Research Article

The Comparison between CAPM and APT Models for Returns Analysis on Securities in Technology Sector

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ABSTRACT

This study aims to evaluate the suitability of CAPM and APT models for analyzing the returns of technology stocks. The data consists of the monthly closing prices of 32 stocks listed on the NASDAQ stock market in the US from January 2015 to December 2022. The study employs the Standard Multivariate Regression Framework, the Davidson and Mackinnon Equation, and the Residual Analysis methods. The results show that the APT model outperforms the CAPM model in explaining the returns of technology stocks based on two of the three methods for 19 out of 32 stocks, namely AMAT, AMKR, AVGO, AZPN, CDNS, EXLS, FFIV, FSLR, FTNT, GEN, INTU, MANH, MTCH, MU, NTAP, PTC, SPLK, SSNC and VRSN.

Keywords: CAPM, APT, NASDAQ, Technology Stocks

1. INTRODUCTION

Technology is a vital and essential factor in various aspects of human daily life. It has created convenience, modernity, time efficiency, problem-solving capabilities, and decision-making benefits in learning, work, and communication. Nowadays, technology is progressing rapidly and introducing new innovations to stimulate economic and societal growth. It also enhances the quality of life (Stanley et al., 2018) and serves as a primary industry that drives other industries and improves a country's competitive edge (Gomez-Barroso & Marban-Flores, 2020a, b). Therefore, it is of great importance in the development of the economy, society, and the stability of a nation.

Investment is a key factor for the economic progress and prosperity of a country, as it indicates the income level and well-being of people. When investments increase, they have positive effects on the overall economic system, such as creating more jobs for the workforce. Nowadays, there are many investment options to choose from, such as depositing money in commercial banks, buying real estate and properties, and investing in various kinds of financial securities (Kanjananantawong & Vichitthamaros, 2016). Stock markets, which include different stock groups, have been growing steadily, especially in the technology sector, which has fast and significant growth, attracting many investors, such as institutional investors, mutual funds, individual investors, and corporations, both beginners and experts. Investors of all ages and backgrounds look for high returns from the stock market. NASDAQ (National Association of Securities Dealers Automated Quotations) is the second-largest stock market in the United States and the first market to trade electronically. It has the most registered companies and the most advanced technological infrastructure. In 2020, the global stock market had 10 groups of stocks, and it was found that the technology sector had the largest share at 48%, followed by the services sector at 19.4%, the healthcare sector at 10.2%, and other sectors at 22.4% (NASDAQ, 2022).

Investopedia reports that technology is a huge component of the U.S. economy. Employment in computer and IT is projected to grow 11% from 2019 to 2029, faster than the average for all occupations. The impact of the tech industry has affected nearly every state, and the industry is ranked in the top five economic contributors in 23 states and in the top 10 of 28 states (Investopedia, 2021). The technology sector is indeed one of the most dynamic and profitable sectors in the global economy, offering investors attractive returns and growth opportunities. However, estimating the expected returns of stocks in this sector is not a straightforward task, as different models may yield different results. A study by Malhotra (2010) analyzed whether a set of factors explained the returns of 20 stocks in the United States, using monthly data from 2000 to 2005. The results indicated that the risk factors that affected stock returns were: number of shares traded, price-earnings ratio (P/E), market capitalization, and growth. Another study by Kabeer (2017) studied the influence of macroeconomic factors on stock markets performance in the South Asian Association for Regional Cooperation (SAARC) and China. The empirical evidence showed that inflation and foreign exchange were positively related with stock returns in Bangladesh. Conversely, in China, they found that stock returns were weakly correlated with foreign direct investment. A study by Du (2023) aimed to construct an arbitrage pricing model to make a regression analysis on Amazon's stock price, which was demonstrated to have a higher prediction accuracy and better fitting degree compared with the self-coding network. The study concluded that the arbitrage pricing model has a high prediction accuracy for Amazon's stock price, and the fitting degree of the final model can reach 0.996, which is better than that of the self-coding network. In conclusion, while CAPM assumes that the market portfolio is the only factor that affects the returns of individual stocks, APT allows for multiple factors that may influence the returns of stocks in different ways. The choice between these two models depends on various factors such as data availability, market conditions, and research objectives.

The technology sector is one of the most dynamic and profitable sectors in the global economy, offering investors attractive returns and growth opportunities. However, estimating the expected returns of stocks in this sector is not a straightforward task, as different models may yield different results. This study aims to utilize stocks in the technology sector, applying the CAPM and APT models to estimate their returns. The CAPM model assumes that the market portfolio is the only factor that affects the returns of individual stocks, while the APT model allows for multiple factors that may influence the returns of stocks in different ways. By comparing the results of these two models, this study seeks to determine which model is more suitable for analyzing stocks in the technology sector. In forecasting the returns of technology stocks. To do so, it employs three econometric tools: the standard multivariate regression framework, the Davidson and Mackinnon equations, and residual analysis. The study applies these tools to a sample of technology stocks from the US market and evaluates the explanatory power and the efficiency of each model. Moreover, this study also examines whether the findings differ from other studies that employ the CAPM and APT models, with a focus on the technology sector.

2. LITERATURE REVIEW

Capital Asset Pricing Model

The Capital Asset Pricing Model (CAPM) is a widely used and influential model that explains how stock returns vary according to market risk factors. It was derived from Markowitz's portfolio theory (1952) by Sharpe (1964), Lintner (1965) and Mossin (1966). The CAPM assumes that investors are rational and well-diversified, and that they only care about the expected return and the systematic risk of their portfolio. The CAPM also implies that the expected return of a stock is linearly related to its beta, which measures its sensitivity to the market portfolio. The CAPM has been tested and compared with other models, such as the Arbitrage Pricing Theory (APT) and the Fama-French model. Some studies, such as Banbaeng et al. (2020), have found that the CAPM performs better than the APT in predicting stock returns, because the APT has limitations in identifying the relevant risk factors. Other studies, such as Yunita et al. (2020), have shown that the CAPM and the APT have different methods in estimating the expected return of a stock. Moreover, Phantaeng (2008) have compared the CAPM, the APT and the Fama-French model, and have concluded that the Fama-French model and the CAPM are superior to the APT in explaining stock returns, because they both include market risk as a variable, while the APT only uses economic factors that may not be sufficient.

The CAPM model and the APT model are two popular methods for estimating stock returns. However, there is a debate about which one is more accurate and reliable. Suroso et al. (2018) compared the two models and concluded that the CAPM model outperforms the APT model in all time horizons. Zubairi & Farooq (2011) also supported the CAPM model and argued that it captures the relationship between risk and return better than the APT model, which does not account for the impact of economic factors on stock returns. On the other hand, Tursoy et al. (2008) tested the APT model and found that different economic variables have different effects on different industry groups. They claimed that the APT model is more flexible and realistic than the CAPM model, which assumes a single market factor. Dash & Rao (2009) also examined the two models and found that the APT model is superior to the CAPM model except for the market factor. They suggested that the APT model can incorporate interest rates as an important determinant of stock returns, but they also acknowledged that the market factor is still the most dominant factor, twice as much as interest rates.

Abdulkarim (2012) tested the validity of the CAPM model using monthly and weekly data from 780 stocks on the New York Stock Exchange (NYSE) between March 1992 and May 2012. The traditional first/second pass methodology was used to test the difference of CAPM test results between static and rolling least-squares techniques. Abdulkarim found that the static OLS method could explain the risk premium better than the rolling OLS method. Similar studies were done by Jamil and Andor et al. on the European stock markets, specifically the London Stock Exchange (LSE) and the Budapest Stock Exchange (BSE). Jamil (2018) reviewed the literature on empirical tests of CAPM models in different stock markets, and then used the least square method to test the CAPM model in the U.K. using stock returns of 70 companies listed on the LSE from 2004 to 2016. The results showed that risk did not have a significant impact on portfolio return. Andor et al. (1999) used monthly data of 17 Hungarian companies listed on the BSE to test the CAPM model in the Hungarian capital market. They found that in Hungary, CAPM's "realistic interpretation" ability lagged behind that of developed capital markets. Andor et al. suggested that this could be due to limited data, data adjustments, segmentation of investors, or underdevelopment of domestic capital markets. Xiao (2022) tested the validity of the Capital Asset Pricing Model (CAPM) in the U.S. stock market before and after the COVID-19 pandemic outbreak. The sample included daily data for 49 U.S. industry portfolios over 36 months from September 2018 to August 2021, with a total of 754 observations. Through linear regression analysis, Xiao concludes that the timely implementation of quantitative easing and interest rate cut by the U.S. government played a role in stimulating the economy after the outbreak of the epidemic. Except for the gold portfolio, the other 48 sectors all demonstrated the validity of CAPM before and after the outbreak, and the validity increased after the outbreak. In addition, the post-outbreak U.S. stock market has been in a high-risk, high-return state for a long time. Al-Afeef (2017) conducted a study on the impact of stock beta and market return on the Capital Asset Pricing Model (CAPM). The study used data from Amazon companies listed in S&P 500 from 2009 to 2016. Multiple regression models were used to test different variables, and all null hypotheses were rejected in favor of alternative hypotheses. The results showed that CAPM can be applied to efficient markets and huge companies. Tsuji (2017) investigated the non-linear CAPM from the automobile industry, specifically Suzuki, Toyota, Nissan, Mazda, Mitsubishi, and Honda Motor Corporation. Monthly basis data from 1989 to 2017 was used. The study found that if the distribution of stock return is fat-tail, non-linear CAPM is too much effect. If stock return is normally distributed, non-linear CAPM also affects. The Wald test was used to estimate standard CAPM and non-linear CAPM. If the stock return distribution is fat-tail and the Wald test estimation of non-linear CAPM is reliable, then the Wald test estimation is standard linear CAPM. Alqisie & Alqurran (2016) studied the validity of Capital Assets Pricing Model (CAPM) for the Amman Stock Exchange using monthly share prices of 60 stocks of Jordanian firms listed in Amman Stock Exchange from 2010 to 2014. The period was divided into three sub-periods. The analysis was done by applying t-test, p-test, regression, beta coefficient, nonlinearity, and some hypothesis tests. The analysis results showed that higher risk is not associated with higher levels. Using data from 35 companies listed on the Hong Kong Stock Exchange from 2010 to 2020, Wang (2021) examined how asset pricing models, prospect theory, and the COVID-19 pandemic explain the changes in stock returns on the Hong Kong stock market. The results showed that the market was highly volatile during the pandemic. The Hang Seng Index had a positive relationship with the portfolios. The index also increased when the government imposed lockdowns and travel restrictions. Crude oil had a negative impact on the market. Stocks with higher returns in the previous month tended to perform better in the current month. Asset pricing models helped to evaluate the market efficiency of the Hong Kong stock market.

Arbitrage Pricing Theory

The Arbitrage Pricing Theory (APT) is a financial model that explains how the expected returns of stocks are influenced by various sources of risk. Unlike the Capital Asset Pricing Model (CAPM), which assumes that only one factor (market risk premium) affects stock returns, APT allows for multiple factors to be considered. The APT was proposed by Ross (1976) as an alternative to CAPM, based on the idea that investors can exploit arbitrage opportunities if the prices of stocks do not reflect their true values. The APT assumes that there are no arbitrage opportunities in the market, and that the expected return of a stock is a linear function of its exposure to different risk factors. The risk factors can be macroeconomic variables, industry-specific factors, or firm-specific factors, depending on the model specification. The APT also assumes that the risk factors are orthogonal, meaning that they are independent of each other and have zero correlation. Roll and Ross (1980) tested APT empirically and found evidence that four or five factors can explain most of the variation in stock returns.

A review of the literature reveals that various economic factors have been examined in relation to the stock returns in different markets. For example, Chen, Roll & Ross (1986) investigated the effects of inflation, interest rate and industrial productivity index on the US stock returns. Azeez & Yonezawa (2006) analyzed the Japanese stock market with respect to money supply (M2), inflation, exchange rate and industrial productivity index. Rjoub et al. (2009) explored the Turkish stock market with regard to inflation, interest, risk premium and money supply. Singh et al. (2011) considered the factors of exchange rate and gross domestic product (GDP) that influence stock returns. Adam & Tweneboah (2008) studied the Ghanaian stock market and found a long-term relationship between macroeconomic variables and stock market index. Siripullop (1978) examined the Thai stock market and found that interest rate, consumer price index (CPI), price-earnings ratio (P/E ratio), inflation and money supply (M2) are related to stock price. Maysami et al. (2004) studied the Singaporean stock market and found that consumer price index (CPI), interest rate, money supply (M2), exchange rate are related to the stock market index. Kewongsa (2014) found that the factors that affect the technology industry stock price index are the Dow Jones industry index and the net buy-sell value of shares in the technology industry. Kanjanantawong & Vichitthamaros (2016) found that the market, inflation and industrial productivity index can explain the change in stock returns.

The APT model is a popular alternative to the CAPM model for calculating stock returns. Many studies have compared the performance of these two models and found different results. For example, Simmons (1995); Chawalit (2000); Febrian & Herwany (2010); Kisman & Restiyanita (2015); Wannathanaphong & Chancharat (2016) and Tungvichitrerk (2017) found that the APT model can better account for stock returns than the CAPM model. On the other hand, Zhang & Li (2012) found that the CAPM model can better predict the response of substitutes than the APT model. However, they also acknowledged that the APT model can capture more factors than the CAPM model. Moreover, Muzir et al. (2010) found that the APT model can measure the impact of the economic crisis on stock returns, while the CAPM model fails to do so. Furthermore, some studies have challenged the validity of the CAPM model by showing that it cannot explain the excess returns of stocks. For instance, Fama & French (1992) found that the market value of the stock, not the beta (β) value in the CAPM, can explain the stock returns in some cases. Similarly, Basu (1997) found that the earnings per share ratio, not the beta (β) value in the CAPM, can explain the total return of the stock if it is higher than normal. Likewise, Jagannathan & Wang (1996) and Kothari et al. (1995) found that the beta (β) value in the CAPM cannot explain the stock returns at all.

Using the APT, several studies have examined the influence of different risk factors on stock returns in various markets. For example, Huang et al. (1996) found that oil futures returns can predict some individual oil company stock returns, as expected. However, oil futures returns do not affect broad market indices such as the S&P 500 significantly. They also show that oil futures volatility is a leading indicator of the volatility of the petroleum stock index. Sadorsky (2003) found that the conditional volatilities of oil prices, the term premium, and the consumer price index each have a significant impact on the conditional volatility of US technology stock prices. This means that the fluctuations in these macroeconomic variables affect the risk and uncertainty associated with investing in technology stocks. Kristjanpoller & Morales (2011) investigated the effect of monthly economic activity index, inflation, and copper price on the Chilean stock market. Králik (2012) explored the relationship between local and global macroeconomic factors and the Romanian stock market indices. Ikoku & Okany (2014) analyzed the impact of economic and financial crises on the sensitivity of stock indices to macroeconomic risk factors in Nigeria and South Africa. They found that inflation rate, exchange rate, oil price, and gold price had a significant impact on the stock prices of those two countries. The relationship between macroeconomic factors and stock market performance has been investigated by various studies in different countries. while Chellaswamy & Faniband (2020) reported that the Chinese consumer price index influenced the Shanghai Stock Exchange returns only for lower quantiles. Keswani and Wadhwa (2021) revealed that disposable income, GDP, foreign institutional investor, and stock returns had a long-term relationship in India, but youth unemployment and inflation had a negative one.

3. RESEARCH METHODOLOGY

The Data

This study aims to analyze the performance of technology stocks in the NASDAQ, which is one of the largest and most active markets for this sector. The data used are shares in the technology Sector listed on the NASDAQ that are traded through the Global Select Market (NASDAQ-GS) and are Common Stock determined from the shares with the highest market value (Market Cap) number of 32 shares according to Table 1.

Table 1: List of technology sector stocks

No	Abbreviation	Companies
1	AAPL	Apple Inc
2	ADBE	Adobe Inc
3	ADI	Analog Devices Inc
4	ADSK	Autodesk Inc
5	AMAT	Applied Materials Inc
6	AMD	Advanced Micro Devices Inc

Table 1: List of technology sector stocks (CONT.)

No	Abbreviation	Companies
7	AMKR	Amkor Technology Inc
8	ANSS	ANSYS Inc
9	AVGO	Broadcom Inc
10	AZPN	Aspen Technology Inc
11	CDNS	Cadence Design Systems Inc
12	ENTG	Entegris Inc
13	EXLS	ExlService Holdings Inc
14	FFIV	F5 Inc
15	FSLR	First Solar Inc
16	FTNT	Fortinet Inc
17	GEN	Gen Digital Inc
18	INTU	Intuit Inc
19	JKHY	Jack Henry & Associates Inc
20	MANH	Manhattan Associates Inc
21	MPWR	Monolithic Power Systems Inc
22	MTCH	Match Group Inc
23	MU	Micron Technology Inc
24	NTAP	NetApp Inc
25	PANW	Palo Alto Networks Inc
26	PTC	PTC Inc
27	SNPS	Synopsys Inc
28	SPLK	Splunk Inc
29	SSNC	SS&C Technologies Holdings Inc
30	SWKS	Skyworks Solutions Inc
31	TTWO	Take-Two Interactive Software Inc
32	VRSN	VeriSign Inc

The data sources and methods for preparing the CAPM and APT models for 32 technology stocks. The monthly closing price data of these stocks from January 2015 to December 2022 (96 months) was obtained from the website finance.yahoo.com. The same website was also used to collect the NASDAQ index data, which served as the market price index for the CAPM model. The NASDAQ data was also based on the monthly closing price at the end of each month. For the APT model, five macroeconomic variables were selected as risk factors: oil price, gold price, bitcoin price, Consumer Price Index (CPI) and MSCI Index (Morgan Stanley Capital International Index). These variables were chosen based on previous studies that found significant relationships between them and stock returns (Siripullop, 1978; Huang et al., 1996; Chawalit, 2000; Sadorsky, 2003; Maysami, 2004; Tursoy et al., 2008; Adam & Tweneboah, 2008).

The Model

1) Capital Asset Pricing Model (CAPM) following by:

$$E(R_{it}) = a_i + b_i(R_{m,t} - R_{f,t}) + e_{it} \quad (1)$$

Where:

$E(R_{it})$ = Expected return on stock i, period t.

a_i = Constant.

b_i = Sensitivity.

R_f = Risk free rate of return.

R_m = Market return:

$$R_{mt} = \frac{P_{m,t} - P_{m,t-1}}{P_{m,t-1}} \times 100 \quad (2)$$

Where:

$R_{m,t}$ = Rate of return of the stock market at time t

$P_{m,t}$ = Stock price index of the stock market at time t

$P_{m,t-1}$ = Stock price index of the stock market at time t–1

e_{it} = Error term

2) Arbitrage Pricing Theory (APT) following by:

$$E(R_{it}) = a_i + \beta_{i1}F_1 + \beta_{i2}F_2 + \beta_{i3}F_3 + \dots + \beta_{in}F_n + e_{it} \tag{3}$$

Where:

$E(R_{it})$ = Expected return on stock i, period t.

a_i = Constant.

$\beta_{i1}, \dots, \beta_{in}$ = Sensitivity of each factor (F_n).

$F_1, \dots, F_n$ = Surprise for a factor (actual value-expected value) follows:

$$F_i = \frac{f_{i,t} - f_{i,t-1}}{f_{i,t-1}} \times 100 \tag{4}$$

Where:

$f_{i,t}$ = Value of the economic variable at time t

$f_{i,t-1}$ = Value of the economic variable at time t–1

e_{it} = error term.

Data Analysis

One of the important steps in time series analysis is to check the stationarity of the data. Stationary data means data that has a constant mean and variance over time, while non-stationary data means data that has a changing mean and variance over time. A common method to test for stationarity is the Augmented Dickey-Fuller test or ADF test (Dickey & Fuller, 1979), which can detect the presence of a unit root in the data. A unit root means that the data has a stochastic trend that makes it non-stationary. The ADF test has the following null and alternative hypotheses: H_0: $\theta = 0$ (Non-stationary) and H_1: $\theta \neq 0$ (Stationary). If the absolute value of the ADF test statistic is greater than the Mackinnon critical values, we can reject the null hypothesis and conclude that the data is stationary. On the other hand, if we fail to reject the null hypothesis, we can infer that the data is non-stationary.

To compare the two models (CAPM and APT), we need to estimate the regression equation using the ordinary least square (OLS) method. This method minimizes the sum of squared errors between the observed and predicted values of the dependent variable. The regression equation will have the form:

$$y = b_0 + b_1x_1 + b_2x_2 + \dots + b_nx_n + e \tag{5}$$

where y is the rate of return of technology stocks, b_0 is the intercept, $b_1, b_2, \dots, b_n$ are the coefficients of the independent variables, $x_1, x_2, \dots, x_n$ are the independent variables, and e is the error term.

The t-test is a way of checking how likely it is that the independent variables in a regression model have a real effect on the dependent variable. The t-test compares the estimated coefficients of the independent variables with zero, which is the value they would have if there was no relationship between them and the dependent variable. The t-test uses a formula to calculate a statistic called t, which measures how far the estimated coefficients are from zero relative to their standard errors. The standard error is a measure of how much the estimated coefficient can vary due to sampling error. The formula for t is:

$$t = \frac{(b - H_0)}{SE(b)} \tag{6}$$

where b is the estimated coefficient, H0 is the null hypothesis value (usually zero), and SE(b) is the standard error of the coefficient.

One of the fundamental tasks in economic analysis is to examine the basic problems that may arise in the estimation of a model. These problems include: 1). Multicollinearity, which occurs when the explanatory variables are highly correlated with each other, 2). Autocorrelation, which occurs when the error terms are correlated across time or space, and 3). Heteroskedasticity, which occurs when the variance of the error terms is not constant. These problems can affect the reliability and validity of the model and its results. Therefore, it is essential to detect and correct these problems before using the model to estimate the rate of return of the technology stock.

The Standard Multivariate Regression Framework method is a way of comparing the abnormal or unexpected returns of two models (CAPM and APT) with the intercept term (a_i). This term represents the excess return over the risk-free rate of return. The method uses a t-test to check if the intercept is zero or not. If the intercept is zero, it means that the model is efficient and explains the return well. The equations for the two models are:

$$\text{CAPM Model: } R_i - R_f = (R_m - R_f) \tag{7}$$

$$\text{APT Model: } R_i - R_f = \beta_{i1}F_1 + \beta_{i2}F_2 + \beta_{i3}F_3 + \ldots + \beta_{in}F_n \tag{8}$$

The null and alternative hypotheses for the t-test are:

H_0: $a_i = 0$ (No relationship between independent and dependent variables)

H_1: $a_i \neq 0$ (There is a relationship between independent and dependent variables)

The Davidson and Mackinnon Equation is a way of comparing how well different models can forecast the stock returns based on Chen's (1983) concept and Groenewold & Fraser's (1997) approach (cited in Chawalit, 2000). The equation is:

$$R_i = K(R_{i,\,CAPM}) + (1 - K)(R_{i,\,APT}) + e_i \quad (9)$$

Where:

R_i = Actual return of stock i.

K = Coefficient.

$R_{i,\,CAPM}$ = Return on stock i from CAPM model

$R_{i,\,APT}$ = return on stock i from APT model.

The Davidson and Mackinnon Equation uses the returns from various models as independent variables to estimate the coefficient K. If the coefficient value is close to 1, it means that the model is very effective in forecasting the stock returns.

The Residual Analysis is a technique to evaluate the effectiveness of a model in predicting the stock returns based on the coefficient of the explanatory variable. The coefficient should be able to account for the stock returns of i and leave no residual (ei) that can be explained by another model. Conversely, if the residual (ei) can be predicted by factors from another model, it indicates that the model is not effective in predicting the stock returns. The regression equations used for the test are:

$$\text{CAPM Model: } \varepsilon_{i,t\,(CAPM)} = \lambda_{0i} + \lambda_{1i}F_1 + \lambda_{2i}F_2 + \lambda_{3i}F_3 + \ldots + \lambda_{ni}F_n + e_i \quad (10)$$

$$\text{APT Model: } \varepsilon_{i,t\,(APT)} = \lambda_{0i} + \lambda_{1i}(R_m - R_f) + e_i \quad (11)$$

$\varepsilon_{i,t}$ (APT) and $\varepsilon_{i,t}$ (CAPM) are both residual terms in the APT and CAPM models for asset i at time t. They represent the difference between the actual return of the asset and the expected return based on the respective models. They are also called the error terms or the disturbance terms in regression analysis. They capture the random or unpredictable component of the asset's return that is not explained by the models. λ_{0i} is the constant term or the intercept in both models for asset i. For CAPM model where λ_{1i}, λ_{2i}, λ_{3i}, ..., λ_{ni} are the betas or the slope coefficients in the APT model for asset i. They represent the sensitivities of the asset's return to each of the n factors in the APT model, such as macroeconomic variables or company-specific variables. They measure how much the asset's return changes when each factor changes by one unit. They are also called the systematic risks or the factor risks of the asset. And CAPM model where λ_{1i} is the beta or the slope coefficient in the APT model for asset i. It represents the sensitivity of the asset's return to the market risk premium ($R_m - R_f$), which is the only factor in this version of the APT model. It measures how much the asset's return changes when the market risk premium changes by one unit. It is also called the systematic risk or the market risk of the asset.

The residual is the dependent variable and the factors from another model are the independent variables. The test aims to examine whether the dependent variable can be explained by the independent variables in a statistically significant way or not. The test is done by using t-test to test the following hypothesis:

H_0: $\theta_i = 0$ which means i = 1, 2, 3, ..., n

H_1: $\theta_i \neq 0$

A model is effective in forecasting stock returns if the residuals from that model cannot be predicted by any variables in other models.

4. RESULTS AND DISCUSSION

Unit Root Test

The data of all variables (independent and dependent) were tested for stationarity at level I(0) using the ADF test method. The order of integration was assumed to be zero and the t-statistic of the ADF test was compared with the MacKinnon critical values at 90%, 95% and 99% confidence levels. The results showed that all variables were stationary at level I(0) because the absolute value of the t-statistic was higher than the MacKinnon critical values at the 99% percent confidence level.

Multicollinearity

The APT model uses 5 macroeconomic factors to explain the variation of asset returns: oil price, gold price, bitcoin price, CPI and MSCI Index. These factors are independent of each other, as shown by the low correlation values (less than 0.6) among them. This means that there is no multicollinearity problem in the model, which could affect the estimation of the factor loadings and risk premiums.

Autocorrelation and heteroskedasticity

The CAPM model was tested for autocorrelation and heteroskedasticity on 23 stocks: AAPL, ADBE, ADSK, AMD, AMKR, AZPN, CDNS, EXLS, FSLR, INTU, JKHY, MANH, MTCH, MU, NTAP, PANW, PTC, SNPS, SPLK, SSNC, SWKS, TTWO and VRSN. The results showed that the data did not have these problems for most of the stocks. The F-statistic (Prob) and Obs*R-squared (Prob) values were higher than 0.1, which supported the null hypotheses of no autocorrelation and homoskedasticity. However, 6 stocks: ADI, ANSS, AVGO, ENTG, GEN and MPWR had autocorrelation issues that were resolved using the Cochran Orcutt Iterative Method. And 3 stocks: AMAT, FFIV and FTNT had heteroskedasticity issues that were resolved using White's Heteroscedasticity Corrected Standard Error.

The APT model of 19 stocks: AAPL, ADBE, ADSK, AMD, CDNS, ENTG, EXLS, FTNT, INTU, JKHY, MPWR, MTCH, MU, NTAP, PANW, PTC, SPLK, TTWO and VRSN was tested for Autocorrelation and Heteroskedasticity. The results showed that the data did not have Autocorrelation or Heteroskedasticity issues for most of the stocks. The null hypotheses H_0: No Autocorrelation and H_0: Homoskedasticity were accepted based on the F-statistic (Prob) and Obs*R-squared (Prob) values of the data, which were greater than 0.1. However, some stocks had either Autocorrelation or Heteroskedasticity or both problems. For the 5 stocks: ANSS, AVGO, AZPN, GEN and SWKS that had Autocorrelation, the Cochran Orcutt Iterative Method was used to correct it. For the 6 stocks: AMAT, FFIV, FSLR, MANH, SNPS and SSNC that had Heteroskedasticity, the White's Heteroscedasticity Corrected Standard Error was used to correct it. For the 2 stocks: ADI and AMKR that had both problems, the combination of Cochran Orcutt Iterative Method and White's Heteroscedasticity Corrected Standard Error was used to correct them.

Estimation of CAPM and APT

According to CAPM model, the expected return of a stock is determined by its beta, which measures its sensitivity to the market risk premium. The market risk premium is the difference between the market return and the risk-free rate ($R_m - R_f$). These stocks are: AAPL, ADBE, ADI, ADSK, AMAT, AMD, AMKR, ANSS, AVGO, AZPN, CDNS, ENTG, EXLS, FFIV, FSLR, FTNT, GEN, INTU, JKHY, MANH, MPWR, MTCH, MU, NTAP, PANW, PTC, SNPS, SPLK, SSNC, SWKS, TTWO and VRSN. We estimate the beta coefficients for each stock using a regression analysis and compare them with the theoretical predictions of the CAPM model.

The APT model is a useful tool to analyze the impact of unexpected macroeconomic factors on the return rate of the technology sector stock. Results showed that: Bitcoin price factor was significant for 7 stocks: AMKR, GEN, SSNC, FSLR, INTU, TTWO and CDNS. This means that these stocks had a positive or negative relationship with the bitcoin price movement. CPI factor was not significant for any stock. This means that the inflation rate did not affect the technology sector stock returns. Gold price factor was significant for 5 stocks: AZPN, NTAP, SNPS, ADSK and GEN. This means that these stocks had a positive or negative relationship with the gold price movement. Oil price factor was significant for 3 stocks: MPWP, PTC and VRSN. This means that these stocks had a positive or negative relationship with the oil price movement. And MSCI index factor was significant for 32 stocks: AAPL, ADBE, ADI, ADSK, AMAT, AMD, AMKR, ANSS, AVGO, AZPN CDNS, ENTG, EXLS, FFIV, FSLR, FTNT, GEN, INTU, JKHY, MANH, MPWR, MTCH, MU, NTAP, PANW, PTC, SNPS, SPLK, SSNC, SWKS, TTWO and VRSN. This means that these stocks had a positive or negative relationship with the MSCI index movement. These findings suggest that the technology sector stock returns are influenced by various unexpected macroeconomic factors and that the APT model can capture these effects.

Comparison of CAPM and APT Models from Standard Multivariate Regression Framework, Davidson and Mackinnon Equation and Residual Analysis Methods

The Standard Multivariate Regression Framework: we compared the APT and CAPM models for forecasting the returns of 32 stocks in the technology sector. These stocks are: AAPL, ADBE, ADI, ADSK, AMAT, AMD, AMKR, ANSS, AVGO, AZPN, CDNS, ENTG, EXLS, FFIV, FSLR, FTNT, GEN, INTU, JKHY, MANH, MPWR, MTCH, MU, NTAP, PANW, PTC, SNPS, SPLK, SSNC, SWKS, TTWO and VRSN. Our results are consistent with previous studies by Phantaeng (2008), who also found that the APT model outperforms the CAPM model in explaining the variation of stock returns.

The Davidson and Mackinnon Equation method: the results show that the CAPM model fits better for 19 stocks, namely: ADI, ADSK, MTCH, FTNT, JKHY, MANH, PANW, TTWO, AAPL, ADBE, AMD, ANSS, CDNS, ENTG, INTU, MPWR, SNPS, SPLK and SWKS. On the other hand, the APT model fits better for 12 stocks, namely: AVGO, FFIV, FSLR, NTAP, VRSN, AMAT, AMKR, AZPN, EXLS, GEN, PCT and SSNC. These findings are consistent with the previous studies by Banbaeng et al. (2020) and Phantaeng (2008) that also found that the CAPM model has a better fit than the APT model when using this method to analyze the stock returns.

The Residual Analysis method: we compared the CAPM and APT models for predicting the stock returns of 32 stocks in the technology sector. We found that the CAPM model was suitable for 17 stocks: AAPL, ADBE, ADI, ADSK, AMAT, AMD, ANSS, AVGO, ENTG, EXLS, FFIV, JKHY, MU, NTAP, PANW, SWKS and TTWO. The APT model was suitable for all 30 stocks. This result is consistent with Tungvichitrerk (2017), who suggested that the APT model is more appropriate than the CAPM model for analyzing stock returns using this method.

The APT model is more suitable for the analysis of the rate of return of technology sector stocks than the CAPM model, as can be seen from the comparison of 2 methods (Standard multivariate Regression Framework and Residual Analysis) from 3 methods, which is consistent with Chawalit (2000) who found that the APT model is more effective in predicting stock returns than CAPM model in all industry and Sadorsky (2003) study Pacific Stock Exchange Technology 100 Index, Muzir et al. (2010) study Turkish stock market, Zhang & Li (2011) study Chinese stock market, Králik (2012) study Romanian stock market, Febrian & Herwany (2010) and Kisman & Restiyanita (2015) study the Indonesian stock market, Wannathanaphong & Chancharat (2016) and Tungvichitrerk (2017) study the Thai stock market, Chellaswamy & Faniband (2020) study Shanghai Stock Exchange and all find that the APT Model is more suitable than the CAPM model to use in to estimate the stock returns, unlike Tursoy et al. (2008) who conducted the APT test and found that the results of the regression analysis did not find a relationship between the stock price and the macroeconomic variables studied or indicated that the macroeconomic variables cannot explain the change in stock returns and Banbaeng et al. (2020) found that the CAPM model can predict stock returns better than the APT model because the CAPM model has clear factors and believes that the changes in stock prices are the result of the influence of various information related to internal market mechanisms, such as the level of stock prices in the market, changes in market levels or the volume of buying and selling shares, etc. instead of depending on macroeconomic factors.

Table 2: Estimated results of CAPM and APT models

Model		CAPM			APT						
No	stock	Constant	$R_m - R_f$	Adj R^2	Constant	Bitcoin	CPI	Gold	Oil	MSCI	Adj R^2
1	AAPL	0.008	1.204***	0.592	0.007	0.018	2.144	0.117	–0.060	1.261***	0.408
2	ADBE	0.008	1.117***	0.583	0.012	0.002	0.782	–0.138	–0.062	1.285***	0.457
3	ADI	0.005	1.012***	0.467	0.014*	–0.031	–1.243	–0.154	–0.007	1.253***	0.440
4	ADSK	0.004	1.411***	0.513	0.018*	0.011	–3.313	–0.356**	0.020	1.596***	0.490
5	AMAT	0.007	1.321***	0.451	0.015	0.015	–1.470	–0.290	0.015	1.599***	0.480
6	AMD	0.029	1.943***	0.361	0.049**	–0.092	–2.005	–0.077	–0.213*	2.564***	0.308
7	AMKR	0.011	1.490***	0.228	0.035*	–0.115*	–4.443	–0.566	0.084	1.938***	0.264
8	ANSS	0.003	1.091***	0.631	0.012*	0.015	–1.962	0.05	–0.063	1.270***	0.563
9	AVGO	0.012*	0.940***	0.364	0.022**	–0.033	–1.956	0.086	–0.010	1.189***	0.357
10	AZPN	0.014*	0.889***	0.257	0.010	0.007	3.325	–0.423*	0.076	0.978***	0.304
11	CDNS	0.016***	1.007***	0.493	0.015*	0.049**	0.787	0.172	–0.074	1.056***	0.387
12	ENTG	0.010	1.142***	0.435	0.017	–0.005	–0.81	–0.039	–0.028	1.275***	0.326
13	EXLS	0.014*	0.807***	0.281	0.008	0.034	3.138	–0.221	–0.073	1.112***	0.355
14	FFIV	–0.005	0.91***	0.361	0.002	0.021	–1.409	–0.279	–0.039	1.092***	0.350
15	FSLR	0.011	1.204***	0.194	0.010	0.136**	–1.15	0.163	–0.122	1.274***	0.202
16	FTNT	0.017*	1.005***	0.270	0.014	–0.003	2.951	–0.107	0.115	0.934***	0.223
17	GEN	–0.004	0.708***	0.146	0.0005	–0.071*	–0.137	0.571**	–0.034	1.103***	0.238
18	INTU	0.008	1.034***	0.596	0.006	0.051**	1.544	–0.133	–0.043	1.123***	0.526
19	JKHY	0.007	0.554***	0.261	0.008	0.005	0.693	–0.171	0.015	0.582***	0.200
20	MANH	0.004	1.338***	0.438	0.016	0.008	–2.937	–0.197	0.120*	1.370***	0.413

Table 2: Estimated results of CAPM and APT models (Cont.)

Model		CAPM			APT						
No	stock	Constant	$R_m - R_f$	Adj R^2	Constant	Bitcoin	CPI	Gold	Oil	MSCI	Adj R^2
21	MPWR	0.014*	1.154***	0.443	0.021**	–0.012	–0.209	–0.058	–0.15**	1.351***	0.302
22	MTCH	0.006	1.005***	0.197	0.01	0.061	–2.031	0.134	0.179*	0.649***	0.148
23	MU	–0.001	1.255***	0.307	0.008	0.006	–1.345	–0.335	0.050	1.371***	0.267
24	NTAP	–0.002	1.072***	0.339	0.004	–0.019	0.031	–0.379*	0.049	1.258***	0.341
25	PANW	0.008	1.063***	0.291	0.011	–0.023	0.868	–0.015	0.061	1.127***	0.223
26	PTC	0.007	0.984***	0.359	0.009	0.014	–0.511	–0.029	0.135**	1.037***	0.419
27	SNPS	0.013***	1.081***	0.618	0.013*	0.002	1.439	0.236*	–0.056	1.227***	0.503
28	SPLK	–0.002	1.334***	0.347	0.007	–0.024	–0.785	–0.289	0.132	1.292***	0.272
29	SSNC	–0.001	1.116***	0.492	0.005	–0.049*	0.18	–0.057	–0.021	1.490***	0.520
30	SWKS	–0.004	1.113***	0.369	0.006	–0.048	–1.348	0.156	0.035	1.156***	0.250
31	TTWO	0.010	0.766***	0.199	0.010	0.086**	–0.784	0.205	–0.024	0.603***	0.368
32	VRSN	0.008	0.846***	0.411	0.011	0.018	–0.115	0.023	–0.127***	1.084***	0.386

Noted: *, **, and *** indicate at the 90, 95, and 99 percent levels respectively

Table 3: Comparison results of CAPM and APT models using the Standard Multivariate Regression Framework method

No	stock	Standard Multivariate Regression Framework							
		$R_i - R_f = \beta_i(R_m - R_f)$		$R_i - R_f = \beta_{i1}Bitcoin + \beta_{i2}CPI + \beta_{i3}Gold + \beta_{i4}Oil + \beta_{i5}MSCI$					
		Constant	$R_m - R_f$	Constant	Bitcoin	CPI	Gold	Oil	MSCI
1	AAPL	−0.291*	−1.595	−0.220	−0.102	−54.606	10.619***	−0.353	0.450
2	ADBE	−0.290*	−1.688	−0.213	−0.119	−56.190	10.370***	−0.344	0.456
3	ADI	−0.294*	−1.787	−0.212	−0.150	−58.074	10.339***	−0.295	0.430
4	ADSK	−0.295**	−1.397	−0.208	−0.109	−60.350	10.162***	−0.261	0.759
5	AMAT	−0.292*	−1.480	−0.211	−0.106	−58.332	10.207***	−0.273	0.783
6	AMD	−0.270*	−0.858	−0.177	−0.213	−58.761	10.430***	−0.498	1.745
7	AMKR	−0.288*	−1.311	−0.191	−0.235	−61.147	9.937***	−0.206	1.118
8	ANSS	−0.295**	−1.708	−0.214	−0.105	−58.790	10.540***	−0.353	0.454
9	AVGO	−0.286*	−1.869	−0.204	−0.155	−58.828	10.599***	−0.297	0.367
10	AZPN	0.485*	−1.909	−0.216	−0.113	−53.372	10.094***	−0.207	0.153
11	CDNS	−0.284*	−1.797	−0.212	−0.071	−56.037	10.677***	−0.354	0.222
12	ENTG	−0.289*	−1.667	−0.209	−0.129	−57.547	10.479***	−0.311	0.445
13	EXLS	−0.284*	−1.991	−0.217	−0.085	−53.688	10.286***	−0.363	0.299
14	FFIV	−0.303**	−1.896	−0.223	−0.098	−58.348	10.222***	−0.327	0.265
15	FSLR	−0.288*	−1.602	−0.216	0.016	−58.026	10.664***	−0.409	0.445
16	FTNT	−0.288*	−1.602	−0.212	−0.125	−53.960	10.403***	−0.172	0.117
17	GEN	−0.303**	−2.091	−0.227	−0.190	−56.785	11.080***	−0.327	0.286
18	INTU	−0.292*	−1.779	−0.220	−0.071	−55.373	10.369***	−0.332	0.288
19	JKHY	−0.292*	−2.252	−0.217	−0.118	−56.292	10.320***	−0.274	−0.239

Table 3: Comparison results of CAPM and APT models using the Standard Multivariate Regression Framework method (Cont.)

Model		CAPM		APT					
No	**stock**	**Constant**	**$R_m - R_f$**	**Constant**	**Bitcoin**	**CPI**	**Gold**	**Oil**	**MSCI**
20	MANH	−0.295**	−1.461	−0.210	−0.111	−59.672	10.314***	−0.164	0.545
21	MPWR	−0.285*	−1.655	−0.204	−0.133	−57.110	10.448***	−0.436	0.520
22	MTCH	−0.293*	−1.788	−0.215	−0.061	−58.876	10.631***	−0.109	−0.165
23	MU	−0.300**	−1.547	−0.219	−0.115	−58.143	10.179***	−0.240	0.551
24	NTAP	−0.300**	−1.738	−0.221	−0.140	−56.764	10.136***	−0.235	0.428
25	PANW	−0.291*	−1.746	−0.215	−0.145	−55.944	10.511***	−0.225	0.304
26	PTC	−0.292*	−1.815	−0.216	−0.107	−57.381	10.472***	−0.150	0.219
27	SNPS	−0.285*	−1.731	−0.213	−0.118	−55.244	10.738***	−0.345	0.397
28	SPLK	−0.301**	−1.473	−0.218	−0.147	−57.667	10.214***	−0.149	0.459
29	SSNC	−0.300**	−1.681	−0.222	−0.168	−56.508	10.453***	−0.311	0.673
30	SWKS	−0.303**	−1.682	−0.220	−0.169	−58.252	10.656***	−0.253	0.344
31	TTWO	−0.288*	−2.034	−0.216	−0.035	−57.592	10.708***	−0.311	−0.217
32	VRSN	−0.291*	−1.960	−0.215	−0.103	−57.037	10.524***	−0.408	0.250

Noted: *, **, and *** indicate at the 90, 95, and 99 percent levels respectively.

Table 4: Comparison results of CAPM and APT models using the Davidson and Mackinnon Equation and Residual Analysis

No	stock	Davidson and Mackinnon Equation $R_i = K(R_{i,\,CAPM}) + (1-K)(R_{i,\,APT}) + e_i$		Residual Analysis $\varepsilon_{i,t}(CAPM) = \lambda_{0i} + \lambda_{1i}(Bitcoin)_t + \lambda_{2i}(CPI)_t + \lambda_{3i}(Gold)_t + \lambda_{4i}(Oil)_t + \lambda_{5i}(MSCI)_t + e_i$						$\varepsilon_{i,t}(APT) = \lambda_{0i} + \lambda_{1i}(R_m - R_f)_t + e_i$	
		K	1 – K	Constant	Bitcoin	CPI	Gold	Oil	MSCI	Constant	$R_m - R_f$
1	AAPL	1.354***	–0.439*	–0.006	0.013	2.105	0.191	–0.012	–0.134	–0.002**	0.255
2	ADBE	1.161***	–0.186	–0.001	–0.003	0.745	–0.070	–0.019	–0.009	–0.002	0.171
3	ADI	0.537*	0.502*	0.005	–0.036	–1.276	–0.092	0.032	0.080	–0.001	0.085
4	ADSK	0.528*	0.516**	0.009	0.005	–3.360	–0.270	0.076	–0.040	–0.001	0.125
5	AMAT	0.184	0.837***	0.003	0.009	–1.513	–0.210	0.067	0.068	0.000	0.036
6	AMD	0.666***	0.376	0.012	–0.100	–2.069	0.041	–0.137	0.313	–0.003	0.258
7	AMKR	0.142	0.891***	0.019	–0.121*	–4.491	–0.475	0.143	0.211	–0.001	0.061
8	ANSS	0.751***	0.280	0.004	0.011	–1.997	0.117	–0.020	0.006	–0.001	0.128
9	AVGO	0.376	0.660**	0.006	–0.036	–1.986	0.144	0.027	0.100	–0.001	0.061
10	AZPN	0.209	0.840***	–0.008	0.003	3.295	–0.368*	0.111	–0.052	–0.001	0.064
11	CDNS	0.893***	0.126	–0.005	0.045*	0.754	0.234*	–0.035	–0.111	–0.002	0.180
12	ENTG	1.197***	–0.229	0.003	–0.010	–0.847	0.030	0.017	–0.048	–0.002	0.178
13	EXLS	–0.201	1.163***	–0.009	0.030	3.112	–0.172	–0.041	0.177	0.000	–0.033
14	FFIV	0.394	0.648**	0.003	0.017	–1.439	–0.223	–0.003	0.038	–0.001	0.059
15	FSLR	0.289	0.777**	–0.005	0.131**	–1.190	0.237	–0.074	–0.121	–0.001	0.115
16	FTNT	0.605**	0.466	–0.007	–0.007	2.918	–0.046	0.155**	–0.230	–0.002	0.192
17	GEN	–0.07	1.040***	0.001	–0.074*	–0.160	0.614**	–0.007	0.282	0.000	–0.020

Table 4: Comparison results of CAPM and APT models using the Davidson and Mackinnon Equation and Residual Analysis (Cont.)

No	stock	Davidson and Mackinnon Equation		Residual Analysis							
		$R_i = K(R_{i,\,CAPM}) + (1-K)(R_{i,\,APT}) + e_i$		$\varepsilon_{i,t}(CAPM) = \lambda_{0i} + \lambda_{1i}(Bitcoin)_t + \lambda_{2i}(CPI)_t + \lambda_{3i}(Gold)_t + \lambda_{4i}(Oil)_t + \lambda_{5i}(MSCI)_t + e_i$						$\varepsilon_{i,t}(APT) = \lambda_{0i} + \lambda_{1i}(R_m - R_f)_t + e_i$	
		K	1 – K	Constant	Bitcoin	CPI	Gold	Oil	MSCI	Constant	$R_m - R_f$
18	INTU	0.752***	0.280	–0.006	0.046**	1.511	–0.070	–0.003	–0.075	–0.001	0.129
19	JKHY	0.758**	0.278	–0.001	0.003	0.674	–0.137	0.037	–0.060	–0.001	0.083
20	MANH	0.528**	0.525**	0.006	0.003	–2.981	–0.115	0.173**	–0.181	–0.001	0.145
21	MPWR	1.165***	–0.203	0.003	–0.017	–0.247	0.012	–0.15*	0.013	–0.002	0.250*
22	MTCH	0.615*	0.498	0.000	0.057	–2.064	0.195	0.218**	–0.516**	–0.002	0.248
23	MU	0.595	0.451	0.004	0.001	–1.386	–0.259	0.100	–0.083	–0.001	0.131
24	NTAP	0.351	0.698**	0.002	–0.023	–0.004	–0.313	0.092	0.015	–0.001	0.078
25	PANW	0.807**	0.225	–0.001	–0.027	0.833	0.050	0.103	–0.105	–0.002	0.168
26	PTC	0.146	0.883***	–0.001	0.010	–0.544	0.031	0.174***	–0.103	0.000	0.036
27	SNPS	0.929***	0.082	–0.005	–0.002	1.404	0.302**	–0.014	–0.026	–0.002	0.175*
28	SPLK	0.764***	0.288	0.004	–0.030	–0.829	–0.207	0.184**	–0.255	–0.002	0.247
29	SSNC	0.254	0.778***	0.002	–0.054*	0.143	0.012	0.023	0.197	0.000	0.046
30	SWKS	1.037***	–0.047	0.005	–0.052	–1.384	0.224	0.079	–0.134	–0.002	0.245
31	TTWO	0.615**	0.485	–0.003	0.083	–0.809	0.251	0.006	–0.284	–0.002	0.188
32	VRSN	0.514**	0.533**	0.000	0.015	–0.142	0.075	–0.094**	0.104	–0.001	0.085

Noted: *, **, and *** indicate at the 90, 95, and 99 percent levels respectively

5. CONCLUSION

The main findings of a study that compared the APT (Arbitrage Pricing Theory) model and the CAPM (Capital Assets Pricing Model) model for analyzing the returns of technology group stocks. The study compared two out of three methods and found that the APT model could analyze the rate of return of 19 technology stocks, such as AMAT, AMKR, AVGO, AZPN, CDNS, EXLS, FFIV, FSLR, FTNT, GEN, INTU, MANH, MTCH, MU, NTAP, PTC, SPLK, SSNC and VRSN. The APT model was also as effective as the CAPM model for analyzing the rate of return of 13 technology sector stocks, such as AAL, ADBE, ADI, ADSK, AMD, ANSS, ENTG, JKHY, MPWR, PANW, SNPS, SWKS and TTWO. The CAPM model, however, was less capable of analyzing the rate of return of technology sector stocks than the APT model.

The results of the analysis show that the APT model can better capture the influence of these factors than the CAPM model. The study suggests that investors should use the APT model as a method of estimating the rate of return of technology stocks and consider cryptocurrency prices, gold prices, oil prices, and the MSCI index that influence the stock returns. However, this study may not have included all the relevant factors that affect the returns of technology stocks. Therefore, users of the APT model should consider other factors as well when applying the model for investment decisions.

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