

Pre- Epidemic and Post-Epidemic Comparison of Firm Market Risk Sensitivity Based on CAPM Model

Xiao Han^{1,*†}, Zixuan Yang^{2,†}, Suming Zou^{3,†}

¹Business School, University of Sydney, Sydney, Australia

²School of Economics and Management, Agricultural University of Hebei, Baoding, China

³School of Mathematics and Statistics, Guangdong University of Foreign Study, Guangzhou, China

*Corresponding author: xhan0721@uni.sydney.edu.au

†These authors contributed equally.

Abstract. According to the Capital Asset Pricing Model (CAPM), the expected return and the risk of the security are related. Since January 2020, due to the COVID-19, numerous businesses failed to adjust to the new reality and grew dangerous and unpredictable for their investors. The goal of this research is to assess how the pandemic might impact asset pricing and company betas. This study has utilized empirical data and regression analysis to measure beta of CAPM model before and after COVID-19 of 5 companies in the airplane industry. The data of return of each company, risk free rate and market rate are calculated from the stock price. From the measurement, the companies had volatile stock returns, and most declined. It is also deduced that, except for Spirit Airlines, all four companies had beta values greater than one in the two years prior to the epidemic, indicating that, prior to the epidemic, the risk associated with airline stocks was greater than the risk associated with the market.

Keywords: CAPM model; COVID-19; aviation industry.

1. Introduction

Capital Asset Pricing Model (CAPM), one of the cornerstones of contemporary finance, serves as the basis for countless academic studies. [1]. The CAPM model was innovated and has been developed since its introduction in the 1960s and has expanded tremendously, emerging in the West as a discipline unto itself. This model is frequently used to calculate the anticipated return on a given asset, explaining the connection between the security's expected return and the risk attached to it. It offers a reference rate of return for valuing assets and helps to predict the expected return on untraded assets.

Fama and MacBeth, the creators of the testing methodology, initially established the CAPM on the US stock market and afterwards tested it [2]. The implications of the testing approach for the CAPM model on different markets were further broadened by other studies. Foreign academics have conducted a great deal of empirical study on the CAPM model's application in developed Western capital markets, particularly in US capital markets. The test results' reliability is still up for discussion. Recent empirical studies have provided new support for the CAPM. If more effective statistical techniques are applied, Amihud discovered that the estimations of the relationship between average returns and beta are favorable and substantial [3]. Reinganum's studies argued that the firm size effect while Kothari and Sloan argued that the beta estimates have large standard deviations [4, 5].

To increase the practical applicability of CAPM models, Ondrej used beta estimation to predict portfolio risk, and used rigorous serial testing of CAPM portfolios, a multivariate approach, to take portfolio correlations into account, which reduced sensitivity to outliers and non-normality assumptions [6]. Asset betas have an effect on discrete investors' expectations of short-term aggregation volatility, according to Arsoy's volatility-based capital asset pricing model (V-CAPM) [7]. The uncertainty about expectations of aggregated volatility is high because market betas are viewed as riskier than themselves and their small-cap and value-cap counterparts that increase during recessions [7]. As anticipated, these excess returns denominated in euros will produce a positive risk premium, while the beta coefficient is always positive and typically less than 1. The estimation of

beta is unaffected significantly by the inclusion of additional parameters. The findings imply that the CAPM model is appropriate for this kind of research. By adding higher order moments of skewness and kurtosis to the traditional model to test the returns of individual stocks, Vasco further investigated the traditional CAPM model [8]. The outcomes showed that the risk premium is positive and considerable as expected by the CAPM model, proving that the CAPM approach is suitable for tame markets.

The CAPM has only recently been developed and used to numerous investment decision-making and theoretical research sectors due to the late launch of China's securities market. Numerous domestic academics have recently conducted empirical research on the CAPM model, and according to the findings of these studies, the model has very limited applicability. Following the investigation, it was discovered that the majority of these articles had used cross-sectional data from several stocks as their research data. The regression's beta value for each stock is fixed, and the derived equation rarely passes the value test. The degree of fit is inadequate in the samples that pass the test.

The CAPM model provides a more thorough description of the standards of behavior for investors in the securities market. A clear understanding and expectation of the relationship between the return and risk of the asset are provided by these codes, which produce a stable linear relationship between the return and risk of the security. Also shown is the connection between risk and predicted return. The projected return of the asset is correlated with the beta value used to estimate its risk, which helps to some extent in determining the capital asset price. In addition to estimating the effects of various macroeconomic developments on stock prices, it might be beneficial to assess the price of stocks that are eligible for listing. When the market reaches equilibrium, the "reasonableness" of the prices of various stocks that are already listed is determined by estimating the expected return of the stock. It determines the quantitative relationship between the standard deviation. The simple CAPM model breaks down the price of any kind of hazardous asset into three components: the risk-free rate of return, the price of risk, and the unit used to calculate risk. It then connects these components.

Since January 2020, the COVID-19 pandemic outbreak has mostly dominated international public conversation. The economies and financial markets of several nations now face a higher level of uncertainty because of the pandemic, including a sudden and violent stock market crash since the financial crisis 2007- 2008.

Increases in COVID cases and fatalities have a big impact on the pace of global inflation, the unemployment rate, and the index of energy commodities. The increasing number of lockdown days, monetary policy decisions, and overseas travel restrictions all had a substantial impact on the level of economic activity as well as the closing, opening, lowest, and highest stock prices of important stock market indices [9]. A lot of companies did not manage to adapt to new reality and become risky and volatile for their investors. Investigating whether the financial models are still applicable under COVID-19 is important.

The use of beta in the securities market measures a stock's sensitivity to market fluctuations, or its correlation with the market, or "stockiness," as it is more popularly called. On the other hand, the COVID-19 epidemic cannot be linked to systematic risk because no one anticipated the problem, and no one was prepared to deal with it.

This paper is attempting to evaluate how the pandemic might affect the companies' betas and the asset pricing. The time series data of selected stocks are regressed over time to compare the market risk coefficients of different time periods before and after the epidemic under the CAPM model, which is useful for stock investment.

2. Methodology

2.1 CAPM Model's Assumptions

This paper uses the traditional CAPM model. The capital asset pricing model has strict model assumptions, which are mainly the following.

Table 1. Assumptions' content

| Assumption | Content |
|------------|--|
| 1 | Market investors will choose the maximum return under the determined risk, or the minimum risk under the determined return |
| 2 | The market is completely efficient, and investors can buy any asset in the stock market according to their own wishes. |
| 3 | There are no institutional restrictions on asset transactions |
| 4 | The market risk-free interest rate is fixed |
| 5 | Personal behavior does not affect the market |
| 6 | There is expected homogeneity, and the probability of return distribution of all investors is expected to exist at the same time |

2.2 CAPM Model

The basic form of the traditional CAPM model is as follows:

$$R_{it} - R_{ft} = \alpha_i + \beta_i(R_{mt} - R_{ft}) + \varepsilon_{it} \quad (1)$$

In formula (1), R_{it} denotes the return of company i in period t , R_{ft} denotes the monthly risk-free return of the market in period t , R_{mt} denotes the market return in period t , β_i denotes the market risk factor of asset portfolio i , α_i denotes the intercept term of the equation, it is the random disturbance term, and the residual term is obtained after establishing the regression of the equation.

2.3 Data Selection

In this paper, five US listed airlines were selected as American Airlines, JetBlue Airways, Southwest Airlines, Spirit Airlines, United Airlines in alphabetical order, respectively, and the monthly closing prices of the above stocks from July 2017 to June 2022 were selected as the data for this paper. The data were obtained from respectively.

The individual stock return R_{it} was also calculated for the five stocks with the following formula.

$$R_{it} = \frac{P_{i,t} - P_{i,t-1}}{P_{i,t-1}} * 100\% \quad (2)$$

Where $P_{i,t}$ is the closing price of i shares in the t period, and similarly $P_{i,t-1}$ is the closing price in the period $t - 1$.

The risk-free rate of return R_{ft} in the formula is measured by using U.S. short-term Treasuries as the risk-free rate, because Treasuries are a product with a default rate almost equal to zero within the market, meaning that the portfolio is invested entirely in Treasuries, and the entire portfolio is equal to the return, so the risk-free rate is generally set equal to the Treasury rate.

The market portfolio return R_{mt} is measured by calculating the return R_{mt} of the U.S. stock market by using the S&P500 index before and after the two periods.

2.4 Model Settings

According to the traditional CAPM model, the traditional CAPM model can be reduced to a one-dimensional linear OLS regression model by setting $R_{mt} - R_{ft}$ to X_{it} , X_{it} is the monthly excess return of stock i in period t . Setting $R_{it} - R_{ft}$ to Y_{it} , Y_{it} is the monthly excess return of market portfolio m in period t . The details are as follows.

$$R_{it} - R_{ft} = \alpha_i + \beta_i(R_{mt} - R_{ft}) + \varepsilon_{it} \quad (3)$$

Reduced one-dimensional linear OLS regression model:

$$Y_{it} = \alpha_i + \beta_i * X_{it} + \varepsilon_{it} \quad (4)$$

In the one-dimensional linear OLS regression model, α_i and β_i are the regression estimates and ε_{it} is the random disturbance term.

3. Results and Discussion

3.1 Descriptive Statistical Analysis

The next two tables present the results of descriptive statistical analysis on the data, with particular attention paid to the minimum, maximum, mean, standard error, standard deviation, and variance of the returns. The outbreak time in the United States was set in December 2019, and descriptive statistical analysis was performed using the previous data as the data before the outbreak, and the results in Table 2 were obtained.

Table 2. Descriptive analysis before COVID-19

| | N | Minimum | Maximum | Mean | Variance |
|--------------------|----|---------|---------|--------|----------|
| Southwest Airlines | 31 | -0.203 | 0.201 | -0.011 | 0.010 |
| United Airlines | 31 | -0.214 | 0.225 | 0.002 | 0.008 |
| American Airlines | 31 | -0.134 | 0.153 | 0.006 | 0.006 |
| JetBlue Airways | 31 | -0.177 | 0.167 | -0.002 | 0.007 |
| Spirit Airlines | 31 | -0.248 | 0.235 | -0.004 | 0.010 |
| Market | 31 | -0.092 | 0.079 | 0.010 | 0.001 |
| Rf | 31 | 0.015 | 0.031 | 0.024 | 0.000 |

Data from December 2019 onward were analyzed descriptively as five airlines after the outbreak in the United States, and the results in Table 3 were obtained.

Table 3. Descriptive analysis during COVID-19

| | N | Minimum | Maximum | Mean | Variance |
|--------------------|----|---------|---------|--------|----------|
| Southwest Airlines | 30 | -0.358 | 0.253 | -0.015 | 0.022 |
| United Airlines | 30 | -0.229 | 0.323 | -0.007 | 0.013 |
| American Airlines | 30 | -0.488 | 0.330 | -0.016 | 0.025 |
| JetBlue Airways | 30 | -0.433 | 0.285 | -0.015 | 0.021 |
| Spirit Airlines | 30 | -0.547 | 0.383 | 0.002 | 0.035 |
| Market | 30 | -0.125 | 0.127 | 0.007 | 0.003 |
| Rf | 30 | 0.005 | 0.030 | 0.014 | 0.000 |

The descriptive analysis table as above for two different periods shows that, on average, the stock returns of the five airlines show a large change, with most of them showing some degree of decrease, while the variance of the stock returns of the five companies after the outbreak can be seen to show a large increasing trend after comparison, indicating that the stock returns of each stock The variance of the stock returns of each stock is more volatile.

The monthly data are averaged to obtain the return of each half year, and three stocks are selected from the five stocks and compared with the market return, and a line graph is drawn for a period of five years to obtain Figure 1.

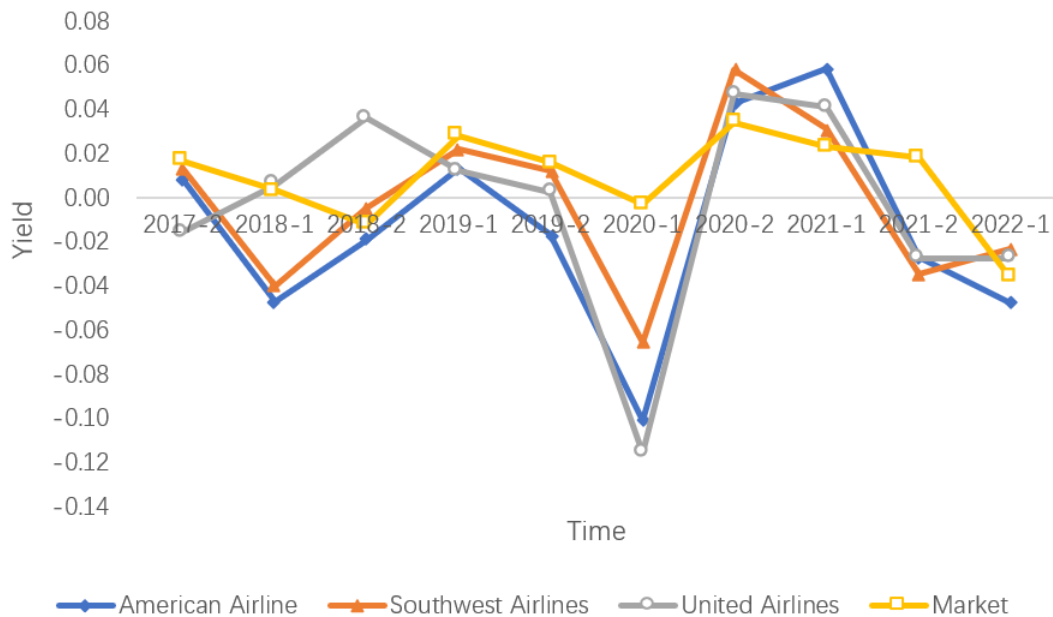


Fig 1. Comparison between the yield of three aviation corporation's stocks and the market

This study also shows from Figure 1 that with the second half of 2019 as the outbreak date, the stock return after the outbreak is more volatile in value. Compared with before the outbreak, the highest and lowest values of volatility increased and decreased by about 0.1 unit.

3.2 Regression Results and Tests

The overall data were divided into two different time periods (pre-epidemic and post-epidemic), and one-dimensional linear regressions were performed on the data from each of the two sections to obtain the results in table 4.

Table 4. Data regression result of CAPM model

| | Before COVID-19 | | | During COVID-19 | | |
|--------------------|-----------------|---------|-------|-----------------|---------|-------|
| | β | p_value | R2 | β | p_value | R2 |
| Southwest Airlines | 1.611 | 0.000 | 0.432 | 0.752 | 0.020 | 0.128 |
| United Airlines | 1.116 | 0.000 | 0.299 | 1.304 | 0.005 | 0.227 |
| American Airlines | 1.947 | 0.000 | 0.520 | 1.313 | 0.002 | 0.258 |
| JetBlue Airlines. | 1.280 | 0.000 | 0.316 | 1.600 | 0.000 | 0.432 |
| Spirit Airlines | 0.717 | 0.138 | 0.042 | 1.104 | 0.052 | 0.097 |

Table 4 shows the β_i coefficients of the five U.S. airlines and their changes in two different periods. The p value of β_i for the five companies (except Spirit Airlines) in the two different periods

is less than 0.05, indicating that the model does not apply to the stock changes of Spirit Airlines. However, the model can satisfactorily account for the stock returns of the remaining four companies.

The β_i coefficient is a reliable indicator of risk and indicates the relationship between the portfolio and the larger market, in accordance with the theory behind the capital asset pricing model. When the β_i value is larger than 1, it denotes that the stock's risk exceeds the market's risk level. Naturally, the portfolio's projected return is higher than the market's expected return, which is consistent with the market's "high risk and high return" features. However, when β_i is equal to 1, the stock risk is equivalent to the market risk level. The risk that the stock faces is lower than the risk that the market faces, and the return of the portfolio is also lower than the projected return of the market, when the β_i is less than 1.

Based on this measure this study can conclude that in the two-year period before the epidemic, all four companies had β_i greater than one, except for spirit Airline, indicating that before the epidemic, the risk of airline stocks was greater than the market risk, while during the epidemic period, only Southwest Airline Co.'s β_i coefficient declined from greater than one to less than one, indicating that during the epidemic period. The β_i coefficient of Southwest Airline Co. decreases from greater than one to less than one during the epidemic period. While the other four airline stocks were often above the overall market risk, its firm stock was exposed to a lower level of risk than that throughout the pandemic period.

The CAPM model is utilized in the empirical analysis to examine the stocks of five American airline firms. The model's analysis still differs from the actual capital market due to many sorts of issues because the data of the stocks chosen for this study are sparse and the CAPM model's assumptions are too strict.

4. Conclusion

This paper selects Southwest Airlines, American Airlines, spirit airlines, United Airlines and JetBlue airlines, which are listed in the United States. The data selects the monthly closing prices of stocks from July 2017 to June 2022. Through statistical analysis and collation, it is found that the stock returns of the five companies fluctuate greatly and most of them decline to a certain extent. Further analysis was made on the changes of stock returns of American Airlines, Southwest Airlines and United Airlines. It was found that the stock returns fluctuated more after the epidemic than before. In addition, based on the traditional CAPM model, this paper makes one-dimensional linear regression for five airlines, and finds that the stock returns of the other four airlines except spirit airlines can be explained by the model, which shows that the model is applicable in this paper. In addition, it was found in the regression that before the epidemic, except for spirit airlines, the stock ratios of the other four companies were higher than the overall market risk, while during the epidemic period, except for Southwest Airlines, the stock ratios of the other four companies were higher than the overall market risk. According to the above analysis, this paper guesses that there are two reasons why the stock risk of Southwest Airlines is lower than the overall market risk. The first reason is that after the outbreak of the epidemic, the company made a decision on aircraft hygiene, that is, to effectively control the cleaning cost and reduce the cleaning time, so as to increase the number of flights and improve flight efficiency. Another possible reason is that the liquidity of Southwest Airlines' liquid assets is poor. The less capital flow leads to less capital flowing into the stock market, which can lead to the decline of stocks.

References

- [1] Levy. The CAPM is Alive and Well: A Review and Synthesis. *European Financial Management: the Journal of the European Financial Management Association*, 2010, 16(1), 43–71.
- [2] Fama, E. F., and MacBeth, J. D. Risk, return, and equilibrium: Empirical tests. *Journal of political economy*, 1973, 81(3), 607-636.

- [3] Amihud Y, Christensen B J, Mendelson H. Further evidence on the risk-return relationship. Graduate School of Business, Stanford University, 1992.
- [4] Reinganum M R. A new empirical perspective on the CAPM. *Journal of financial and quantitative analysis*, 1981, 16(4): 439-462.
- [5] Kothari S P, Shanken J, Sloan R G. Another look at the cross-section of expected stock returns. *The journal of finance*, 1995, 50(1): 185-224.
- [6] Chochola O, Hušková M, Prášková Z, et al. Robust monitoring of CAPM portfolio betas II. *Journal of Multivariate Analysis*, 2014, 132: 58-81.
- [7] Arisoy Y E, Altay-Salih A, Akdeniz L. Aggregate volatility expectations and threshold CAPM. *The North American Journal of Economics and Finance*, 2015, 34: 231-253.
- [8] Vendrame V, Guermat C, Tucker J. A conditional regime switching CAPM. *International Review of Financial Analysis*, 2018, 56: 1-11.
- [9] Ozili P K, Arun T. Spillover of COVID-19: impact on the Global Economy. Available at SSRN 3562570, 2020.
- [10] Fan Shicheng. Empirical research based on CAPM model in traditional Chinese medicine industry. *China collective economy*, 2021 (17): 66-68