no significant causal relationship with the Metaverse event. In the early stages of the Metaverse event, people doubt its reliability. However, later, a series of advertisement demonstrated Meta's trustworthiness, and the successful commercial events of Metaverse has injected a boost to the capital market.

Table 2. Descriptive statistics of real estate industry factor returns before and after the Metaverse event.

Time	Indicators	Three-factor Model			Five-factor Model				
		MKT	SMB	HML	MKT	SMB	HML	RMW	CMA
Before Metaverse	coefficient	0.78*	1.18*	0.06	0.39*	0.27	−0.06	−0.39*	0.09
	T-value	13.21	1.73	1.96	16.72	2.87	−2.72	−4.08	0.32
After Metaverse	coefficient	1.32*	1.90*	0.13	0.47*	0.93	0.02	−3.61*	0.10
	T-value	27.69	7.04	2.35	24.94	9.70	−0.19	−6.05	0.72

5 Conclusion

In conclusion, the paper implements three-factor Fama–French model and the five-factor Fama–French model to analyze the effect of Metaverse on the stock market. It finds that Metaverse has affected the stock price technology related companies, especially the monopolies of the technology related companies. Moreover, the emergence of Metaverse has also influenced the stock price of the real estate industry. However, the stock prices of other industries have no significant causal relationship with the Metaverse event, such as the traditional manufactory industry. Meanwhile, Metaverse brings a new business model to the world. The Internet giants around the world are vigorously and actively applying the Metaverse to seize the great business opportunities, such as Meta, Tencent, NetEase, ByteDance, etc. More small and medium-sized enterprises are also following the trend.

The good performance of Metaverse related stocks has brought confidence to the society and financial markets. However, despite its strong growth, the Metaverse may be still a niche market. For instance, while virtual land prices have skyrocketed, investing in real estate in the Metaverse is a speculative venture and no one can ensure whether virtual land is promising. China's official media People's Daily also commented that the real estate speculation in the Metaverse and virtual asset transactions are not subject to legal supervision in many countries. The question for investors is whether this craze will fade away like the previous craze a few years ago. In this regard, large technology companies such as Meta and Microsoft are conducting research and development, and the chances of VR success may be even greater in the near future. In the long run, it may still take several years for the Metaverse to become mature.

As with the majority of studies, the design of the current study is subject to limitations. Since Metaverse is still a new concept, the size of the data is relatively small due to the time limit. In the future, the size of the data after the Metaverse event can be expanded. Thus, more data can be implemented to study the effects of Metaverse on the stock market. Furthermore, the Fama and French three-factor and five-factor model may be improved to better explain the effects on different industries. In the future, scholars can also combine the Fama and French three-factor and five-factor model with other models to study the impacts of Metaverse more accurately.

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