INTRODUCTION

Investors want to know the “fair” value or “equilibrium” price of an asset. Once they find out the appropriate, i.e. “fair”, price of an asset, they will compare it with the market price. If the market price is higher than the “fair” price, then the asset is said to be over-priced. By the same token, if the market price is lower than the “fair” price, then the asset is said to be under-priced. For decades, academics in the fields of finance and economics have tried to develop a model that accurately predicts the “fair” value of an asset. In this topic you are introduced to several asset-pricing models that can help us predict or explain the “fair” or “equilibrium” returns on securities.

The capital asset pricing model (CAPM) serves exactly this purpose, i.e. of predicting the “fair” value of an asset, so this is the first model we will discuss. The CAPM is an extension of Markowitz’s portfolio selection, which does not tell us the “fair” value of an asset. Professor William Sharpe initiated the CAPM in 1964. The main theme of Professor Sharpe’s CAPM is to predict the return
relationship of an individual asset. The model simply tells us that if some assumptions are held, the CAPM can enable us to estimate the “fair” return on securities. It provides substantial information about how to estimate the equilibrium expected rates of return on individual assets as well as on a portfolio.

The security market line (SML) could simply be the CAPM graphed in a diagram. The SML also depicts the positive linear relationship between risk and return. If the beta value is greater than 1 (remember that beta is a measure of the systematic or market risk), then we should expect that the rate of return of that stock will be higher than the market portfolio’s return. Thus, the greater the beta value, the higher the rate of return on that asset. Again, this reflects the trade-off between risk and return.

5.1 CAPITAL ASSET PRICING MODEL (CAPM)

The CAPM is a simple asset-pricing model that helps us to determine the “fair” values of assets. The integral element of the CAPM is the estimation of the beta coefficient; that is, determining the CAPM’s beta coefficient can help investors select which securities to invest in. For example, if the beta value of a particular asset is very high, say greater than 1, then we know that this particular stock has a higher risk than the market portfolio.

CAPM is a simple model that requires certain strong assumptions to be held. If these assumptions are not held, then the CAPM collapses. You should also note that empirical tests of the CAPM show that the CAPM fails to predict and explain the “fair” value of assets. The main reason for this failure is that some of assumptions of the CAPM are not held in reality. Nevertheless, the CAPM is an easy model to learn, and the construction of the CAPM is not sophisticated, so it provides useful information on the risk characteristics of securities.

However, **Markowitz portfolio selection** is based on the information about expected returns and the co-variances of the stocks concerned. However, using historical information to construct a well-diversified portfolio will not make a fortune for us. Only if we can measure the **expected returns** on stocks can we make profits from our investments! In reality, the expected returns on stocks are, of course, very hard to measure.

One thing that would be very useful, but which we don’t yet have, of course, is a model that accurately predicts what the expected returns on stocks should be. The capital asset pricing model (the CAPM) is an equilibrium model that represents the relationship between the expected rate of return and the return co-variances for all assets. As you will learn later, this equilibrium is the most important assumption of the CAPM. “Equilibrium” is an economic term that characterises a situation where no investor wants to do anything differently.
Let’s look at this example: if, for instance, you think the equilibrium price of TENAGA stock at this moment is RM10 per share, and the market price of TENAGA is exactly RM10 per share, then you may not want to trade (buy or sell) TENAGA stock at this moment.

In other words, you would say that the stock of TENAGA is fairly priced. However, if the market price of TENAGA stock were below the equilibrium price, say RM9 per share, then TENAGA stock would be said to be under-priced. If you know the equilibrium price of TENAGA is RM10, then you have the incentive to buy TENAGA stock at RM10 per share, since you will earn a profit of RM1 per share if the market price of TENAGA goes back to RM10 per share (i.e., the equilibrium price). When investors realise that TENAGA stock is under-priced, then the overall buying pressure will push the price up. After the market adjusts, the price of TENAGA stock might eventually go back to RM10 per share (i.e., the equilibrium price).

On the other hand, if the market price of TENAGA were RM12 per share, the market price would be above the equilibrium price. Thus, TENAGA stock is said to be over-priced. Investors have the incentive to sell over-priced stock. The selling pressure would eventually take the price back to the equilibrium price, i.e. RM10 per share.

In the real world, the equilibrium price will of course not be constant; it may change in accordance with Malaysia’s economic fundamentals, or the internal developments of TENAGA, the company.

Instead of using price, therefore, the CAPM expresses its results in terms of returns to predict or forecast the equilibrium expected return of all assets. Professor William Sharpe developed the foundations of the CAPM in a 1964 article. The contributions of Professor Sharpe earned him the Nobel Prize in Economics in 1990.

Practically speaking, the CAPM is very useful for predicting the equilibrium expected return on assets. Fund managers do, in fact, use this model to select stocks in their portfolios. In the process of capital budgeting, financial managers use the CAPM to evaluate the risk of new projects.

5.1.1 The Assumptions of the CAPM

Before you learn more about the CAPM, you have to understand its assumptions. This model must make a number of assumptions to formally derive the CAPM relationship. Some of these assumptions can be relaxed without too much effect on the results. In the later section on the extensions to the CAPM, we will discuss
the effects on the model when some of its assumptions are relaxed. Of course, relaxing its assumptions makes the CAPM more amenable to practical usage.

It is important to stress that the CAPM is a theory about the real world; it is not necessarily a description of the real world. In order to evaluate the usefulness and applicability of the CAPM we must thus try to determine how much the theory corresponds to the real world. You can refer to the textbooks mentioned to learn more about the assumptions of the CAPM.

You should now have a good grasp of the basic assumptions of the CAPM. Let me make some critical remarks here regarding some of these assumptions.

(a) Investors can borrow and lend any amount at a fixed, risk-free rate. The implication of this assumption is that the rate of borrowing and rate of lending are equal to the risk-free rate, in short \( r_B = r_L = r_f \). However, in the real world, the rate of borrowing is higher than the rate of lending \( r_B > r_L \). The difference between the rate of borrowing and the rate of lending is the spread that is regarded as the profit to the financial institutions \( r_B - r_L = \text{spread} \). In Malaysia, the Base Lending Rate (BLR) is much higher than the savings and time deposit rates. Therefore, the difference between the BLR and the time deposit rate is the spread that it provides profits for financial institutions. By definition, the risk-free rate is the interest rate that provides an appropriate default-free (riskless, guaranteed) investment. In the US, the Treasury Bill Interest Rate is the proxy for the risk-free rate. In Malaysia, Kuala Lumpur Interbank Offer Rate (KLIBOR) is the proxy for the risk-free rate.

(b) Investors pay no taxes on returns and no transaction costs (commissions and stamp duties). Investors have to pay commission to brokers, as well as stamp duties to the government of Malaysia. Recently, the commissions charge has been significantly reduced because of the introduction of e-trading of stocks. In the US, the institutional arrangement is quite different: investors in the US have to pay both capital gains taxes and dividend income taxes for buying and selling stocks.

(c) Homogeneous expectation. This assumption states that all investors have the same expectations regarding the performance of the stock market. For instance, during a period of deflation and economic recession, the model assumes that all investors will have the same feeling, i.e. that the stock price of HSBC will decline. Practically speaking, this is not necessarily the case; different investors may have different opinions about the price distribution of a certain asset. Some investors may think that it is a good time to buy banking stocks during a time of deflation and economic recession. Thus, in the real world, investors have different expectations. This so-called heterogeneous expectation is quite common in investment decision-making.
The simplifying assumptions underlying the CAPM were relaxed one at a time. Each time, the implications of the model were slightly obscured. I will show you in the subsequent section how the CAPM is altered if the assumptions are relaxed one at a time. If all assumptions are relaxed simultaneously, however, the results of the CAPM cannot even be determined. However, the fact that such analysis is not derivable under realistic assumptions does not mean it has no value. The CAPM still rationalises the complex behavior that is observed in the financial markets.

**ACTIVITY 5.1**

That all investors are rational is an implicit assumption of both efficient diversification and the CAPM. Do you think this assumption is realistic? Why or why not?

In the real world, we do not expect all individual investors to behave rationally. Of course, we expect most investors to be rational. Still, there are some investors who behave irrationally. For instance, a risk loving investor might invest all of her wealth in a single stock.

### 5.2 MARKET PORTFOLIO AND MARKET RISK PREMIUM

The market portfolio is an integral part of the CAPM. By definition, the market portfolio is a portfolio of all risky securities held in proportion to their market value. This means that the return on the market portfolio is given by the following:

\[ r_M = \sum_{i=1}^{N} v_i r_i \]

where

\[ v_i = \frac{\text{total dollar value of security } i}{\text{total dollar value of all risky securities}} \]

\[ r_M \] is the return on market portfolio

\[ r_i \] is the return of security \( i \)

In practice, the “market portfolio” usually refers to national market indices, such as the S&P500 for the US, the Financial Times 100 for the UK, the Nikkei 225 for Japan, the All Ordinaries for Australia, the Hang Seng Index (HSI) for Hong Kong and KLCI for Malaysia. These national market indices can be found in
financial time series databases such as Data Stream International. Fund managers use these national market indices as the benchmarks for their locally or globally diversified portfolios. Once we have the information on the market portfolio, we can easily estimate the market portfolio risk premium. You’re introduced to this in the next reading.

Investors now face two different investment instruments: namely, the risk-free rate investment and investment in the risky market portfolio. If investors allocate their wealth in these two investments, then the risk-free rate is considered as the opportunity cost of holding the risky market portfolio. The opportunity cost is defined as an implicit cost that equals the difference between what was actually earned and what could have been earned in the highest-paid alternative use of the capital. For instance, suppose a risk-averse investor has RM1 million to invest. Let’s say he allocates RM0.5 million to the risk-free rate investment and the other RM0.5 million to the risky market portfolio. However, if another investor is less risk-averse, she could invest the entire RM1 million in the risky market portfolio. This investor will earn a higher rate of return because she bears more risk.

The market risk premium is simply defined as the difference between the return on the market portfolio and the return on the risk-free investment:

\[
\text{Market portfolio risk premium} = E(r_M) - r_f
\]

The market portfolio risk premium is also known as the excess expected return on the market portfolio. If the risk-free rate is getting smaller, then the excess expected return on the market portfolio, or the market portfolio risk premium, will be higher according to the definition of the market portfolio risk premium. For example, if the annual expected return for the KLCI is 5%, and the annual rate of the 1-month KLIBOR (the proxy for the risk-free rate) is 2%, then the market portfolio risk premium is simply 5% – 2% = 3%. The market portfolio risk premium will not be constant over time; the market portfolio risk premium is a time-varying parameter, which means that the market portfolio risk premium will change from time to time. Both the expected return on the market portfolio and the KLIBOR will change over time to reflect the changing economic fundamentals in Malaysia.

### 5.2.1 The Excess Return on Individual Stocks

Similar to the excess market portfolio return, the excess expected return on an individual stock is defined as the difference between the expected return on that individual stock and the risk-free rate (i.e., excess expected return = \( E(r_i) - r_f \)). The excess expected return on an individual stock could also be considered as the risk premium of that individual stock. If the opportunity cost of holding risky
stocks is higher (i.e., the higher the level of the risk-free rate), then the risk premium for an individual stock is smaller if the expected return on individual stock is held constant. On the other hand, if the opportunity cost of holding risky stocks is lower, then the risk premium for an individual stock is greater than if the expected return on individual stock is held constant. Both the expected return on an individual stock and the risk-free rate will change in response to economic fundamentals. Thus, the risk premiums of individual stocks will also change over time.

5.2.2 The Expected Return on Individual Stocks

You need to know how the return on an individual stock is determined under the framework of the CAPM. In the following reading you’ll learn more about the theoretical background of the CAPM. After the reading, I will make some comments that emphasize the application of the model.

So far we have discussed two important risk premiums, namely the market risk premium \( \frac{E(r_M) - r_f}{r_f} \) and the individual stock risk premium \( \frac{E(r_i) - r_f}{r_f} \). The main objective of the CAPM is to explain the relationship between these two risk premiums. The relationship can be written in the following fashion:

\[
E(r_i) - r_f = \beta_i [E(r_M) - r_f]
\]

If we switch the term for the risk-free on the left-hand side to the right-hand side, then we obtain the following:

\[
E(r_i) = r_f + \beta_i [E(r_M) - r_f]
\]

This is the well-known relationship characteristic of the CAPM that shows that the expected return on an individual stock is equal to the sum of the risk-free rate plus the beta \( \beta_i \) times the expected market risk premium. The beta \( \beta_i \) coefficient is the measure of the systematic risk of a stock, i.e. the tendency of a stock’s returns to respond to swings in the market portfolio. We will discuss the beta coefficient and the estimation of beta in subsequent sections.

The intuition of the CAPM is quite precise. The expected return on individual stock is equal to the opportunity cost of holding risky assets (i.e., \( r_f \)) plus the reward of bearing more risk, which is the second term of the CAPM (i.e., \( \beta_i [E(r_M) - r_f] \)). For example, if the annual rate of the 1-month KLIBOR (the proxy for the risk-free rate in Malaysia) is 2%, the expected growth on the KLCI is 5%, and the beta coefficient of HSBC stock is 1.2, then the expected return on HBSC is as follows:

\[
E(r_{HSBC}) = 2\% + 1.2(5\% - 2\%)
\]

5.6% = 2% + 1.2(5% - 2%)
Since the CAPM is an equilibrium model, the equilibrium expected return on HSBC is 5.6%, which is higher than the return on the KLCI. Now, suppose the beta coefficient of HSBC is 0.9 instead of 1.2. Then the equilibrium expected return on HSBC is:

\[4.7\% = 2\% + 0.9(5\% - 2\%)\]

The result tells us that if the beta coefficient of HSBC or the measure of the systematic risk of HSBC is lower, the equilibrium expected return for HSBC becomes lower. The new equilibrium expected return for HSBC (4.7%) is lower than the return on the KLCI.

In practice, it is very easy to calculate any individual stock’s equilibrium expected return. The only information we need to know is the risk-free rate, the expected return on the market portfolio, and the beta coefficient. The risk-free rate and the return on the market portfolio (ex-post) can be found in financial newspapers. We only have to estimate the beta coefficient. Once we’ve obtained the value of the beta coefficient, we can easily determine the equilibrium expected return.

Fund managers use the information on stocks’ betas to make investment decisions from time to time. For instance, the security analyst from a fund house might estimate the value of beta for a number of individual stocks. Then the fund managers use this information, i.e. the estimated betas, to form their portfolios. An aggressive portfolio will comprise stocks with high betas. Normally speaking, stocks with beta values greater than 1 are considered to be aggressive investments. Conversely, a defensive portfolio will comprise stocks with low betas, i.e. with values less than 1. A fund manager can also form a mixed portfolio, which consists of stocks with both high and low beta values. This is why the beta values are significant for fund managers making investment decisions related to portfolio selection. As I will show you later, the calculation of beta is rather handy and requires only a few bits of information.

### 5.2.3 The Ex-ante and Ex-post Versions of the CAPM

There are two versions of the CAPM, namely the ex-ante version and the ex-post version.

**Ex-ante version:**

\[E(r_i) = r_f + \beta_i[E(r_M) - r_f]\]

**Ex-post version:**

\[r_i = r_f + \beta_i[r_M - r_f]\]

The ex-ante version is based on information about the future market risk premium, and the ex-post version is based on historical data related to the market risk premium.
The CAPM analyses the linear relationship between an individual stock and the market risk premium. We can actually plot this linear relationship into a graph. This graphical presentation makes it easier for us to visualise the CAPM. When the CAPM is depicted graphically, it is known as the security market line (SML). Plotting the CAPM, we find that the SML will, in fact, be a straight line which is similar to the capital market line (CML). The SML indicates the equilibrium expected rate, or sometimes we refer to the required rate of return the investor should earn in the stock market for each level of systematic risk (i.e., the beta). I will now show you how to graph the SML and discuss the implications of the SML thereafter.

### 5.3.1 Graphing the SML

The CAPM can be plotted by simply calculating the equilibrium expected return, or the required rate of return for a series of betas when holding the risk-free rate and the return on market portfolio constant. Referring back to our previous example with HSBC using the ex-post version of the CAPM:

\[
 r_{HSBC} = 2\% + \beta_{HSBC}(5\% - 2\%)
 \]

The following table shows the required rate of return for a number of betas when we apply the above CAPM to HSBC:

<table>
<thead>
<tr>
<th>Beta of HSBC</th>
<th>Require rate of return</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2%</td>
</tr>
<tr>
<td>0.5</td>
<td>3.5%</td>
</tr>
<tr>
<td>1</td>
<td>5%</td>
</tr>
<tr>
<td>1.5</td>
<td>6.5%</td>
</tr>
<tr>
<td>2</td>
<td>8%</td>
</tr>
</tbody>
</table>
Plotting these values on a graph (with the beta on the horizontal axis and the required rate of return on the vertical axis), we have a straight line that is known as the SML (Figure 5.1). The SML clearly shows that as the beta (i.e. the systematic risk) increases, so does the required rate of return. Any point along the SML is considered as the equilibrium rate of return.

![Figure 5.1: The security market line (SML)](image)

### 5.3.2 The Investment Decision-making Process

According to the CAPM, the SML reflects the equilibrium condition of a stock’s required rate of return and that of the market return. However, the security’s actual return may not be on the SML. For instance, points U and O are not on the SML in Figure 5.2.

As shown in Figure 5.2, point U lies above the SML and point O is below the SML. When the actual return of a stock is above the SML, it is considered to be an under-priced stock. In other words, the expected return of stock U is higher than that predicted by the CAPM. Therefore, when investors identify stock U as an under-priced stock, there will be pressure in the marketplace for buying it. As a result, the price of stock U will be bid up and the expected return on stock U will be lower. Please bear in mind that when the price of a security is bid up, its return becomes lower since return at time t is defined as follows:

\[ r_t = \frac{\text{selling price} - \text{buying price}}{\text{buying price}} \]

When the buying price is bid up because of buying pressure in the marketplace, then the return at time t will be lower because the denominator is getting larger. Eventually, point U will move towards the SML and an equilibrium condition will be re-established.
By the same token, stock O is an over-priced stock, since its expected return is lower than that of the equilibrium return. When investors see that stock O is over-priced, then there will be pressure in the market for selling stock O. As a result, the price of stock O will drop, and the required rate of return on stock O will be higher when the equilibrium condition is re-established. Thus, when there is a disequilibrium situation in the market place, the market forces of supply and demand will push prices toward the equilibrium position suggested by the CAPM.

![Figure 5.2: A disequilibrium situation](image)

The SML will not stay at the same position all the time – it will move up and down in accordance with economic fundamentals. In the real world, fund managers tend to use the SML as an indicator to manage stocks in their portfolios. Nowadays, thanks to widespread ease of access to financial databases, we can easily estimate betas and plot the SML. The SML therefore serves as a preliminary procedure for identifying under-priced and over-priced securities.

There are real limitations on using the CAPM/SML to predict return patterns for securities. We cannot totally rely on the CAPM/SML to make our investment decisions. You should understand right now, however, that the CAPM is not the only tool that we can use to predict the returns on stocks. There are, of course, other tools such as the multifactor model and arbitrage pricing theory (APT) models, and using them is preferable to simply employing the CAPM on its own.

One of the major shortcomings of the CAPM is that we assume beta is stable over time. In fact, the beta value of any stock will keep on changing. For example, let’s say you obtain a beta during a bull market period. Then, all of a sudden, the market experiences a downturn. If you still keep on using the same beta to make
predictions, then the outcome will definitely be unfavourable. In this case, you need to have a dynamic CAPM to handle the problem. The dynamic CAPM allows the beta to be changed over time. In this case, the predictions that result will be more reliable.

**SELF-CHECK 5.2**

Use all the information you have obtained from Activity 3.3 and plot the security market line (SML). If the actual market return of the stock is 18%, what is your investment decision?

### 5.4 SYSTEMATIC RISK

You know by now that the beta coefficient is a measure of systematic risk or non-diversifiable risk. It is your task in this topic to learn how to estimate the beta coefficient of a stock. Once we obtain the value of the beta coefficient, we can then use this beta value and plug it into the CAPM equation in order to obtain the appropriate equilibrium expected return for an individual stock.

**ACTIVITY 5.2**

Let’s say you are considering investing in two stocks, Stock X and Stock Y. After doing your research, you’ve come up with some information on these stocks, as given below:

<table>
<thead>
<tr>
<th>Stock</th>
<th>Beta</th>
<th>Standard deviation of annual return</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>0.35</td>
<td>20.50%</td>
</tr>
<tr>
<td>Y</td>
<td>1.85</td>
<td>20.00%</td>
</tr>
</tbody>
</table>

After you show the information above to your classmate he points out that you have made some mistakes in your analysis. He further explains that, as the beta of Stock Y is much greater than that of Stock X, it is impossible for these two stocks to have similar total risk (standard deviation of annual return). Do you think his argument is correct? Why or why not?
5.4.1 The Estimation of the Beta Coefficient

To gain deeper insight into systematic risk, let’s consider the estimation of the beta coefficient from an ordinary least squares regression:

\[ r_{it} - r_{ft} = \alpha_i + \beta_i (r_{Mt} - r_f) + \varepsilon_{it} \]

where

- \( r_{it} - r_{ft} \) is the excess rate of return on individual stock \( i \) at time \( t \).
- \( r_{Mt} - r_f \) is the excess rate of return on market portfolio or the market risk premium at time \( t \).
- \( \alpha_i \) is the alpha coefficient in the regression at time \( t \).
- \( \beta_i \) is the beta coefficient in the regression, the measure of systematic risk at time \( t \).
- \( \varepsilon_{it} \) is the error terms of the regression at time \( t \).

In the above characteristics line regression, which is also known as the Market Model regression, the alpha is the intercept in the regression, and the beta is the slope of the regression. Remember, this is not the CAPM equation. This is a regression that allows us to estimate the security beta coefficient. The CAPM equation suggests that the higher the beta value, the higher the equilibrium expected return. Note that this is the only type of risk that is rewarded in the CAPM. The beta risk is referred to as systematic, non-diversifiable, or market risk. This risk is rewarded with expected returns. The other type of risk, which we mentioned in earlier topics, is known as unsystematic risk, or diversifiable risk. This type of risk is represented by the error terms in the above states time-series regression.

To sum up, the term \( \beta_i (r_{Mt} - r_f) \) represents the systematic risk or non-diversifiable risk, and the \( \varepsilon_{it} \) represents the error terms, which are also known as residual terms in the regression, and which represent unsystematic risk or diversifiable risk. The security characteristics line is the line of the best fit for the scatter plot that represents simultaneous excess returns on an individual stock and the market portfolio. This was illustrated in Figure 5.3.
As you can see, this is just the fitted value from a regression line. As you learned earlier, the beta will be the regression slope and the alpha will be the intercept. The error in the regression, the epsilon, is the distance from the line (predicted) to each point on the graph (actual). The CAPM implies that the alpha is zero. So we can interpret, in the context of the CAPM, the alpha as being the difference between the expected excess return on the individual stock and the actual excess return. Therefore, in an equilibrium situation, the expected excess return on the individual stock is same as the predicted excess return in the market. The alpha value should be zero. If a disequilibrium exists in which the expected excess return on the individual stock is not the same as the actual excess return, the value of alpha should be non-zero.

Now, let me summarise the procedures for estimating the coefficients of alpha and beta as follows:

(a) Obtain the historical data on the individual stock (HSBC), the market portfolio (the KLCI) and the risk-free return (the 1-month KLIBOR).
(b) Calculate the excess return on the individual stock and the excess return on the market portfolio (i.e., market risk premium).
(c) Uses Microsoft Excel to run the regression (i.e., a two-variable regression, where the excess return on the individual stock is the dependent variable and the market risk premium is the independent variable).
(d) Obtain the values of alpha and beta from the regression line.
(e) You can also calculate the error terms or residual terms using the actual data minus the values predicted from the regression line.

This is the most simple and standard way to obtain the values of alpha and beta for an individual stock. There is, however, another even more direct way to obtain the value of beta for an individual stock, as depicted in the following equation:

\[ \beta_i = \frac{\text{Cov}(r_i, r_M)}{\text{Var}(r_M)} \]

where

- \( \text{Cov}(r_i, r_M) \) is the covariance between returns of individual stock and the market portfolio.
- \( \text{Var}(r_M) \) is the variance of the market portfolio.

The covariance between returns on the individual stock and the market portfolio can also be written in the following equation:

\[ \text{Cov}(r_i, r_M) = \rho_{r_i r_M} \sigma_i \sigma_M \]

Note also that \( \rho_{r_i r_M} \) is the correlation coefficient of returns between the individual stock and the market portfolio, which you have learned about in topic 2 in the context of portfolio risk. \( \sigma_i \) is the standard deviation of the individual stock and \( \sigma_M \) is the standard deviation of the market portfolio. In other words, once we know the covariance of returns between the individual stock and the market portfolio and the variance of the market portfolio, we can easily obtain the beta value right away.

Finally, note that the beta of the market portfolio is 1:

\[ \beta_M = \frac{\text{Cov}(r_M, r_M)}{\text{Var}(r_M)} = \frac{\text{Var}(r_M)}{\text{Var}(r_M)} = 1 \]

The market portfolio \( (\beta_M) \) serves as a benchmark for investment decision-making. This provides a reference point against which the risks of other securities can be measured. The average risk (or beta) of all securities is the beta of the market portfolio, which is one. Stocks that have a beta greater than one have above average risk, tending to move more than the market portfolio. On the other hand, stocks with betas less than one are of below average risk and tend to move less than the market portfolio. If we invest in a stock with a beta value greater than 1, this is known as an aggressive investment (i.e., we’ll encounter risk that is higher than the average risk). Conversely, if we invest in a stock with a beta value of less than 1, this is considered a defensive investment (i.e., we’ll encounter risk that is lower than the average risk).
In the real world, whether a fund manager wants to invest in aggressive securities or portfolios merely depends upon the risk preference of the fund manager as well as the nature of the fund. For example, if the fund is a pension fund, then the fund manager will likely have to invest in less aggressive securities or portfolios. In other words, the pension fund manager has to invest in securities with low beta values. On the other hand, if the nature of the fund is a growth fund, then the fund manager has to invest in stocks with high beta values. The same is true for an individual investor. If the individual investor is rather risk averse, then that individual investor should invest in stocks with low beta values. Needless to say, if an individual is less risk averse, then that individual investor will want to invest in stocks with high beta values. Now you can really appreciate why beta is so important for investment decision making.

The state of the economy is another element that enters into investment decision making that uses beta value as the benchmark. During economic booms, investors and fund managers would like to invest in stocks or portfolios with high beta values in order to take advantage of the free ride of the economy’s growth. Generally speaking, during the periods of economic boom, firms have better earning performance, and this will immediately be reflected in share prices. Investors pay more attention to capital gains (i.e., the appreciation of share prices) during booms. Clearly, stocks with high beta values will provide more capital gains to investors. Conversely, during recessions investors generally want to invest in stocks with low beta values. For example, the stocks of public utilities usually have low beta values. Investors want to invest in such stocks during recessions in order to avoid capital losses (i.e., depreciation of share prices) and at the same time to get higher dividend yields.

5.5 **EXTENSIONS OF THE CAPM**

So far we have focused on the use of the CAPM for an individual stock. We need to be able to construct the CAPM to cover a portfolio comprising a series of risky securities. This is so-called portfolio CAPM. In addition, in this topic we look into the stability problem of beta - in other words, whether beta is constant over time. Finally, we examine what happens to the CAPM if some of its assumptions are relaxed.

5.5.1 **The CAPM for a Portfolio**

Instead of having an individual stock, let’s say we now have a portfolio that consists of risky securities. The CAPM for a portfolio can be set out as follows:

\[ r_P = r_f + \beta_p (r_M - r_f) \]
where

\( r_P \) is the equilibrium rate of return of a portfolio

\( \beta_P \) is the portfolio beta, which is defined:

\[
\beta_p = \sum_{i=1}^{n} \beta_i w_i
\]

and

\( w_i \) is the weights of individual stocks in the portfolio

The beta of the portfolio is the weighted average of the individual stock betas where the weights are the portfolio weights. Thus we can think of constructing a portfolio with whatever beta we want. All the information we need is the betas of the underlying stocks. For instance, if I wanted to construct a portfolio with zero systematic or non-diversifiable risk, then I could choose an appropriate combination of stocks and weights that delivers a portfolio beta of zero.

Once we obtain the information on \( \beta_p \), we can easily calculate the equilibrium or the required rate of return of the portfolio. At this point you should understand that the CAPM not only applies to individual stocks, but also to portfolios that comprise a series of risky assets. Practically speaking, then, portfolio managers can employ the CAPM to help manage their portfolios. The portfolio beta (\( \beta_p \)) provides information on the risk profile of the entire portfolio and is useful in portfolio managers’ investment decision-making.

### SELF-CHECK 5.4

Let’s say a well-diversified portfolio is composed of the following five stocks:

<table>
<thead>
<tr>
<th>Stocks</th>
<th>Prices</th>
<th>Shares held</th>
<th>Beta (( \beta ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$10</td>
<td>1,000</td>
<td>0.8</td>
</tr>
<tr>
<td>B</td>
<td>$20</td>
<td>1,500</td>
<td>0.9</td>
</tr>
<tr>
<td>C</td>
<td>$5</td>
<td>5,000</td>
<td>1.2</td>
</tr>
<tr>
<td>D</td>
<td>$35</td>
<td>2,000</td>
<td>1.3</td>
</tr>
<tr>
<td>E</td>
<td>$50</td>
<td>1,500</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Let’s also say that the capital asset pricing model (CAPM) holds, the expected return on the market portfolio is 12%, the market portfolio’s standard deviation is 8%, and the risk-free rate is 4%. What is the expected return on this five-stock portfolio?
5.5.2 The Beta Stability Problem

You should now be aware that beta is a measure of systematic or non-diversifiable risk. However, there is one question concerning the stability problem of beta that we must raise here: is beta constant over time? I am sorry to tell you that the answer is that beta is *not* constant over time. In other words, beta is a time-varying parameter so its value will change at different time periods.

If the beta coefficient is not constant over time, then the CAPM will fail to predict the equilibrium expected return or the required rate of return for an individual stock as well as for a portfolio of stocks. This means a more advanced version of the CAPM should be used to counter the stability problem of beta. However, pursuing this is not within the scope of this course.

5.6 THE RELAXATION OF CAPM ASSUMPTIONS

It is important to stress that the CAPM is a theory about the real world. It is not necessarily a *description* of the real world. In order to evaluate the usefulness and applicability of the CAPM, we must therefore try to determine how well the theory actually corresponds to the real world. One way of doing this is to relax some of its assumptions and thereby allow the CAPM to be more flexible and correspond to the real world:

(a) We can relax the assumption that the borrowing rate is equal to the lending rate, and assume instead that the borrowing rate is higher than the lending rate (i.e., \( r_B > r_L \)). As we have mentioned before, in the real world the borrowing rate is indeed higher than the lending rate, and the spread between borrowing rate and lending rate is the operating cost as well as the profit of financial institutions. If separate borrowing and lending rates are assumed, then two different CAPMs emerge:

\[
E(r_i) = r_B + \beta_i(r_M - r_B)
\]

and

\[
E(r_j) = r_L + \beta_j(r_M - r_L)
\]

The corresponding SMLs are depicted in Figure 5.4.
Figure 5.4: The SML for a borrowing rate that does not align perfectly with the SML for the lending rate.

(b) If transaction costs such as brokerage commissions and search cost are taken into account, then these realities can be modelled as “bands” on the sides of SML, as shown in Figure 5.5.

Figure 5.5: The SML with bands on the sides when transaction costs are taken into account.

There may be only a few percentage points of spread between the top and bottom transaction cost bands. Within this band, it is not profitable for investors to trade securities, because the transaction costs would consume
the potential profit that would induce such trading. Consequently, the market will never attain the equilibrium situation indicated in the solid line of SML, even if there are no changes in the other assumptions.

(c) Incorporate taxes into the CAPM model. Many countries in the world have legislated capital gains taxes as well as dividend income taxes for buying and selling stocks. In the US an investor is subject to both capital gains tax and dividend income tax when trading stocks. However, there are no such taxes in Hong Kong except for the stamp duties that are levied on the trading of stocks. With the existence of taxes taken into account, every investor would see a slightly different CAPM in terms of after-tax returns, since those returns would depend upon their particular tax situations. As a result, a static equilibrium condition will never emerge, even if other assumptions are maintained.

(d) Eliminating the assumption of homogeneous expectations will eventually allow investors to use different expected returns as well as the covariance of returns to construct the efficient frontier. The efficient frontier and the CAPM are composed of “fuzzy” curves and lines. The static equilibrium situation again could never emerge, even if other assumptions are held constant.

I believe that you are now very familiar with the CAPM. Before you go on to the next section, I just want to ask you one more question. What useful implications does the CAPM have for investors, in spite of its shortcomings?

For investors, the CAPM’s implications can be summarised as follows:

(a) If you are a diversified investor, all you need to be concerned with is the systematic risk you bear. Total risk or the volatility of any individual security in your portfolio is irrelevant.

(b) Is your desired level of risk consistent with your portfolio’s beta or systematic risk? Is the risk level of your portfolio what you intended? If not, you can simply adjust your portfolio beta by changing the component securities in your portfolio to match your desired level of risk.

(c) Based on existing finance literature, although it is strongly doubtful whether beta is a useful measure of expected return, beta is still a very useful measure of market-related volatility.
SUMMARY

- We have discussed the importance of Capital Asset Pricing Model (CAPM) and its assumptions.
- We have also learned how to derive Security Market Line (SML).
- It is important to learn how to apply Security Market Line (SML) for investment decision making.
- The empirical evidence of CAPM has been shown using example a stock, KLCI and KLIBOR.
- The implication of CAPM to investors has also been discussed.
- However, there are limitations of CAPM, and therefore we must move forward to other asset pricing models (to be discussed in next topic)

KEY TERMS

<table>
<thead>
<tr>
<th>Attainable frontier</th>
<th>Market risk premium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Lending Rate (BLR)</td>
<td>Markowitz portfolio selection</td>
</tr>
<tr>
<td>Beta</td>
<td>Modern portfolio theory</td>
</tr>
<tr>
<td>Capital asset pricing model</td>
<td>Over-priced stock</td>
</tr>
<tr>
<td>Equilibrium price</td>
<td>Relative risk</td>
</tr>
<tr>
<td>Excess return</td>
<td>Required return</td>
</tr>
<tr>
<td>Expected returns</td>
<td>Risk-free rate</td>
</tr>
<tr>
<td>Fair value</td>
<td>Security market line</td>
</tr>
<tr>
<td>Feasible frontier</td>
<td>Systematic risk</td>
</tr>
<tr>
<td>Market portfolio</td>
<td>Under-priced stock</td>
</tr>
</tbody>
</table>

SELF-TEST 1

1. Discuss the relevant risks that are measured by beta?

2. Using Kuala Lumpur Composite Index (KLCI) as example. Explain what is market return and how beta is related to it?

3. Discuss the relationship between market return and interpretation of beta for a stock listed in the exchange?
4. Discuss the range of values typically exhibited by beta.

5. Discuss the role of beta in the Capital Asset Pricing Model (CAPM).

6. Discuss the relationship between security market line (SML) and the Capital Asset Pricing Model (CAPM)?

7. Discuss the role of CAPM as a predictive model and its importance to investors.

8. What does the coefficient of determination (R-squared) for the regression equation used to derive a beta coefficient indicate?

**SELF-TEST 2**

1. Given that the risk-free rate (Rf) is 10 percent and the market return (RM) is 14 percent. Compute the required return

<table>
<thead>
<tr>
<th>Stock</th>
<th>Beta</th>
<th>E(R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABC</td>
<td>0.85</td>
<td></td>
</tr>
<tr>
<td>XYZ</td>
<td>1.25</td>
<td></td>
</tr>
</tbody>
</table>

2. You are given the betas for securities A, B and C as follows:

<table>
<thead>
<tr>
<th>Security</th>
<th>Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.40</td>
</tr>
<tr>
<td>B</td>
<td>0.80</td>
</tr>
<tr>
<td>C</td>
<td>-0.90</td>
</tr>
</tbody>
</table>

(a) Calculate the change in return for each security if the market experiences an increase in the rate of return of 13.2% over the next period.

(b) Calculate the change in return for each security if the market experiences a decrease in the rate of return of 10.8% over the next period.

(c) Discuss the relative risk of each security based on (a) and (b).
3. Use Capital Asset Pricing Model (CAPM) to find the required return for each of the following securities.

<table>
<thead>
<tr>
<th>Security</th>
<th>Rf (%)</th>
<th>Market Return(%)</th>
<th>Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5</td>
<td>8</td>
<td>1.30</td>
</tr>
<tr>
<td>B</td>
<td>8</td>
<td>13</td>
<td>0.90</td>
</tr>
<tr>
<td>C</td>
<td>9</td>
<td>12</td>
<td>-0.20</td>
</tr>
<tr>
<td>D</td>
<td>10</td>
<td>15</td>
<td>1.00</td>
</tr>
<tr>
<td>E</td>
<td>6</td>
<td>10</td>
<td>0.60</td>
</tr>
</tbody>
</table>

Given that the risk-free is 7%, market return is 12% and the following asset classes which you are interested to invest in (for Questions 4 to 6):

<table>
<thead>
<tr>
<th>Asset Classes</th>
<th>Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.50</td>
</tr>
<tr>
<td>B</td>
<td>1.00</td>
</tr>
<tr>
<td>C</td>
<td>0.75</td>
</tr>
<tr>
<td>D</td>
<td>0</td>
</tr>
<tr>
<td>E</td>
<td>2.00</td>
</tr>
</tbody>
</table>

4. Which asset class is the most risky and least risky?

5. Using CAPM, calculate the required return on each of these asset classes.

6. Draw the security market line (SML), based on answers from no. 5.

You are given a number of portfolios with their returns and risk (for Questions 7 to 8):

<table>
<thead>
<tr>
<th>Portfolio</th>
<th>Return(%)</th>
<th>Risk(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>B</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>C</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>D</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>E</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>F</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>G</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>H</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>I</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>J</td>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>
7.  
(a) Plot the feasible or attainable set represented by these data on a set of portfolio risk on x-axis and portfolio return on y-axis.

(b) Draw the efficient frontier on the graph in 7(a).

8.  
(a) Which portfolio lies on the efficient frontier and explain the reason why is these portfolios dominate the others in the feasible or attainable set?

(b) How would an investor’s utility function or risk-indifference curves be used together with the efficient frontier in finding the optimal portfolios?