Return, Risk and Volatility of the Top Ten Vaccine Manufacturer Company Stocks

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Abstract

A number of medical studies have proven that the COVID-19 vaccine is effective in preventing people from becoming infected with COVID-19. Mostly all governments and organizations have pledged to buy billions of vaccine doses. Therefore, vaccine manufacturer companies stock had been in the focus of interest by many investors.

This research was a quantitative research using financial modelling that attempted to calculate and compare returns, risks, and volatility of the top ten vaccine manufacturer stocks during January 2020 to April 2021. This research chose to study only the top 10 of these companies according to Meticulous Research (2021), which provides the top ten world leading manufacturer in vaccines market in 2021. These companies were listed in the different stock market such as Euronext Paris, New York Stock Exchange, Tokyo Stock Exchange, Australia Stock Exchange and London Stock Exchange. Daily closing index prices were gathered during January 2020 to April 2021. All stock market prices had been converted to U.S. dollar.

This research utilized Excel (NumXL) add-in as a method of calculating return, risk and volatility by adopting Capital Asset Pricing Model (CAPM) for risk-return relationship, and EGARCH as volatility estimation. Based on the daily stock prices, the Exponential process is used in estimating and forecasting the volatility.

For comparison of the actual returns of the top 10 vaccine manufacturer stocks, the result shows that Daiichi Sankyo had the highest actual returns, which followed by Carlisle, Emergent BioSolutions, Johnson & Johnson, Merck, Pfizer, AstraZeneca, Takeda Pharmaceutical, GlaxoSmithKline and Sanofi.

For comparison of the systematic risk of the top 10 vaccine manufacturer stocks, the result shows that Daiichi Sankyo had the lowest systematic risk, which followed by Sanofi, AstraZeneca, Takeda Pharmaceutical, Pfizer, Johnson & Johnson, GlaxoSmithKline, Merck, Carlisle and Emergent Bio Solutions consecutively.

For comparison of volatility of the top 10 vaccine manufacturer stocks, the result shows that Emergent Bio Solutions had the highest stock volatility, which followed by Carlisle, Daiichi Sankyo, AstraZeneca, Pfizer, Takeda Pharmaceutical, GlaxoSmithKline, Merck, Sanofi, and Johnson & Johnson.

Keywords: Investment, Return, Risk, Volatility, Vaccine Manufacturer Stock

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Introduction

Vaccines are one of the greatest achievements of science and medicine in the fight against infectious diseases. Vaccination is one of the most cost-effective public health tools to prevent infectious diseases. The coronavirus outbreak had destroyed livelihoods and killed more than two million people worldwide during this research period of December 2019 until April 2021. The COVID-19 vaccine is being exported worldwide as part of an international effort to tackle the still disastrous epidemic around the world.

Creating a vaccine during an outbreak in a few months instead of a year is unprecedented. The race is now spreading billions of doses from different manufacturers fast enough to suppress the viral stream. It is not just human life in jeopardy as governments spend a lot of money on vaccination efforts hoping that installing a vaccine will help the economy recover.

Investors have invested a lump sum amount of money in companies that develop vaccines. A recent study by the Asian Development Bank Institute states that more than 40% of the firms that went public and transitioned to public equity markets were technology and pharmaceutical companies (Gecgil 2020). Public equity markets influence the vaccine development process through various dimensions. Perhaps the most important role is financing major vaccine and pharmaceutical companies.

The COVID-19 pandemic undoubtedly creating one of the more unpleasant and challenging months during year 2020-2021 in modern world history. Throughout November 2020, 10.7 million people were unemployed in the United States, an increase of nearly 5 million from a record low unemployment rate in February. Millions of more people stopped searching for jobs altogether in 2021 (BBC News 2021). This affected the overall economy and the stock market. The situation would tend to revolve around the timing and effectiveness of factors such as the introduction of the vaccine for COVID-19, alongside fiscal stimulus and government assistance programs. As countries compete for the post-epidemic phase, investors are looking for better earning/yielding stocks and definitely vaccine manufacturer stocks were among them.

According to Meticulous Research (2021), followings are the top ten world leading manufacturer in vaccines market in 2021. These companies are Sanofi, Merck, GlaxoSmithKline, Pfizer, Johnson & Johnson, Daiichi Sankyo, Takeda Pharmaceutical, Carlisle, Emergent BioSolutions and AstraZeneca, which located in France, USA, Japan, Australia and England.

Table 1 Top ten vaccine manufacturer company stocks

Rank	Company (Based)	Stock Abbreviation	Stock Market
1	Sanofi (France)	SAN	Euronext Paris (EPA)
2	Merck (USA)	MRK	New York Stock Exchange (NYSE)
3	GlaxoSmithKline (USA)	GSK	NYSE
4	Pfizer (USA)	PFE	NYSE
5	Johnson & Johnson (USA)	JNJ	NYSE
6	Daiichi Sankyo (Japan)	DSN	Tokyo Stock Exchange (TSE)
7	Takeda Pharmaceutical (Japan)	TAK	TSE
8	Carlisle (Australia)	CSL	Australia Stock Exchange (ASX)
9	Emergent BioSolutions (USA)	EBS	NYSE
10	AstraZeneca (England)	AZN	London Stock Exchange (LSE)

Research Questions

What are the stock returns of the top 10 manufacturer stocks in vaccines market during January 2020 to April 2021? What are their level of risk on investment of the top 10 manufacturer stocks in vaccines market during January 2020 to April 2021? What are the level of volatility of the top 10 manufacturer stocks in vaccines market during January 2020 to April 2021?

Research Objectives

To calculate and compare returns of the top 10 vaccine manufacturer stocks during January 2020 to April 2021. To calculate and compare level of risks of the top 10 vaccine manufacturer stocks during January 2020 to April 2021. To calculate and compare volatility of the top 10 vaccine manufacturer stocks during January 2020 to April 2021.

Literature Review

The aim of this section is to review relevant literature regarding to investment return, risk and volatility of the stocks. We use the Capital Asset Pricing Model (CAPM) as a measurement of investment risk. It tracks how the asset pricing model is enhanced using Arbitrage Pricing Theory (APT), which it has led to the development of the Fama French 3-Factor and other models. The use of EGARCH is for measuring volatility of the particular stock.

Capital Asset Pricing Model (CAPM)

According to Campbell et al. (1997), The Capital Asset Price Model (CAPM) describes the relationship between systematic risk and expected return for a particular asset. CAPM stocks are widely used in finance for pricing risky securities and creating the expected return on an asset based on the asset's risk profile and the cost of capital. Investors expect to be compensated for their risk and time value of their money. The risk-free rate in the CAPM formula calculates the money value over time. Other components of the CAPM formula account for additional risk-taking investors.

The beta of a potential investment is a measure of how much an investment increases the exposure to a market-like portfolio. If a stock is more at risk than the market, then there will be more than one beta. If a stock has less than one beta formula, it is assumed that it reduces portfolio risk. The stock's beta is then multiplied by the market risk premium, which is the expected return on the market that is higher than the risk-free rate. Then the risk-free rate is added to the product of the stock beta and the market risk surplus. The result should give investors a return or discount rate that can be used to determine the value of the asset.

The goal of the CAPM formula is to estimate whether a stock has a fair value when its risks and money's value over time versus expected return. There are several hypotheses behind the CAPM formula that do not hold the truth. Modern financial theory is based on two assumptions: (1) The stock market is highly competitive and efficient. (That is, relevant information about companies is quickly and thoroughly dissipated and absorbed worldwide.) (2) These markets are dominated by rational and risk-averse investors who want to maximize their satisfaction from the return on investment. Despite these problems, the CAPM formula is still widely used because of its simplicity and makes it easy to compare investment options. Including beta in the formula assumes that risk can be measured by the volatility of the stock price. However, the price action in both directions does not have the same risk. A retrospective period to determine a stock's volatility is not standardized due to a stock's returns. (And the risks) are not normally distributed (Cuthbertson 1996).

An investor, before investing in a stock, he needs to know how much of a risk it is to calculate all the risks associated with returns, variance or standard deviation is used. Variance and square root Standard deviation is a measure of diffusion or distribution in a probability distribution. The larger the distribution, the larger the variance or standard deviation. The greater the probability distribution of the expected return, the smaller the standard deviation and the smaller the risk (Campbell el al. 1997).

Investment risk can be defined as the probability or probability of a loss in relation to the expected return on any investment. In other word, it is a measure of the degree of uncertainty in achieving returns that meet investor expectations. It is the extent of the unexpected results to be realized. Risk is a key component in assessing investment opportunities. Most investors, while making investments, should consider less risk. Less investment risk, more profitable investment.

Market Efficiency

Possibly one of the most controversial issues in finance is whether the financial and stock market are efficient in allocating economic resources or not. Theoretical issues such as volatility, predictability, speculation and anomalies are also related to the efficiency issue and are all interdependent (Islam and Oh 2003; Cuthbertson 1996). "An efficient capital market is a market that is efficient in processing information... In an efficient market, prices 'fully reflect' available information" (Fama 1970, p. 133). In the broadest terms of EMH, there are three types of market efficiency. Firstly, in weak form efficiency, the information set includes only the history of prices or returns themselves. Secondly, in semi-strong form efficiency, the information set includes most information known to all market participants. Finally, in strong form efficiency, the information set includes all information known to any market participant.

In the 1960s and early 1970s, the controversy focused on the extent to which successive changes in prices of the stocks were independent of each other or whether stock prices followed a random walk. The early tests to answer this question were conducted by Fama (1970) and Samuelson (1965), in which they concluded that most of the evidence seems to have been consistent with the efficient market hypothesis (EMH). Stock prices followed a random walk model and the predictable variations in equity returns, if any, were found to be statistically insignificant. Other studies in the US with similar findings included those of Sharpe (1966), and Williamson (1972).

Throughout the 1980s, EMH has provided the theoretical basis for much of the research, and most empirical studies during these years focused on predicting prices from historical data, while also attempting to produce forecasts based on variables such as P/E ratios (Campbell and Shiller 1987), dividend yield (Fama and French 1988), term structure variables (Harvey 1991), and announcement of various events, i.e. earnings, stock splits, capital expenditure, divestitures, and takeovers (Jensen and Ruback 1983; McConnell and Muscarella 1985).

The concept of EMH in relation to stock prices is fundamental for an investigation of the characteristics of the Thai stock market. Some recent studies have maintained EMH and also stimulated models, which reflect the influence of various factors toward stock prices. The results from testing the EMH can assist in the identification of these factors, which could be seen as the influence of anomalies (Berument and Kayimaz 2001), insider trading and asymmetric information (Jagadeesh and Titman. 1993), stock splits (Ikenberry et al. 1996), dividend initiations and omissions (Michaely et al. 1995), etc. Various methods for testing market efficiency of the stock market have been widely used such as the run-test, autocorrelation test, rational speculative bubble test, seasonal anomalies test and autoregressive (AR) test.

Market Efficient Hypothesis

The efficient market hypothesis (EMH) is a statement about: (1) the theory that stock prices reflect the true value of stocks; (2) the absence of arbitrage opportunities in an economy populated by rational, profit-maximizing agents; and (3) the hypothesis that market prices always fully reflect available information (Fama 1970). In Jensen (1978), an efficient market is defined with respect to an information set if it is impossible to earn economic profits by trading. Fama (1970) presented a general notation describing how investors generate price expectations for stocks.

Non-parametric testing of market efficiency is based on the premise of no arbitrage opportunities, i.e., that opportunities for earning unusual returns do not exist (Fama 1970). Along with other empirical studies (Ball 1978; Banz 1981; Fama and French 1988) have also jointly tested the market efficiency with an asset pricing model. If the null hypothesis is rejected, the failure of either market efficiency or the model does exist. However, the authors have often preferred to conclude that difficulties in asset pricing theory, rather than market efficiency, underlie the rejection of the null which have been uncovered in tests of asset pricing. In addition, the rejection of the null hypothesis is likely to have resulted from the misspecification of the asset pricing theory and not market efficiency itself.

To reiterate, the absence of arbitrage opportunities expresses the idea that the only chance for speculators to gain an opportunity to earn abnormal profits occurs if mispriced stocks exist in an economy populated by rational agents. In fact, the mispriced stocks will be automatically adjusted.

Since this scenario will be replayed every time an arbitrage opportunity arises, price levels will be continuously maintained according to the Samuelson's fair game theory or martingale difference. Samuelson (1965) modeled this property of prices as the random walk: $Y_t = Y_{t-1} + \varepsilon_t$ and random walk with drift (time trend):

$$Y_t = \mu + Y_{t-1} + \varepsilon_t$$

Random walks also exhibit Markov and martingale properties. A Markov property is the information for determining the probability of a future value of the random variable already contained or expressed in the current status of that variable. The martingale property is the conditional expectation of a future value of the random variable. The positive drift (called sub-martingale) in random walk exists when α is greater than zero. On the other hand, negative drift (called super-martingale) in random walk exists when α is less than zero. However, if α is equal to zero, then it would be a normal random walk. The martingale property is defined as: $Y_t = Y_{t-1} + \alpha + \varepsilon_t$

Campbell et al. (1997, p. 29) summarize the classification of random walk and martingale hypotheses as in Table 2.

Table 2: Classification of Random Walk and Martingale Hypotheses

$Cov[f(r_t), g(r_{t+k})] = 0$	$g(r_{t+k}), \forall g(.)$	$g(r_{t+k}), \forall g(.)$
$f(r_t), \forall f(.)$ Linear	Uncorrelated Increments, Random Walk 3: $\Pr oj[r_{t+k} \mid r_t] = \mu$	
$f(r_t), \forall f(.)$	Martingale/Fair Game: $E[r_{t+k} \mid r_t] = \mu$	Independent Increments, Random Walks 1 and 2: $pdf[r_{t+k} \mid r_t] = pdf(r_{t+k})$

Source: Campbell et al. 1997. p. 29.

If the stock prices follow a random walk, then price changes are white noise. Therefore, testing whether returns are white noise is observationally equivalent to the test of random walk in stock prices. Given r_t as the percentage change in Y_t, the null hypothesis of market efficiency is thus formed as testing for the standard statistical properties of a homoscedastic white noise process as $H_0 : E(r_t) = 0 ; E(r_t r_t) = \sigma_r^2 ; E(r_t r_s) = 0; \forall t \neq s$.

Auto Regressive Model (ARCH)

Mills (1999) developed a model to describe time-varying variance. The methodology is called Autoregressive Conditional Heteroscedasticity (ARCH). The concept of the ARCH model has led to the development of other related formulations in order to identify and explain the variance of time series. Engle introduced the linear ARCH(*q*) model where the time varying conditional variance is postulated to be a linear function of the past *q* squared innovations. The ARCH (*q*) model is defined by: $r_t = \mu + \sigma_t \varepsilon_t$, and $\sigma_t^2 = \lambda + \alpha_1 (r_{t-1} - \mu)^2 +,...,+ \alpha_q (r_{t-q} - \mu)^2$ where r_t is the returns, μ is the conditional mean of the return process and is constant, $\varepsilon_t \sim NID(0,1)$ is conditionally Gaussian (*NID* denotes normally and independently distributed), σ_t is the first alternative of the stochastic volatility models and is modelled by a stochastic process, λ_1 and α are real constants, and ε_t are zero mean, uncorrelated, random variables or white noise. The model could also be represented as: $\sigma_t^2 = \lambda + \sum \alpha_1 r_{t-1}^2 + \varepsilon_t$. Hence the volatility σ_{t+1}^2 can be represented by: $\sigma_{t+1}^2 = E((r_{t+1} - \mu)^2 \mid \Phi_t)$ and $\sigma_{t+1}^2 = \lambda + \alpha_1 (r_{t-1} - \mu)^2 +,...,+ \alpha_q (r_{t-q} - \mu)^2$ where Φ_t is the information set at the end of period *t*. This is an AR(*q*) model in terms of $(r_t - \mu)^2$. Therefore, the optimal one-day ahead forecast of period *t+1* volatility can be obtained based on the returns on the most recent *q* days. In general, an *h*-day ahead step forecast can be formed as: $\hat{\sigma}_{t+h}^2 = \lambda + \alpha_1 (\hat{r}_{t+h-1} - \mu)^2 +,...,+ \alpha_q (\hat{r}_{t+1-q} - \mu)^2$ where $\hat{r}_{t+h-1} = r_{t+h-j}$ if 1 ≤ *h* ≤ *j* and ($\hat{\sigma}_{t+h-j}^2 = (\hat{r}_{t+h-1} - \mu)^2$ if *h* > *j*.

This simple ARCH model exhibits constant unconditional variance but non-constant conditional variance: $r_t = \mu + \sigma_t \varepsilon_t$ given that $\varepsilon_t = u_t \sqrt{(\lambda + \alpha \varepsilon_{t-1}^2)}$ where u_t ~ *IID(0,1)* (IID, Independent and Identically Distributed, or strict white noise); and λ and α > 0. Note that $\sqrt{(\lambda + \alpha \varepsilon_{t-1}^2)}$ is the conditional standard deviation; and σ_t is defined as $\sqrt{E(\varepsilon_t^2 \mid \varepsilon_{t-1}^2, \varepsilon_{t-2}^2, ..., \varepsilon_{t-i}^2)}$.

The simplest form of ARCH (1) model for the conditional expectation of ε_t given that ε_t is equal to zero, is defined as $E(\varepsilon_t \varepsilon_{t-1}) = E(u_t \mid \varepsilon_{t-1}) \sqrt{\lambda + \alpha \varepsilon_{t-1}^2} = 0$, note that $E(u_t \mid \varepsilon_{t-1}) = E(u_t) = 0$ since u_t ~ *IID*(0,1); conditional variance is defined as $Var(\varepsilon_t \mid \varepsilon_{t-1}) = E(u_t^2 \mid \varepsilon_{t-1})(\lambda + \alpha \varepsilon_{t-1}^2)$, where $E(u_t^2 \mid \varepsilon_{t-1}) = E(u_t^2) = 1$ since u_t ~ *IID*(0,1). Thus, the conditional mean and variance of r_t are given by the following formulae $E(r_t \mid r_{t-1}) = \mu$ and $Var(r_t \mid r_{t-1}) = (\lambda + \alpha \varepsilon_{t-1}^2)$.

Therefore, the conditional variance of r_t is time varying. However, it can be easily seen that the unconditional variance is time invariant given that ε_t^2 is stationary: $Var(r_t) = Var(\varepsilon_t) = \frac{\lambda}{(1-\alpha)}$. We obtain similar results provided that the process for *t* is stationary given that the autoregressive parameter is smaller than one in absolute value. Assume the following first order autoregressive process: $r_t = \theta r_{t-1} + \varepsilon_t$ where $\varepsilon_t = u_t \sqrt{\lambda + \alpha \varepsilon_{t-1}^2}$, u_t ~ IIN(0,1), and λ > 0 , α = 0. The conditional expectation of ε_t given that ε_t is equal to zero is: $E(\varepsilon_t \varepsilon_{t-1}) = E(u_t^2 \mid \varepsilon_{t-1})(\lambda + \alpha \varepsilon_{t-1}^2) = 0$, note that $E(u_t \mid \varepsilon_{t-1}) = E(u_t) = 0$. The conditional variance is given by the formula: $Var(\varepsilon_t \mid \varepsilon_{t-1}) = E(u_t^2 \mid \varepsilon_{t-1})(\lambda + \alpha \varepsilon_{t-1}^2) = \lambda + \alpha \varepsilon_{t-1}^2$, note that $E(u_t^2 \mid \varepsilon_{t-1}) = E(u_t) = 1$ since u_t ~ IIN(0,1). Then the conditional mean and variance of r_t are $E(r_t \mid r_{t-1}) = \theta r_{t-1}$ and $Var(r_t \mid r_{t-1}) = (\lambda + \alpha \varepsilon_{t-1}^2)$. To find the unconditional variance of r_t we recall the following property for the variance $Var(r_t) = E(Var(r_t \mid r_{t-1})) + Var(E(r_t \mid r_{t-1}))$. According to Aydemir (1998), the important property of ARCH models is their ability to capture the tendency for volatility clustering in stock prices data, i.e. a tendency for large or small swings in prices to be followed by large or small swings in random direction.

Methodology

This quantitative research used various financial models such as Excel (NumXL) add-in as a method of calculating return, risk and volatility by adopting Capital Asset Pricing Model (CAPM) for risk-return relationship, and EGARCH as volatility estimation. Based on the daily stock prices, the Exponential Generalized Autoregressive Conditionally Heteroscedastic (EGARCH) process is used in estimating and forecasting the volatility.

Research Models

1) Returns (R)

The formula for stock return (R) is price appreciation divided by the stock's original price. The source of income from stocks is its increased value. The first part of the numerator of the total return formula looks at how much value has increased (P1 - P0). It is formulated as $R = (\frac{P_1 - P_0}{P_0})$.

2) **CAPM Model**

The Capital Asset Pricing Model (CAPM) describes the relationship between systematic risk and expected return for assets, particularly stocks. CAPM is widely used throughout finance for pricing risky securities and generating expected returns for assets given the risk of those assets and cost of capital. The "ER" notation above represents the expected return of a capital asset over time, given all of the other variables in the equation. "Expected return" is a long-term assumption about how an investment will play out over its entire life. The ER formula is "Expected Return = Risk Free Rate + (Beta X Market Risk Premium)", where market risk premium = ($ER_m – R_f$). The formula for calculating the expected return of an asset given its risk is as $ER_i = R_f + \beta_i(ER_m – R_f)$ where: ER_i = expected return of investment, R_f = risk-free rate, β_i = beta of the investment, ($ER_m – R_f$) = market risk premium.

Investors expect to be compensated for their risk and time value of their money. The risk-free rate in the CAPM formula calculates the money value over time. Any other component of the CAPM formula account for additional risk-taking investors. The beta of a potential investment is a measure of the risk that an investment will add to an investment portfolio that looks like the market. If a stock is more at risk, the market has more than one beta. If a stock has less than one beta formula, it is assumed to reduce portfolio risk.

The stock beta is then multiplied by the market risk premium, which is the expected return on the market, which is higher than the risk-free rate. Then the risk-free rate is added to the product of the stock beta and the market risk surplus. The result should give investors a return or discount rate that can be used to determine the value of the asset. The goal of the CAPM formula is to estimate whether a stock has a fair value when its risks and money value over time versus expected return.

3) EGARCH

The EGARCH function returns an EGARCH object specifying the functional form of an EGARCH(P,Q) model, and stores its parameter values. The key components of an EGARCH model include the GARCH polynomial, which is composed of lagged, logged conditional variances. The degree is denoted by P. ARCH polynomial, which is composed of the magnitudes of lagged standardized innovations. Leverage polynomial, which is composed of lagged standardized innovations. Maximum of the ARCH and leverage polynomial degrees, denoted by Q. P is the maximum nonzero lag in the GARCH polynomial, and Q is the maximum nonzero lag in the ARCH and leverage polynomials. Other model components include an innovation mean model offset, a conditional variance model constant, and the innovations distribution.

To estimate models containing all or partially unknown parameter values given data, use estimate. For completely specified models (models in which all parameter values are known), simulate or forecast responses using simulate or forecast, respectively. The exponential GARCH (EGARCH) where σ_t^2 depends on both the sign and the size of lagged residuals, EGARCH(1,1) model is represented as follows:

$$\ln \sigma_t^2 = \lambda_1 + \beta_1 \ln \sigma_{t-1}^2 + \gamma_1\left(\left[\left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right| - (2/\pi)^{1/2}\right] + \delta\left[\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right]\right)$$

EGARCH model always produces a positive conditional variance σ_t^2 for any choice of λ_1, β_1, γ_1 so that no restrictions need to be placed on these coefficients (except $|\beta_1| < 1$). Because of the use of both $|\varepsilon_t / \sigma_t|$ and $(\varepsilon_t / \sigma_t), \sigma_t^2$, it will also be non-symmetric in ε_t and, for negative δ, it will exhibit higher volatility for large negative ε_t. In addition, the EGARCH model is capable of capturing any asymmetric impact of shocks on volatility.

Empirical Results

The first part, we identify investment returns of the top ten vaccine manufacturer company stocks. The second part contains analysis of risk by using CAPM analysis. The third part involves the results of volatility test of the top ten vaccine manufacturer company stocks by using EGARCH(1,1) model. Microsoft Excel program NumXL (add-ins) was used to find return, risk and volatility of the stock.

Return

The result shows that Daiichi Sankyo had the highest actual returns, which followed by Carlisle, Emergent BioSolutions, Johnson & Johnson, Merck, Pfizer, AstraZeneca, Takeda Pharmaceutical, GlaxoSmithKline and Sanofi respectively. Seven of the top 10 vaccine manufacturer stocks had a positive return, while three of them yielded a negative return (see Table 3).

Table 3 Comparison of the actual returns of the top 10 vaccine manufacturer stocks.

Rank	Company	Actual Return (%)
1	Daiichi Sankyo (DSN)	28.68
2	Carlisle (CSL)	18.47
3	Emergent BioSolutions (EBS)	16.94
4	Johnson & Johnson (JNJ)	12.48
5	Merck (MRK)	4.01
6	Pfizer (PFE)	3.95
7	AstraZeneca (AZN)	1.94
8	Takeda Pharmaceutical (TAK)	-16.22
9	GlaxoSmithKline (GSK)	-19.95
10	Sanofi (SAN)	-20.08

Risk

Modern portfolio theory shows that investors are paid for the systematic risk of an investment and not for the entire risk of an investment, since all risks include certain specific risks that can be eliminated. It can be in a diversified investment portfolio. The specific risk of an individual stock is the slope coefficient of the characteristic line, which is the regression line between the expected return (ER) for particular stock and the return for the market index.

Beta coefficient lines are calculated using a daily data regression for fourteen months. In this research, the beta coefficient for the top ten vaccine manufacturer company stocks is calculated using fourteen monthly observations of daily expected returns for the top ten vaccine manufacturer company stocks from January 2020 to April 2021 and returns for the corresponding stock market index such as EPA, NYSE, TSE, ASX and LSE for the same time period. Beta is the covariance between returns for the top ten vaccine manufacturer company stocks and returns for the S&P 500 divided by the variance for the S&P 500.

CAPM Beta is a theoretical measure of how a single stock moves against the market based on the correlation between the two. The market represents an unsystematic risk, and the beta represents a systemic risk. The results of the test of the stock systematic risk can be found as in Table 4.

Table 4 Comparison of the systematic risk of the top 10 vaccine manufacturer stocks.

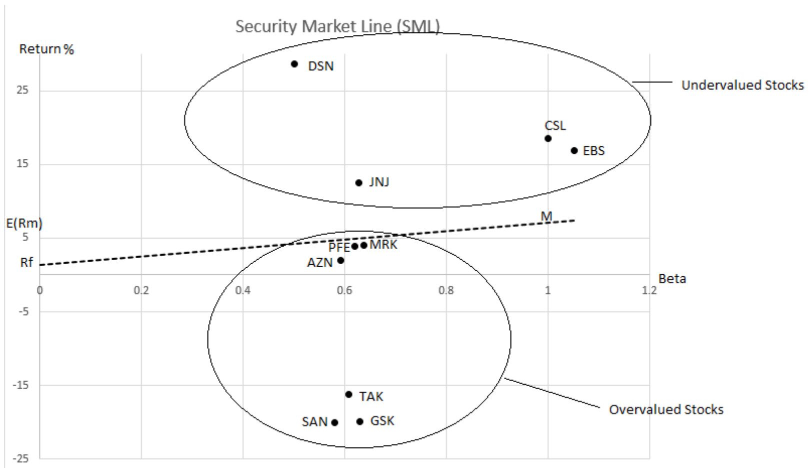
Rank	Company	Systematic Risk (β)
1	Daiichi Sankyo (DSN)	0.501938
2	Sanofi (SAN)	0.580639
3	AstraZeneca (AZN)	0.592247
4	Takeda Pharmaceutical (TAK)	0.608811
5	Pfizer (PFE)	0.620163
6	Johnson & Johnson (JNJ)	0.628462
7	GlaxoSmithKline (GSK)	0.630702
8	Merck (MRK)	0.638605
9	Carlisle (CSL)	1.000913
10	Emergent BioSolutions (EBS)	1.051722

According to the table 4, we found that Daiichi Sankyo had the lowest systematic risk, which followed by Sanofi, AstraZeneca, Takeda Pharmaceutical, Pfizer, Johnson & Johnson, GlaxoSmithKline, Merck, Carlisle and Emergent BioSolutions consecutively.

Security Market Line

We took the average risk free rate (R_f) across all stock markets to compare actual stock returns (R) and risk (β) of the top 10 vaccine manufacturer stocks. The result from Figure 1 shows that Daiichi Sankyo (DSN), Johnson & Johnson (JNJ), Carlisle (CSL) and Emergent BioSolutions (EBS) were undervalued stock. While Sanofi (SAN), Merck (MRK), GlaxoSmithKline (GSK), Pfizer (PFE), Takeda Pharmaceutical (TAK) and AstraZeneca (AZN) were considered to be overvalued stocks.

Figure 1 Security Market Line of the Top 10 Vaccine Manufacturer Stocks



Volatility

Volatility measures the risk of stocks or securities, which is used in option pricing formulas to measure the volatility of the return of an underlying asset. Volatility indicates a stock's pricing behavior and helps estimate potential fluctuations in a short period of time. If the stock prices or returns fluctuate frequently over a short period of time, it is referred to as high volatility. If the security price fluctuates slowly over a longer period of time, the security price is referred to as low volatility.

Table 5 Sanofi EGARCH(1,1) estimation during January 2020 to April 2021.

SAN				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	-0.067805	-0.052375	0.818790	0.0000
AR(2)	-0.959177	-1.077478	34.21670	0.0000
AR(3)	-1.136030	-0.192825	-5.845469	0.5609
AR(4)	4.982818	-1.529891	-37.24214	0.4900
MA(1)	-0.330686	-0.029601	49.39751	0.0000
MA(2)	-1.241784	0.158510	2.338188	0.0000
Variance Equation				
λ	0.059884	-0.078562	7.589600	0.0000
α	3.388497	-1.400721	-0.872822	0.0000
γ	-5.016586	0.237175	-0.286538	0.3969
β	8.950609	-0.151000	0.050730	0.0000
R-squared	0.523228	Mean dependent var		0.218830
Adjusted R-squared	1.228124	S.D depenndent var		1.523601
S.E of regression	0.926519	Akake info criterion		0.628678
Sum squared resid	0.402834	Schwarz criterion		2.431439
Log likelihood	514.2180	Hannan-Quinn criter.		0.600319
Durbin-Watson stat	1.329353			
Inverted AR Roots	.51+.86i	.51+.86i	.01+.5i	.01+.5i
Inverted MA Roots	.51+.86i	.51+.86i		

We adopted EGARCH(1,1) model for measuring volatility of the top 10 vaccine manufacturer stocks. According to table 5, α refers to the extent that the magnitude of a shock to the variance affects future volatility in the returns of an asset, γ provides how the sign of the shock has an influence on the future volatility of an asset's returns, and β gives an insight into persistence of past volatility and how past volatility helps to predict volatility in the future.

The key coefficient to focus in this model are α, γ and β. If the size of α is large, it means a higher volatility of an asset. If γ is statistically significant and has a negative sign, this implies that a fall in returns results in greater volatility than an increase in returns of the same magnitude or leverage effect. If β has a p-value of 0.0000, this means that past volatility helps to predict future volatility.

Table 5 result shows that α has a p-value of 0.0000 with α of 3.388497. Therefore, size of the shock has a significant impact on the volatility of return. Sanofi's γ is -5.016586, which indicates that bad news will increase volatility more than good news of the same size evidence of leverage effect, and Sanofi's β has a p-value of 0.0000, which explains that past volatility of returns helps to predict future volatility.

According to Table 6, we found that Emergent BioSolutions had the highest stock volatility, which followed by Carlisle, Daiichi Sankyo, AstraZeneca, Pfizer, Takeda Pharmaceutical, GlaxoSmithKline, Merck, Sanofi, and Johnson & Johnson respectively.

Table 6 Comparison of volatility of the top 10 vaccine manufacturer stocks (from high to low volatility).

Rank	Company	Volatility (α)
1	Emergent BioSolutions (EBS)	7.883880
2	Carlisle (CSL)	5.013429
3	Daiichi Sankyo (DSN)	3.994861
4	AstraZeneca (AZN)	3.903000
5	Pfizer (PFE)	3.756626
6	Takeda Pharmaceutical (TAK)	3.740722
7	GlaxoSmithKline (GSK)	3.438712
8	Merck (MRK)	3.431365
9	Sanofi (SAN)	3.388497
10	Johnson & Johnson (JNJ)	3.233425

Conclusions and Discussion

Several medical studies have proven that the COVID-19 vaccine is effective in preventing people from becoming infected with COVID-19. It also helps alleviate the severity of the disease in case of an infected person and the vaccine appears to be accepted around the world because of its effectiveness. Multilateral governments and organizations have pledged to buy billions of doses at a fixed price. So in the coming months, vaccine manufacturer companies would be busy fulfilling those orders as quickly as possible. It is interesting to see whether those vaccine manufacturer companies could generate profit in both short and medium term.

This research attempted to calculate and compare returns, risks, and volatility of the top 10 vaccine manufacturer stocks during January 2020 to April 2021. This research chose to study only the top 10 of these companies according to Meticulous Research (2021), which provides the top ten world leading manufacturer in vaccines market in 2021. These companies were listed in the different stock market such as Euronext Paris, New York Stock Exchange, Tokyo Stock Exchange, Australia Stock Exchange and London Stock Exchange. Daily closing index prices were gathered during January 2020 to April 2021. All stock market prices had been converted to U.S. dollar.

This research utilized Excel (NumXL) add-in as a method of calculating return, risk and volatility by adopting Capital Asset Pricing Model (CAPM) for risk-return relationship, and EGARCH as volatility estimation. Based on the daily stock prices, the Exponential Generalized Autoregressive Conditionally Heteroscedastic (EGARCH) process is used in estimating and forecasting the volatility.

For comparison of the actual returns of the top 10 vaccine manufacturer stocks, the result shows that Daiichi Sankyo had the highest actual returns, which followed by Carlisle, Emergent BioSolutions, Johnson & Johnson, Merck, Pfizer, AstraZeneca, Takeda Pharmaceutical, GlaxoSmithKline and Sanofi.

We utilizes CAPM model to calculate systematic risk of the top 10 vaccine manufacturer stocks, the result shows that Daiichi Sankyo had the lowest systematic risk, which followed by Sanofi, AstraZeneca, Takeda Pharmaceutical, Pfizer, Johnson & Johnson, GlaxoSmithKline, Merck, Carlisle and Emergent BioSolutions consecutively.

Finally, EGARCH model was constructed to compute the degree of volatility of the top 10 vaccine manufacturer stocks, the result shows that Emergent BioSolutions had the highest stock volatility, which followed by Carlisle, Daiichi Sankyo, AstraZeneca, Pfizer, Takeda Pharmaceutical, GlaxoSmithKline, Merck, Sanofi, and Johnson & Johnson.

Discussion on Stock Return, Risk and Volatility

The arithmetic stock return formulas have been widely used and generally accepted as one of the better methods to calculate stock returns, which were used in Jensen and Ruback (1983), Fama and French (1988), Mill (1999), Panna (2017) models. Daiichai Sankyo stock return was the highest of all top 10 vaccine manufacturer company stocks, which yielded an actual return of 28.68%. Carlisle, Emergent BioSolutions and Johnson & Johnson were ranked second, third and fourth, which had an actual return of 18.47%, 16.94 and 12.48. The results show that Merck, Pfizer and AstraZeneca were not performing well, which had actual returns fell below 5% during the 14-months period. The disappointed stocks were Takeda Pharmaceutical, GlaxoSmithKline and Sanofi, these stock produce negative stock returns of around -16 and -20%.

According to Global News (2021), an experimental COVID-19 vaccine jointly developed by Sanofi and GlaxoSmithKline. They showed strong immune responses in early clinical trial results, allowing them to be transferred to end-stage studies. Referring to Figure 4.1.1 and 4.1.3, we further test Sanofi and GlaxoSmithKline stock returns and found that they had a correlation coefficient of 0.68, the result show that their stock returns, 68% likely to move in the same direction. Furthermore, according to the Guardian (2021), AstraZeneca had pledged to provide their vaccines on a not-for-profit basis. These could explain why AstraZeneca did not really perform well on their profitability.

CAPM is the dominant model to forecast cost of common equity, which adjusted by a ratio expressing the relationship between the movement of a stock price and the market index. This movement is call beta or specific risk. This CAPM test of risk have been calculated for the top ten vaccine manufacturer company stocks. The results were incorporated with the study of Banz (1981), McConnell and Muscarella (1985), Bruner et al. (1998), Mills (1999) and Arnold (2008). The results show that Daiichi Sankyo had the lowest systematic risk (beta) of 0.501938, which followed by Sanofi, AstraZeneca, Takeda Pharmaceutical, Pfizer, Johnson & Johnson, GlaxoSmithKline, and Merck. Their beta ranges between 0.5 to 0.65. However, Carlisle and Emergent BioSolutions pose quite a significant beta of round 1.00.

To clearly explain return vs risk relationship, the security market line (SML) was drawn. It is a chart that serves as a graphical representation of the CAPM, which shows different levels of systematic (beta) of the top ten vaccine manufacturer company stocks, plotted against the actual rate of return during the study period of fourteen months, i.e. January 2020 to April 2021. The SML is a visualization of the CAPM, where the x-axis of the chart represents systematic risk (beta), and the y-axis of the chart represents actual rate of return. According to the result, it was unarguable that Daiichi Sankyo was the best performer in term of highest actual rate of return and poses the lowest risk. There were three other stocks which could be suggested to the investors. Johnson & Johnson was one of them. Carlisle and Emergent BioSolutions were the other two but with a considerate systematic risk. However, Sanofi (SAN), Merck (MRK), GlaxoSmithKline (GSK), Pfizer (PFE), Takeda Pharmaceutical (TAK) and AstraZeneca (AZN) were considered to be overvalued stocks and they are not suggested to the investors.

The results of the volatility test were consistent with the study of Samuelson (1965), Cuthbertson (1996), Campbell et al. (1997), Aydemir (1998), and Mills (1999). The EGARCH model was the method of choice for modelling the volatility in order to investigate the leverage effect in the volatilities of the study period of January 2020 to April 2021 for the top ten vaccine manufacturer company stocks. EGARCH model describes the degree or level in which volatility or fluctuations of prices/returns can change and becoming more volatile during the periods of financial, other crisis or world events and less volatile during periods of relative calm and steady economic growth. The result indicates that that Emergent BioSolutions had the highest stock volatility/fluctuation of its prices, which followed by Carlisle, Daiichi Sankyo, AstraZeneca, Pfizer, Takeda Pharmaceutical, GlaxoSmithKline, Merck, Sanofi, and Johnson & Johnson was the least volatile stock.

When we compare returns, risks and volatility of these 10 vaccine manufacturer company stocks, Johnson & Johnson was the best of these 10 stocks. It had positive return, less risk, least volatility. On the other hand, Takeda Pharmaceutical and GlaxoSmithKline produced negative return, moderate risk and moderate volatility, which could be seen as the two that were least favorable stocks to invest at this moment.

Recommendation

The results of this research could help investors to see how the top ten vaccine manufacturer company stocks performed in term of returns risks and volatility. It should be noted that CAPM risk describes only systematic risk, which makes it restrictive and inflexible in some cases. In addition, due to lack of true market portfolio, investors could use different proxies for the market portfolio which causes them to generate different return estimates for the same security. Despite these few loopholes, this research could be useful to investors generally.

This research mainly focuses on the movement of stock prices and returns but did not look into some other factors such as behavior finance. There could be other reason why these vaccine manufacturer companies did not gain extraordinary profit for their vaccine. For example, according to Guardian (2021), AstraZeneca had pledged to provide their vaccines on a not-for-profit basis until the pandemic comes to an end. Hence, this other factor could be further studied for a more accurate results between return, risk and volatility relationship.

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