NATIONAL ECONOMICS UNIVERSITY
FACULTY OF MATHEMATICS ECONOMICS

The Capital Asset Pricing Model : Test of the model on Hanoi Stock Exchange

AN INVESTMENT AND FINANCIAL MARKET REPORT
SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE COURSE

Submitted by :
Hoang Le My Anh 11204296
Nguyen Huynh Duc 11200853
Lai Thi Hanh 11201358
Le Bao Trung 11207312
Nguyen Thao My 11202634

NOVEMBER 2022

ABSTRACT

Because of their high levels of profitability, stock markets around the world in general, and in Vietnam in particular, have long piqued the interest of investment institutions and individual investors. They are, nonetheless, vulnerable to a wide range of potential risks. Measuring the stock's systemic risks can assist investors in developing effective risk-mitigation measures. As a result, economists are interested in developing econometric models that are consistent with the facts. The capital asset pricing model (CAPM) is widely used in many nations throughout the world due to its basic methods and easy application. It states that in a competitive market the expected rate of return on an asset varies in direct proportion to its beta.

In this paper the performance of 50 stocks traded continuously on the Hanoi Stock Exchange from January 1, 2021, to the end of June 2022 has been tested. We conducted two independent tests of the CAPM using different approaches and techniques to better check the theory's validity, and then compared the results.

Table of contents

1 Introduction

1.1 Introduction of Hanoi Stock Exchange

1.1.1 Hanoi Stock Exchange

As an organizer and regulator of the securities market, the HNX has made considerable contribution to the development of securities market as a whole, supporting the aim of the country's economic growth. The HNX has organized share auction, Government Bond bidding positively and efficiently, and has operated markets including Listed stock market, Government Bond market, Unlisted Public Company market (UPCoM) and Derivatives market.

1.1.2 Function of Hanoi Stock Exchange

The HNX has typical functions such as :

Financial raising system. The idle money of residents when investing in stocks of large enterprises listed on HNX is a form of capital contribution to that company. This indirectly helps businesses raised financial resources to serve production of the company.

Redistribution of shares. Creating opportunities to help all individual and institutional investors to own shares of public companies. Investors are distributed profits, reducing the current income difference ratio.

Measure of the economy. Conditions for a Stock codes listed on the exchange will create a filter to evaluate the size of the business. Stocks listed on HNX will be valued by the market according to economic laws. We will see economic development through rising or falling of these stocks.

1.2 Purpose of the study

This study uses the assets traded on the Hanoi Stock Exchange to examine the accuracy of the Capital Asset Pricing Model. The Capital Asset Pricing Model, or CAPM for short, is an equilibrium model that relates the beta - measured for stock risk to returns. Its key message is that stock returns increase proportionally to their betas and this relationship is positive and linear which is called Security Market Line. In Chapter 9, the model's full derivation and logic will be explained. The testing process will be focused on the characteristics of this Security Market Line ordinary least squares and multiple regressions as main analytical tool. Three independent tests of the model will be conducted in this study based on following researchers : Black, Jensen, Scholes, Fama, and MacBeth. Their studies will be described in more detail in Chapter 8, 13 and 21. We will use the daily stock returns from 4/1/2021 to 30/6/2022. Due to this relatively short testing period the original tests must be modified to accommodate the available data. [2]

2 Theoretical background

2.1 Modern portfolio theory

Modern portfolio theory is a collection of ideas developed by Harry Markowitz in the early 1950s. He pioneered asset risk measurement and established methods for mixing assets into risk-adjusted portfolios, laying the groundwork for later advancements in financial theory. [3]

The two most important values of any asset are its returns over time and the volatility of these returns. Measured over some short interval of time, the rates of returns conform closely to normal distribution, while studying longer periods of time exhibits the distribution that could be described as lognormal. However, it is commonly assumed that rates of returns are distributed normally.

Modern portfolio theory assumes that investors are risk averse, meaning that given two portfolios that offer the same expected return, investors will prefer the less risky one. Thus, an investor will take on increased risk only if compensated by higher expected returns. Conversely, an investor who wants higher expected returns must accept more risk. The exact trade-off will not be the same for all investors. Different investors will evaluate the trade-off differently based on individual risk aversion characteristics. The implication is that a rational investor will not invest in a portfolio if a second portfolio exists with a more favorable risk-expected return profile, if for that level of risk an alternative portfolio exists that has better expected returns.

Under the model :

Portfolio return is the proportion-weighted combination of the constituent assets' returns.

$$E(R_p) = \sum_i w_i E(R_i)$$

Portfolio return volatility is a function of the correlations of the component assets, for all asset pairs (i,j). The volatility gives insight into the risk which is associated with the investment. The higher the volatility, the higher the risk.

$$\sigma_p^2 = \sum_i \omega_i^2 \sigma_i^2 + \sum_i \sum_j \omega_i \omega_j \sigma_i \sigma_j \rho_{ij}$$

Knowing where the stock price comes from, how diversity decreases risk, and how investors make investment decisions by selecting efficient portfolios, an extension of Markowitz's current portfolio theory : The Capital Asset Pricing Model (CAPM), can now be derived.

2.2 The Capital Asset Pricing Model (CAPM)

2.2.1 Beta coefficient

β coefficient is a coefficient that measures the volatility of a security before changes in factors (market, macro, internal company....) or is also known as a measure of systematic risk. of a security. β is an important parameter in the capital asset pricing model (CAPM), which is calculated based on regression analysis to calculate the expected return of an asset based on market rate of return. [4]

The β coefficient is a measure of systematic risk, it represents the relationship between the risk of an individual asset compared to the risk level of the entire market. This coefficient will change as economic conditions change. As their market price fluctuates with strong factors, the β of the security (or business) will be larger. Therefore, β coefficients are also known as their sensitivity coefficients to changes.

$$\beta_i = \frac{Cov[r_i, r_m]}{Var[r_m]}$$

Where :

$Cov[r_i, r_m]$ - Covariance between the market portfolio and a single asset.

$Var[r_m]$ - Variance of the market portfolio return.

When a security has :

$\beta_i = 0$: The expected return is the risk-free return.

$\beta_i = 1$: The expected return is the market return.

$\beta_i < 1$: The level of risk of the ticker is less than the market risk, these stocks are less affected by market volatility.

$\beta_i > 1$: The level of risk of the ticket is more than the market risk, changes in the market have a strong impact on these stocks.

2.2.2 Model concept

The capital asset pricing model (CAPM) was developed in the 1960s by three economists William Sharpe, John Lintner and Jack Treynor and has had many applications since then. CAPM is a model that describes the relationship between risk and expected return, used to value securities with a high level of risk.

In this model, the expected return of a security is equal to the risk-free return plus a risk premium based on the security's systemic risk basis. Unsystematic risk is not considered in this model because investors can build a more diversified portfolio to eliminate this type of risk. [5]

Meaning : The CAPM is a market equilibrium model, representing the portion of an asset's return in relation to the market return that has a bearing on the impact of risk.

$$R_i = R_f + \beta_i \times (R_m - R_f)$$

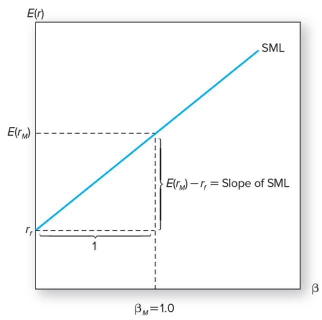
In which,

R_i : is the return of the asset i.

R_f : is the risk-free return.

R_m : is the return of the market portfolio.

β_i is the market beta of asset portfolio 1 usually determined using a regression model based on historical data.



If CAPM assumptions hold, all investments should be on the Security Market Line (SML). Note that it applies to any security, not just efficient portfolios.

We can rearrange it to express it in terms of an expected excess of returns on an asset or portfolio over the risk –free return :

$$E(z_i) = \beta_i E(z_m)$$

Where :

$E(z_i) = E(r_i) - r_f$

$E(z_m) = E(r_M) - r_f$

This excess is also defined as a risk premium which is demanded by investors for bearing additional risk. According to the model, this premium should be proportional to the stock's beta, hence all assets should be on the SML in equilibrium. If a stock was trading above the security market line, it would provide a higher return with the same beta than would be projected in equilibrium. Investors would rush to acquire it, driving up the price and cutting the return, putting the stock on the line. The opposite would occur if the stock was below the SML. Other assets would provide a higher return with the same risk ; thus, investors would sell the asset at a lower price, increasing its return.

2.2.3 Model Assumptions

Perfect market. The value of the funds on the market is formed by the interaction of all the investors in the market, investors are just price takers. There are no investors in the market large enough to influence stock prices. Borrow and lend at risk-free rates, no transaction fees, all assets are divisible and market-traded, tax-free, short-sold.

Efficient market. All information related to security on the market is immediately reflected in the price of that item. Investors cannot rely on known information in the past and present to seek profits. Any information that affects the future value of securities is random and unpredictable.

- Investors are risk-averse, making decisions based on expected returns and standard deviations of returns.
- Investors have equal access to investment opportunities.
- Investors have uniform periods of return and risk (standard deviation, variance) of an investment opportunity.
- Investors have two ways to invest : risk-free securities and market portfolios.
- The risks mentioned in the model are systematic risk, investors will eliminate systematic risk by diversifying investment portfolios.

2.3 Theory of the efficient capital market

The Efficient Market Hypothesis is another significant contribution to financial market knowledge. The idea was founded on the discovery made by Maurice Kendall in 1953 while studying the pricing of financial instruments and commodities. He discovered that there is no pattern in the behavior of these prices and named the phenomenon the random walk. This indicates that investors cannot forecast what will happen in the future by researching past pricing. Based on Kendall's discovery, Fama developed three forms of market efficiency in the late 1970s [6] :

- Weak-form efficiency : no extra profits can be made by studying historical prices. In other words, present prices already reflect all the information that can be gained from past prices.
- Semi-strong-form efficiency : no extra profits can be made by interpreting publicly available information. The prices already reflect all published information.
- Strong-form efficiency : no extra profits can be made by using any information whether it is public or not because prices already reflect all possible information.

The idea that stock prices are unpredictable and move without any clear pattern will be used later in the paper in order to modify the Capital Asset Pricing Model so it can be tested using historical returns.

3 Literature review

STUDY	FINDING	MAIN RESULT
Treynor (1962), Sharpe (1964)	The original Capital Asset Pricing Model.	CAPM provides precise expectation of the relationship that should be monitored between the expected return of an asset and its risk.
Black, Jensen and Scholes (1972)	The relationship between portfolios betas and their average returns.	By using all stocks listed on the New York Stock Exchange in years 1926-1965, they found the relationship between portfolios betas and their average returns was linear with a positive and significant slope.
Fama and MacBeth (1973)	The relationship between expected returns and exposure to (priced) risk factors.	The regression approach to estimate risk premiums in various markets, exploit a linear relationship between expected returns and exposure to (priced) risk factors.
Fama and French (1992)	Value and small-cap stocks outperform markets on a regular basis.	Through three-factor models, they found a better measure to market returns and value stocks outperform growth stocks, which is supportive for CAPM.
Hasan et al. (2011)	The relationship between beta and return of stocks.	By using monthly stock returns from 80 non-financial companies from 2005 to 2009 to study risk-return relationship with CAPM. The result showed that the intercept term was significantly non-zero and there was a positive relationship between beta and return of stocks.

4 Data selection

We have taken the closing stock price of 50 companies by day, from January 1, 2021, to June 30, 2022 (including 370 observations) listed on Hanoi Stock Exchange (HNX). The source to update the data is tvsi.com.vn website.

From the closing price data, we calculate the return of the stock based on the natural logarithm of each day's closing price divided by the day's closing price of previous transaction. Thus, returns of the stock do not include dividends distributed in years. The log-return data series will start from the 2nd day to the last day of the data collection period (including 369 observations).

$$R_t = ln(\frac{P_t}{P_{t-1}})$$

In which, P_t is the closing price at day t, P_{t-1} is the closing price at day t-1.

R_m is the expected return of the market portfolio. In this study, we have used stock's return of companies listed on Hanoi Stock Exchange. Therefore, I have used the HNX-Index to ensure that R_m fully represents the market portfolio.

R_f is the risk-free return. Typically calculated using government bond yields. In the US market, it is often measured as a 10-year government bond. In Vietnam, I used the 10-year government bond yield average for the research period (from January 1, 2021 to June 30, 2022). The rationale for this is that government bonds do not have any liquidity risk, and the government always ensures revenue to pay for the bonds. As a result, there is almost no risk. The risk-free rate is about 2.3857% per year and is approximately equal to 0.000654% per day.

5 Methodology

We decided to run two independent tests of the CAPM using different techniques and then compare the results with each other. The first test is based on one of the earliest attempts to check the validity of the theory which uses so a called two-pass regression technique. The second test will be based on Black, Jensen, and Scholes (BJS) research from 1972 and will employ a cross-sectional analysis of the assets.

5.1 The two-pass regression test

The first step in testing the CAPM using this method is to use the daily excess returns on 50 chosen assets over the testing period from the first quarter of 2021 to the end of the second quarter of 2022 to estimate their betas. To do it a time series OSL regression will be run for every single asset (First-pass regression). The regression equation will be :

$$z_{ti} = \alpha_i + \beta_i z_{Mt} + \varepsilon_{ti} \tag{1}$$

Where :

z_{ti} - Excess of an asset's returns over the risk-free rate at time t.

α_i - Regressions intercept.

β_i - Estimated beta of asset i.

z_{Mt} - Excess of the market returns over the risk-free rate at time t.

ε_{ti} - Random disturbance term at time t.

In total 50 time-series regressions will be performed on this stage of analysis. According to CAPM the intercept of the regression described by above equation should be 0, whereas there are no restrictions on the value of beta. After estimating betas, we will attempt to estimate the security market line for the testing period. To do so a second-pass regression will be run according to the equation :

$$\overline{z_i} = \gamma_0 + \gamma_1 \beta_i + \varepsilon_i \tag{2}$$

Where :

$\overline{z_i}$ - Average excess of returns on asset i over the testing period

γ_0 - Regression intercept

γ_1 - Regression coefficient

β_i - Estimated beta of the asset i

ε_i - Random disturbance term

This regression will be run across all one hundred assets resulting in an estimation of SML. If CAPM holds the results should be as follows :

$$\boldsymbol{\gamma_0 = 0}$$
$$\boldsymbol{\gamma_1 = \textbf{avarage excess of market returns over the risk-free rate}}$$

The next step will be to perform so called non-linearity test. As mentioned in the theoretical section CAPM predicts that assets' returns are linearly related to their betas. In order to test this hypothesis an additional term will be added to the previous equation :

$$\overline{z_i} = \gamma_0 + \gamma_1\beta_i + \gamma_2\beta_i^2 + \varepsilon_i \tag{3}$$

Term β_i^2 is simply a second power of our estimated beta. If the model indeed holds and the linear relationship between beta and returns is strong, then adding the beta square term shouldn't influence the previous results. Thus, if CAPM is true then :

$$\gamma_2 = 0$$

The last check of the theory that can be performed is a test for nonsystematic risk. The CAPM says that the only risk that matters to investors, which is reflected in returns, is measured by beta. Other factors simply don't matter. To account for nonsystematic risk yet another parameter will be added to the regression equation :

$$\overline{z_i} = \gamma_0 + \gamma_1\beta_i + \gamma_2\beta_i^2 + \gamma_3 RV_i + \varepsilon_i \tag{4}$$

The RV_i term stands for the variance of residuals of an asset i. We obtain the value of this term from the first-pass regression that has been used to estimate stocks betas. Residual variance in this case will be the measure of the risk not accounted for beta. If CAPM holds then :

$$\gamma_3 = 0$$

5.2 Black, Jensen and Scholes Test

The second CAPM test that we will run is based on the 1972 Black, Jensen, and Scholes test. Their technique must be changed to accommodate available data due to the substantially shorter testing period. The BJS test examines the CAPM's performance on portfolios rather than single equities. Portfolios will diversify a set level of company-specific risk in accordance with Markowitz's modern portfolio theory. The testing procedure will be carried out in the following steps :

1. Stocks' betas will be estimated using equation 1 based on daily returns from the first quarter of 2021 to the third quarter of 2021.

2. Stocks will be ranked by their estimated betas and 10 portfolios will be created based on stocks' betas ; 10% of the stocks with the lowest betas create the first portfolio and so on, until 10 portfolios are created.

3. The daily returns on these portfolios will be computed in the fourth quarter of 2021. A daily return on a portfolio is simply an arithmetic average of the daily returns on the stocks in the portfolio.

4. Stocks' betas will be re-estimated using equation 1 based on daily returns from the the second quarter to the fourth quarter of 2021.

5. The portfolios will be reconstructed using the same method described in step 2 and betas from step 4. The daily returns on the portfolios in the first quarter of 2022 will be computed.

6. Stocks' beta will be estimated one more time using equation 1 based on the daily returns from the fourth quarter of 2021 to the first quarter of 2022.

7. The portfolios will be reconstructed again, and their returns will be computed for the second quarter of 2022.

8. The portfolios betas will be estimated by regressing returns computed in steps 3, 5 and 7 to the market index. The regression equation is :

$$z_t p = \alpha_p + \beta_p z_{Mt} + \varepsilon_{tp} \tag{5}$$

Where :

z_{tp} - - Excess of the portfolio returns over the risk-free rate at time t.

α_p - Regressions intercept.

β_p - Estimated beta of the portfolio p.

z_{Mt} - Excess of the market returns over the risk-free rate at time t.

ε_{tp} - Random disturbance term at time t.

9. The cross-sectional regression will be performed to estimate SML by regressing portfolios' average excess of returns over the risk-free rate from the fourth quarter of 2021 to the second quarter of 2022 to their betas estimated in step 8. The regression equation is :

$$\overline{z}_p = \gamma_0 + \gamma_1 \beta_p + \varepsilon_p \tag{6}$$

Where :

$\overline{z}_p$ - Average excess of returns on portfolio p over the testing period

β_p - Estimated beta of the portfolio p

ε_p - Random disturbance term

10. The non-linearity and non-systematic risk tests will be performed according to the equations :

$$\overline{z}_p = \gamma_0 + \gamma_1 \beta_p + \gamma_2 \beta_p^2 + \varepsilon_p \tag{7}$$

$$\overline{z}_p = \gamma_0 + \gamma_1 \beta_2 + \gamma_2 \beta_p^2 + \gamma_3 RV_p + \varepsilon_p \tag{8}$$

The logic behind equations 7 and 8 is exactly the same as in the first test using a two-pass regression technique. If the Capital Asset Pricing Model is true the values of regressions' coefficients should equal to :

$$\gamma_0 = 0$$
$$\gamma_1 = \text{average excess of market returns over the risk free rate}$$
$$\gamma_2 = 0$$
$$\gamma_3 = 0$$

6 Empirical Analysis

6.1 The two-pass regression test

The first step in testing the CAPM will be to estimate the beta values of all 50 assets involved in the study during the testing period 2021Q1 to 2022Q2. Fifty time-series regressions have been performed according to equation 1 and the results are summarized in the Table 1 below. (For more detailed results of the regressions please see Table A in Appendix A)

Stock name	Beta	p-value	Stock name	Beta	p-value
AME	0.2489	0.0199	CX8	0.3509	0.0024
API	1.1650	0.0000	D11	0.7009	0.0000
MBS	1.5902	0.0000	DAD	0.1914	0.0240
ART	1.7543	0.0000	DHT	0.1066	0.0000
BAX	1.2064	0.0000	VIT	0.4817	0.0000
BCC	1.2064	0.0000	VIF	0.2536	0.0023
BII	1.2641	0.0000	DS3	0.7321	0.0000
BKC	0.4658	0.0000	DST	1.3676	0.0000
WSS	1.4750	0.0000	DTD	1.0930	0.0000
WCS	0.2437	0.0003	DXP	1.0562	0.0000
VTJ	0.5504	0.0001	EID	0.4606	0.0000
BNA	0.4525	0.0003	LDP	0.5538	0.0000
BTS	1.0645	0.0000	LIG	1.3391	0.0000
C69	0.7965	0.0000	MBG	1.5065	0.0000
CAP	0.2702	0.0017	MDC	0.5638	0.0000
CDN	0.3683	0.0000	MST	0.8325	0.0000
CEO	0.3683	0.0000	FID	1.3081	0.0000
CIA	0.6158	0.0000	GIC	0.5362	0.0000
SZB	0.4588	0.0000	HAT	0.2730	0.0000
TC6	0.9778	0.0000	HBS	1.5617	0.0000
TAR	1.0633	0.0000	HCC	0.5013	0.0000
CLH	0.1787	0.0044	HHG	1.2388	0.0000
CET	-0.1362	0.3419	HLC	0.5483	0.0000
CPC	0.1944	0.0397	HLD	0.8671	0.0000
CSC	1.0604	0.0000	HMH	0.1987	0.0366

Table 1. The results of first-pass regression. Estimated betas and their p-value

The range of estimated betas is from -0.136 to 1.941. The results are quite promising, 98% of all estimated betas are significant with 95% confidence. As mentioned earlier according to CAPM the intercepts of estimated regression lines should be 0. Considering that matter, the results of first-pass regression are also good : 0% of estimations exhibited an intercept significantly different from zero.

6.1.1 SML Estimation

The next step is to perform second pass regression according to equation 2 where average excesses of all assets' returns over the appropriate risk-free interest rate will be regressed against their estimated betas. Here this is the results of this regression ; however, regression inputs are summarized in Table B in Appendix A.

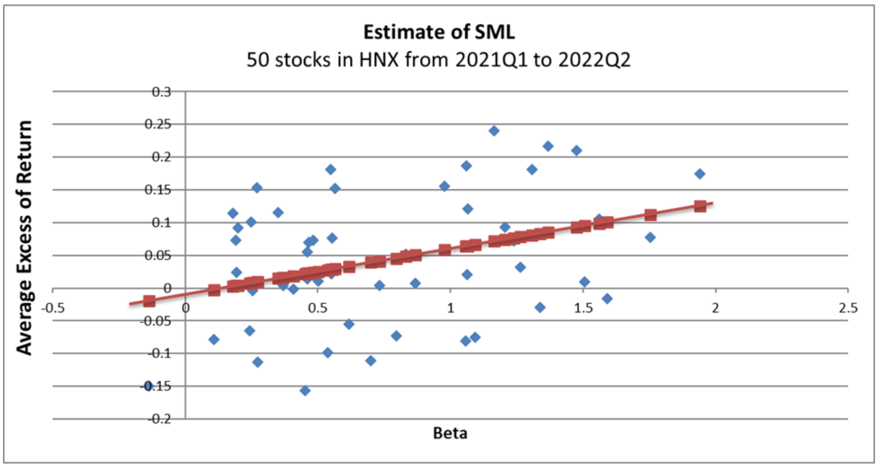


Figure 1. Estimation of the Security Market Line of 50 stocks in HNX from 2021Q1 to 2022Q2

Figure 1 above shows the graphical representation of the estimated Security Market Line of 50 stocks in HNX from 2021Q1 to 2022Q2. Line intercept is nearly zero, but the SML is upward sloping which supports the idea of CAPM that expected returns are positively and proportionally related to beta. However, to draw any constructive conclusions we must examine regression results which are summarized in the *Table 2* below.

	Regression results	t-value	p-value	CAPM predicted values
γ_0	-0.009678	-0.391	0.6976	0
γ_1	0.069608	2.561	0.0136	0.0740154
R-square	12.02%			
Standard Error	0.09475			

Table 2. Second-pass regression results and CAPM predicted values.

As we can see from 2 the estimated SML supports the CAPM theory. The p-value of regression test for γ_0 is great, so not reject H0 (Null hypothesis is $\gamma_0 = 0$), the $\gamma_0 = 0$ is equal to 0. Analysis shows that the slope of the estimated SML is positive and significant, which is consistent with the model. This slope is somewhat a bit lower than this predicted by the CAPM, but still approximate with predicted CAPM value. Finally, the R-square value is low suggesting that only a small portion of variation in stocks' returns can be explained by the beta.

6.1.2 Non-linearity test

The non-linearity test has been performed according to 5.1. The results of this regression are presented in the *Table 3* below.

	Regression results	t-value	p-value	CAPM predicted values
γ_0	-0.011355	-0.301	0.764	0
γ_1	0.075346	0.752	0.456	0.0740154
γ_2	-0.003275	-0.060	0.953	0
R-square	12.03%			
Standard Error	0.09575			

Table 3. Second-pass regression results with non-linearity test.

The p-value for regression test coefficient γ_0 and γ_2 are so high, so not reject Ho. The slope of SML γ_1 is positive and statistically significant which is in accordance with the CAPM.

Nevertheless, CAPM prediction of SML slope is a bit lower than the estimated one, but still approximate with predicted CAPM value. Finally, the estimated value of the coefficient γ_2 is significantly different from the CAPM prediction which implies no linear relationship between stocks' beta and return.

6.1.3 Non-systematic risk test

To perform test for non-systematic risk I will utilize 5.1. The results of the regression are presented in the *Table 4 :*

	Regression results	t-value	p-value	CAPM predicted values
γ_0	-0.045297	-0.999	0.323	0
γ_1	0.076640	0.771	0.455	0.0740154
γ_2	-0.011860	-0.216	0.830	0
γ_3	0.003241	1.322	0.193	0
R-square	15.25%			
Standard Error	0.095			

Table 4. Second-pass regression results with non-linearity and non-systematic risk test.

Regressions intercept γ_0 is insignificantly different from 0 which is consistent with the CAPM prediction. The estimated average markets' risk-premium γ_1 is positive but insignificant and higher than the premium predicted by the model. Significant estimation of γ_2 implies no linear relationship between beta and return. Finally, the estimated value of coefficient γ_3 is insignificantly different from 0 which is with accordance with the CAPM. It implies that all the risk is captured by beta and non-systematic risk has no influence on stocks' returns. This result supports the Capital Asset Pricing Model.

6.2 Black, Jensen and Scholes Test

Summarizing all the testing sub – periods for convenience :

	Sub – period 1	Sub – period 2	Sub – period 3
Stocks' beta estimation	Q1 2021 – Q3 2021	Q2 2021 – Q4 2021	Q3 2021 – Q1 2022
Portfolio creation date	30 – 9 - 2021	31 – 12 -2021	31 – 3 -2022
Portfolio returns computation	Q4 2021	Q1 2022	Q2 2022

Table 5. Testing sub – periods in the BJS test.

The stocks' betas have been calculated according to equation 5 in each of the 3 sub-periods. In Q1 2021 – Q3 2021, 82% of estimated betas are significant while 98% of estimated intercepts are insignificantly different from 0. Estimates in the next sub-period are somewhat better : 76% significant betas and 98% intercepts insignificantly different from 0. In the last sub-period the corresponding percentages are 82% for betas and 98% for intercepts.

After estimating the betas 10 portfolios have been constructed based on these betas. The content of each portfolio in corresponding sub-period is presented in the 6

Portfolio 1.

Q3-2021	Beta	p-value	Q4-2021	Beta	p-value	Q1-2022	Beta	p-value
CET	-0.2182	0.3122	CET	-0.3038	0.2158	CET	0.5011	0.9552
CPC	-0.0071	0.9611	DAD	0.0621	0.6936	DHT	0.1671	0.1013
CLH	0.0421	0.6357	DHT	0.1374	0.0073	BNA	0.6577	0.6537
DHT	0.1825	0.0000	CPC	0.1402	0.4379	BAX	0.5386	0.0701
DAD	0.1942	0.1796	WCS	0.1783	0.0889	CAP	0.0096	0.0018

Portfolio 2.

Q3-2021	Beta	p-value	Q4-2021	Beta	p-value	Q1-2022	Beta	p-value
HMH	0.2304	0.0599	EID	0.1898	0.0901	WCS	0.2057	0.0444
CX8	0.2662	0.0267	CAP	0.1992	0.0072	DAD	0.2067	0.1277
MDC	0.2685	0.1750	LDP	0.2055	0.4331	HAT	0.2441	0.1252
AME	0.2727	0.1229	BNA	0.2068	0.4195	VIF	0.3215	0.0199
LDP	0.2895	0.1150	HAT	0.2161	0.1563	HMH	0.3342	0.0275

Portfolio 3.

Q3-2021	Beta	p-value	Q4-2021	Beta	p-value	Q1-2022	Beta	p-value
CAP	0.3098	0.0003	HMH	0.2409	0.0788	EID	0.3412	0.0016
BKC	0.3182	0.1053	BKC	0.2788	0.1978	AME	0.3424	0.0515
EID	0.3352	0.0007	CLH	0.3506	0.0013	VIT	0.3640	0.0865
HAT	0.3395	0.0041	BAX	0.3539	0.0111	SZB	0.3757	0.0005
VIF	0.3844	0.0000	VIF	0.3597	0.0103	CLH	0.3787	0.0003

Portfolio 4.

Q3-2021	Beta	p-value	Q4-2021	Beta	p-value	Q1-2022	Beta	p-value
WCS	0.3884	0.000	HCC	0.3727	0.0000	CPC	0.3810	0.0211
VTJ	0.4145	0.0334	CX8	0.3889	0.0327	LDP	0.4002	0.0771
BNA	0.4338	0.0028	SZB	0.4024	0.0000	CDN	0.4280	0.0009
HLD	0.4503	0.0000	VTJ	0.4068	0.1063	GIC	0.4296	0.0000
HLC	0.5013	0.0076	VIT	0.4160	0.0866	CX8	0.4772	0.0141

Portfolio 5.

Q3-2021	Beta	p-value	Q4-2021	Beta	p-value	Q1-2022	Beta	p-value
WCS	0.3884	0.000	HCC	0.3727	0.0000	CPC	0.3810	0.0211
VTJ	0.4145	0.0334	CX8	0.3889	0.0327	LDP	0.4002	0.0771
BNA	0.4338	0.0028	SZB	0.4024	0.0000	CDN	0.4280	0.0009
HLD	0.4503	0.0000	VTJ	0.4068	0.1063	GIC	0.4296	0.0000
HLC	0.5013	0.0076	VIT	0.4160	0.0866	CX8	0.4772	0.0141

Portfolio 6.

Q3-2021	Beta	p-value	Q4-2021	Beta	p-value	Q1-2022	Beta	p-value
CIA	0.5518	0.0000	HLD	0.5627	0.0000	MST	0.7265	0.0000
CSC	0.6084	0.0000	GIC	0.5739	0.0000	HLC	0.7452	0.0011
C69	0.6167	0.0000	BII	0.5951	0.0463	HLD	0.8057	0.0000
BAX	0.6248	0.0000	HLC	0.5963	0.0134	D11	0.8347	0.0000
TC6	0.6317	0.0007	MDC	0.6493	0.0121	C69	0.8645	0.0000

Portfolio 7.

Q3-2021	Beta	p-value	Q4-2021	Beta	p-value	Q1-2022	Beta	p-value
DTD	0.6595	0.0000	CSC	0.6551	0.0002	MDC	0.9529	0.0000
TAR	0.6673	0.0000	D11	0.6644	0.0003	CSC	0.9635	0.0000
HHG	0.7274	0.0011	C69	0.6925	0.0001	TAR	0.9815	0.0000
LIG	0.7342	0.0000	CIA	0.7306	0.0000	BTS	0.9873	0.0000
DS3	0.7374	0.0000	DTD	0.7642	0.0000	BII	1.0627	0.0003

Portfolio 8.

Q3-2021	Beta	p-value	Q4-2021	Beta	p-value	Q1-2022	Beta	p-value
API	0.7592	0.0000	LIG	0.8147	0.0002	DTD	1.1558	0.0000
MST	0.7885	0.0000	TC6	0.9551	0.0001	DXP	1.1703	0.0000
GIC	0.8037	0.0000	API	1.0021	0.0000	TC6	1.1998	0.0000
BII	0.8143	0.0013	DXP	1.0413	0.0000	API	1.2997	0.0000
FID	0.8288	0.0002	FID	1.0661	0.0000	BCC	1.3995	0.0000

Portfolio 9.

Q3-2021	Beta	p-value	Q4-2021	Beta	p-value	Q1-2022	Beta	p-value
DXP	0.9282	0.0000	BCC	1.1492	0.0000	LIG	1.4083	0.0000
BCC	0.9601	0.0000	HHG	1.1531	0.0000	HBS	1.4103	0.0000
BTS	0.9997	0.0000	BTS	1.2369	0.0000	WSS	1.5492	0.0000
DST	1.0810	0.0000	MBG	1.2759	0.0000	MBS	1.5538	0.0000
CEO	1.2792	0.0000	DST	1.5121	0.0000	FID	1.5642	0.0000

Portfolio 10.

Q3-2021	Beta	p-value	Q4-2021	Beta	p-value	Q1-2022	Beta	p-value
MBG	1.3463	0.0000	HBS	1.6627	0.0000	DST	1.6006	0.0000
WSS	1.4946	0.0000	CEO	1.6813	0.0000	MBG	1.6886	0.0000
ART	1.6765	0.0000	WSS	1.7435	0.0000	HHG	1.7214	0.0000
HBS	1.7491	0.0000	ART	1.8481	0.0000	ART	1.8503	0.0000
MBS	1.7726	0.0000	MBS	1.8911	0.0000	CEO	2.3665	0.0000

Table 6. Portfolio content in various sub-periods.

The next step is to estimate portfolios betas by regressing their monthly returns from Q3 2021 – Q2 2022 against the market index in the same period according to equation 5. All of the estimates of portfolios betas showed to be significant however the intercept is in 2 cases significantly different from 0.

Having portfolios' betas the data set to cross-sectional regression must be prepared. In cross-sectional regression the average portfolios' risk premiums calculated from Q3 2021 – Q2 2022 will be related to their betas resulting in estimation of the security market line. Table 3 presents the regression inputs :

Portfolio	Average Risk Premium	Beta	Beta Square	Variance Residual
p1	-0.18%	0.21401975	0.04580445	0.00025337
p2	-0.12%	0.29863989	0.08918579	0.00020072
p3	0.10%	0.30332168	0.09200404	0.00020478
p4	-0.03%	0.27680962	0.07662356	0.0002227
p5	0.03%	0.23622669	0.05580305	0.00022671
p6	0.13%	0.20255241	0.04102748	0.00023375
p7	0.14%	0.25021424	0.06260717	0.00023
p8	0.14%	0.29875589	0.08925508	0.00023032
p9	0.21%	0.31433639	0.09880737	0.00021612
p10	0.17%	0.37356506	0.13955085	0.00021207

Table 7. Cross – sectional regression inputs.

6.2.1 SML Estimation

Based on data from 7 and using 5.2 the security market line has been estimated. Its graphical representation can be found in the *Figure 2* below :

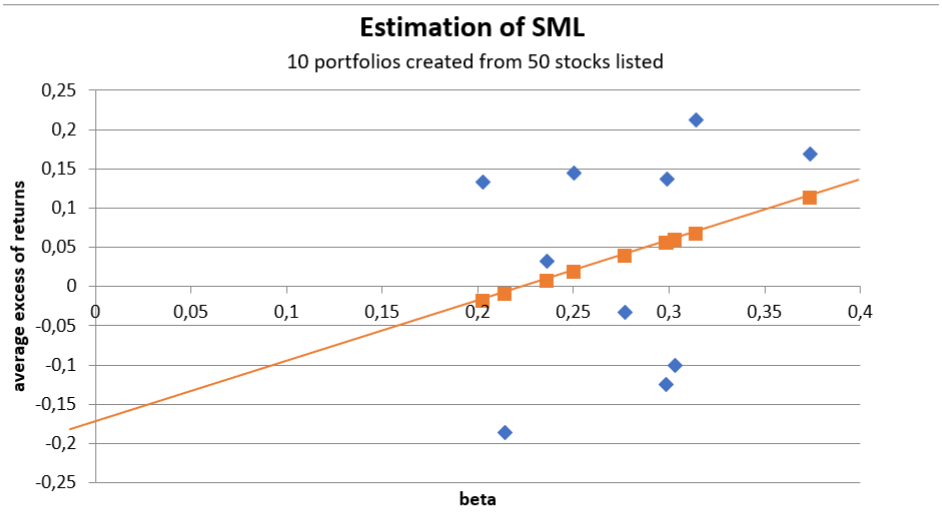


Figure 2. Estimation of the Security Market Line on Hanoi Stock Exchange. Testing period Q3 2021 – Q2 2022

Table 8 summarizes the regression results :

	Regression results	t-value	p-value	CAPM predicted values
γ_0	-0.1730	-0.669	0.522	0
γ_1	0.522	0.830	0.431	0.0740154
R-square	7.92%			
Standard Error	0.1431			

Table 8. Cross-sectional regression results

According to cross-sectional regression the estimated SML has an intercept insignificantly different from 0 which supports the CAPM hypothesis. The estimated slope is positive but insignificant and much higher than the predicted by the model. Furthermore the R-square value is extremely low implying almost no relation between portfolios' returns and their betas.

6.2.2 Non–linearity test

The non – linearity test's results performed according to 5.2. It results are summarized in the *Table 9* :

	Regression results	t-value	p-value	CAPM predicted values
γ_0	0.6538	0.497	0.634	0
γ_1	-5.3188	-0.558	0.594	0.0740154
γ_2	10.7807	0.641	0.542	0
R-square	13.04%			
Standard Error	0.1487			

Table 9. Cross-sectional regression results with non-linearity test.

After performing the non-linearity test we can see that estimated intercept of SML γ_0 is still in accordance with CAPM : insignificantly different from 0. The slope however is negative and insignificant this time. Coefficient γ_2 which should be 0 if there is no linear relationship between beta and excess returns is insignificantly different from 0. In that matter the CAPM is supported.

6.2.3 Non–systematic risk test

The last step is to perform non-systematic risk test using *5.2*. Its results are summarized in the *Table 10* :

	Regression results	t-value	p-value	CAPM predicted values
γ_0	-0.2015	-0.080	0.939	0
γ_1	-3.0922	-0.269	0.797	0.0740154
γ_2	7.6636	0.395	0.707	0
γ_3	0.2196	0.414	0.693	0
R-square	15.45%			
Standard Error	0.1584			

Table 10. Cross-sectional regression results with non-linearity and non-systematic risk tests.

The values of estimated coefficients γ_0, γ_1, γ_2 are approximately the same as in the previous cross - sectional regression. Intercept in insignificantly different from 0, slope is negative and insignificant. Coefficient γ_3 is insignificantly different from 0 which means that non-systematic risk has no influence on portfolios returns. This result supports the Capital Asset Pricing Model.

7 Conclusion

The results of all two test are summarized in the *Table 11*

	Two-Pass Technique	Back, Jensen and Scholes
Intercept = 0	Passed	Passed
Slope = average risk premium	Significantly positive and nearly equal	Positive but much higher and insignificant
Non-linearity	Passed	Passed
Non-systematic	Passed	Passed

The Capital Asset Pricing Model is entirely supported by empirical data, according to the first test based on the two-pass regression technique. The estimated stock market curve is theoretically consistent. The intercept is insignificantly different from zero, the slope of the SML is significant and roughly equivalent to that predicted by the model, and there is a clear linear relationship between beta and excess return that can be discerned. The non-systematic risk test also gives CAPM a consistent result that the fact that unsystematic risk, i.e., the risk not captured by beta, has no effect on the required risk premium.

Changing methodologies and studying individual assets rather than portfolios did not produce the desired outcomes. The estimated SML intercept level seems to support the CAPM theory. However, the results show that the slope is not equal to the average risk premium nor significant, the SML does not show a linear relationship between beta and excess return. Because of this, the results of the last 2 tests are meaningless.

Changing methodologies and studying individual assets rather than portfolios did not produce the desired outcomes. The estimated SML intercept level seems to support the CAPM theory. However, the results show that the slope is not equal to the average risk premium nor significant, the SML does not show a linear relationship between beta and excess return. Because of this, the results of the last 2 tests are meaningless.

In short, the key result reached after conducting an empirical analysis on the Hanoi Stock Exchange to test the performance of the Capital Asset Pricing Model is that only the Two-Pass Technique is supported by data, which shows that the excess return of the stocks under test depends on the excess return of the market and the beta estimate is suitable to measure the systematic risk of the stock. This result strongly concurs with the findings of Hasan et al. (2011) on 80 non-financial companies from 2005 to 2009, also the conclusion of Treynor (1962) and Sharpe (1964). Although the test is fully supported, the coefficient of determinant is quite low which means only a small portion of variation in stocks' returns can be explained by the Beta. [1]

A better idea for future study of assets traded on the Hanoi Stock Exchange could be to test a theory developed after the CAPM namely the Arbitrage Pricing Theory, which allows more factors than just beta to influence securities' rate of returns.

8 Limitation

Although the analysis nearly achieves the purposes of the study, there are still some limitations :

Because, firstly, the assumptions of CAPM theory may not completely match the current reality of the market. The Capital Asset Pricing Model assumes investors can borrow and lend money without any limitations at a risk-free rate. This is an impractical assumption as practically investors cannot do so. When estimating the rate of return on an investment, the Capital Asset Pricing Model assumes a perfect market. A perfect market is one in which all financial information is freely available to investors. A perfect market exists only in theory but not in reality. The Capital Asset Pricing Model also assumes there are no transaction fees involved when investing. Practically, there are many transaction fees like legal fee, taxes and bid-ask spread involved.

Secondly, the price level accounts for only a minor portion of the business, owing to the influence of supply and demand on the stock of speculators. Vietnamese stock market is heavily influenced by a number of factors, including investor attitude, the impact of other stock markets, information on policy changes. The market portfolio is the final. For all stocks listed on Hanoi Stock Exchange, the HNX-Index currently does not represent the market portfolio because there are insufficient business lines and significant firms.

Finally, the Capital Asset Pricing Model can be used to calculate an investment's rate of return. While it is widely used and has numerous benefits, it does have some restrictions or drawbacks. These constraints may arise when calculating the rate of return utilizing the model with other variables such as the risk-free rate of return, the beta coefficient, or the market average return. Furthermore, these restrictions may be caused by the assumptions made by this model.

References

[1] John Y. Campbell et Tuomo Vuolteenaho. « Bad Beta, Good Beta ». In : *American Economic Review* 94.5 (déc. 2004), p. 1249-1275. doi : 10.1257/0002828043052240. url : https://www.aeaweb.org/articles?id=10.1257/0002828043052240.

[2] Bartosz Czekierda. *The Capital Asset Pricing ModelTest of the model on the Warsaw Stock Exchange*. 2007.

[3] Frank J. Fabozzi, Francis Gupta et Harry M. Markowitz. « The Legacy of Modern Portfolio Theory ». In : *The Journal of Investing* 11.3 (2002), p. 7-22. issn : 1068-0896. doi : 10.3905/joi.2002.319510. eprint : https://joi.pm-research.com/content/11/3/7.full.pdf. url : https://joi.pm-research.com/content/11/3/7.

[4] Eugene F. Fama et Kenneth R. French. « The Capital Asset Pricing Model : Theory and Evidence ». In : *Journal of Economic Perspectives* 18.3 (sept. 2004), p. 25-46. doi : 10.1257/0895330042162430. url : https://www.aeaweb.org/articles?id=10.1257/0895330042162430.

[5] André F. Perold. « The Capital Asset Pricing Model ». In : *The Journal of Economic Perspectives* 18.3 (2004), p. 3-24. issn : 08953309. url : http://www.jstor.org/stable/3216804 (visité le 17/11/2022).

[6] Oussama Tilfani, Paulo Ferreira et My Youssef El Boukfaoui. « Multiscale optimal portfolios using CAPM fractal regression : estimation for emerging stock markets ». In : *Post-Communist Economies* 32.1 (2020), p. 77-112. doi : 10.1080/14631377.2019.1640983. eprint : https://doi.org/10.1080/14631377.2019.1640983. url : https://doi.org/10.1080/14631377.2019.1640983.