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ASSET PRICING MODELS: CAPM AND APT

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INTRODUCTION

Capital Asset Pricing Model (CAPM) is an equilibrium model that underlies all modern financial theories and explains why different assets have different expected returns. In particular, this asset pricing model strongly asserts that assets have different expected returns because they have different betas. On the other hand, there is another asset pricing model which known as Arbitrage Pricing Theory (APT) which states the returns on any asset must be linearly related to a set of factors and returns are related to factors other than just beta β. In some manners, APT is being considered less complicated than CAPM with fewer assumptions and less restrictive. These two influential asset pricing theories, CAPM and APT, will be examined in greater details in this report.

CAPITAL ASSET PRICING MODEL: MECHANICS AND FACTOR

CAPM was developed by William Sharpe in 1964 and his parallel work was performed further by Jack Treynor, Jan Mossin and John Lintner independently. CAPM extended Harry Markowitz's portfolio theory by introducing the concept of systematic and specific risks. It is based on the idea that investment should always include and take in both systematic and unsystematic risks. From there, CAPM then has evolved as an approach to measure systematic risk.

The basic idea behind CAPM is that when investors make their investment choices, assets will be priced in the market place with respect to their risks. In return, investors will be compensated in 3 ways for taking the risks:

1. The time value of money given by the risk free rate of interest.
2. Compensation for taking additional undiversified risk - systematic risk.
3. Expected Inflation.

All investors require a risk premium as compensation for bearing the risk. As mentioned above, the only risk that investors are compensated is for bearing the risk that cannot be diversified away which is systematic risk. The way how the investors are being compensated and calculated is by taking a risk measurement which is beta β, and compares it with the return of the portfolio to the market over a certain period of time. Beta is the sensitivity of the portfolio's return to the market return. In greater perspective, the beta is equal to the covariance between the portfolio and market return divided by the variance of the market's returns. With that, in the midst of Sharpe's suggestion, beta stands for the systematic way of measuring risk in the context of CAPM.

CAPM is expressed in the following equation:

$$R_s = R_f + \beta\,(R_m - R_f)$$

where:

- R_s = *Required rate of return of the investment*
- R_f = *Return of the risk free investment*
- β = *Beta of the security - systematic risk*
- R_m= *Average return on all the securities*

From the equation above, it showed that CAPM is an equilibrium model that specifies the relationship between the risk and the required rate of return for assets that held in well-diversified portfolios. Sharpe argued that beta is the only determinant of return. The higher the risk or beta is, the higher is the required rate of return. In the point of fact, CAPM is actually reflects the mathematical relationship between the risk and return. The equation clearly indicated that CAPM is actually built on the simple premise that only one factor affects the return, which is beta.

Under the CAPM framework, the relationship between the expected return and beta can be expressed and graphed by using Securities Market Line (SML) in which all assets' returns must lay on the SML. The slope of the SML measures and quantifies the expected market risk premium while the intercept of the SML is the risk free rate. If all investors become more risk averse, the SML will have the same intercept with a steeper slope and the asset prices will fall.

CAPITAL ASSET PRICING MODEL: ASSUMPTIONS

CAPM requires a large number of assumptions. It is imperative to note that CAPM was developed with the following assumptions:

- All investors are risk adverse.
- All investors can borrow and lend unlimited at risk-free rate.
- All investors have homogeneous, identical and rational expectations.
- All investors analyze securities in the same way and share the same economic view of the world.
- All investors are rational mean-variance optimizers.
- All investors are in agreement to a single holding period for the investment time horizon and the distribution of the security returns.
- All investors are price takers under perfect capital market.
- Buying and selling activities of the investors won't influence the stock prices.
- There is no arbitrage opportunity.
- There is no inflation with any change in interest rate.
- There is no friction in the capital market.
- There is no tax.
- There is no transaction cost.
- There is no restriction on short-selling.
- All assets are perfectly and infinitely dividable.
- Quantities of all assets are given and fixed.
- Information is free, costless and available to all investors

CAPITAL ASSET PRICING MODEL: EFFICIENT FRONTIER

According to CAPM, under a simple and perfect world, all investors will choose to hold the portfolio that includes all risky assets, namely market portfolio. The proportion of each risky asset is made through its market value as a percentage of total market value for the market portfolio. Because the market portfolio contains all risky assets, the portfolio is considered as a completely well diversified portfolio and has a beta value of 1. The market portfolio should provide the highest reward-to-variability ratio as CAPM took as a fact that the market portfolio is the most efficient portfolio. CAPM

presupposed that kind of portfolio will be on the efficient frontier and it will be the most optimal risky portfolio for the investors to hold. Consequently, CAPM is evidently framed on the efficient frontier.

The key determinant of portfolio returns is the systematic risk of the portfolio. The construction of the investors' portfolio is fully depending on their risk aversion. Researches have revealed that regardless of what the current estimate of an asset's beta value is, the beta will eventually move closer to the value of 1 in the fullness of time. Accordingly, it also means the return per unit of the risk is identical for all individual assets, as all the risks that are unique to the individual assets have been fully diversified. As a result, all unsystematic risks have been fully eliminated and leaving systematic risks undiversified. For this reason, unsystematic risk is fully negligible under a well-diversified portfolio.

CAPITAL ASSET PRICING MODEL: CRITICS AND LIMITATIONS

CAPM is theoretically agreeable but it is not a perfect model. Since this theory of asset pricing is first published in the Journal of Finance, its validity has been questioned and criticized throughout the years. Many have argued that while the predictions of the CAPM are qualitatively supported, empirical tests do not support its quantitative predictions. Nevertheless, CAPM still provides a very good framework for thinking and thoughts on risk and return. Here are the critics and limitations of CAPM:

- Recent studies have questioned the validity of CAPM framework. Richard Roll questioned whether it is possible to test and corroborate the CAPM. In his famous critique of the CAPM, Roll argued that the CAPM is not testable because the true market portfolio can never be observed. In his studies, he showed that it is virtually impossible to prove that investors will behave in accordance with CAPM theory. Thus, it may be impossible to verify and validate CAPM theory.
- Fama and French claimed that book to market ratio and firm size both can do a better job in explaining and predicting future returns, rather than beta.
- CAPM does not appear sufficiently and adequately enough in explaining the variations in asset returns as many empirical studies shows that assets with low beta assets offer higher return than what is expected in the model.
- Jagannathan and Wang found that the performance of beta in explicating and explaining returns could be considerably enhanced by including human capital in the market portfolio and allowing beta to change over time.

- CAPM assumes that all investors agree about the risk and expected return of all assets. This homogeneous expectation assumption can not be holds true fully, and it is unrealistic in the real financial and capital world.
- CAPM assumes no taxes and transactions cost. This assumption is pretty much not viable and impracticable in the case of real business world.
- CAPM assumes all investors demand higher return in exchange of a higher risk. This may not hold true always and can not apply to all investors.
- CAPM and SML are derived from expectations while beta is predicted and calculated by using historical data. A company's historical data or price movement which had happen in the past may not fully reflect the investors' expectations and behaviors on future risks.

ARBITRAGE

Based on the Law of One Price, two items that are the same and identical cannot sell at different prices. In detailed perspective, assets with identical risks must have the same expected rate of return. The possibility of arbitrage arises when mis-pricing among assets creates opportunities for risk-free profits. With that, arbitrage is possible and can occur when an asset's price is not in equilibrium phase.

A widely applied investment stratagem, arbitrage allow investors to sell the assets with low return and go long on the other side using the proceeds of the sale of the first transaction, reaping theoretically infinite returns with no risk to the investors. An important remark here is the price differences between the assets will immediately disappear in an efficient market as arbitrage activities take place and equilibrium stage will be restored in a very short time manner.

ARBITRAGE PRICING THEORY: MECHANICS AND FACTORS

Steve Ross initiated and presented the APT in 1976 as an alternative to CAPM. In concise, APT holds that the expected return of an asset can be modeled as a linear function of various macro-economic factors or theoretical market indices, where sensitivity to changes in each factor is represented by a factor with specific beta coefficient.

The APT model can be expressed in the following equation:

$$R_{pt} = E(R_p) + \beta_{p1}I_{1t} + \beta_{p2}I_{2t} + \ldots + \beta_{pK}I_{Kt} + e_{pt}$$

where:

- I_t = *Value of the* i^{th} *factor*
- β_{pi} = *Sensitivity of the return to the* i^{th} *factor*
- K = *Number of factors*
- e_{pt}= *Eccentric variation in return*

Ross assumed that in an efficient market with equilibrium condition, $E(R_p)$ is common to all securities or assets and approximately equal to risk-free rate. Subsequently, the other terms of the equation will depend on several different systematic factors whether anticipated or unanticipated together with a whole set of β values, as opposed to the single market risk premium factor of the CAPM.

In dissimilarity to CAPM which insists that only beta is relevant, systematic factors that likely to affect the return of all assets and included in the APT equation can be multiple and these are including:

- Changes in Gross Domestic Product (GDP) and Gross National Product (GNP) growth
- Monthly industrial production
- Unexpected inflation
- Changes in the Treasury Bill's yield due to inflation
- Unexpected shifts in the term structure of interest rates
- Unexpected changes in the risk premium
- Changes in dividend yield
- Major political turmoil or upheaval event

It is crucial to comprehend that all factors mentioned above are not exclusive or inclusive for APT. The theory itself gives no direction or guidance on the choice of factors and does not provide information on the factors that determine risk premium. As a general rule of thumb, the APT factors must correlate with major sources of uncertainty. Sources of uncertainty are including those that are in concern to all investors and correlate with primary consumption and investment opportunities. In view of that, GDP, GNP, monetary policy, inflation rate, interest rate and economic condition are among those macro-economic factors that can be expected to affect and determine risk premium.

ARBITRAGE PRICING THEORY: ASSUMPTIONS

As indicated well in above paragraphs, APT is much disparity as oppose to CAPM in its assumptions and explanation of risk factors associated with the risk of an asset. As a matter of fact, APT has 6 major assumptions which very important to be on familiar terms with:

1. There is no arbitrage opportunity before hand. APT is derived by showing that, when the expected return of a well-diversified portfolio is not equal to the expected return forecasted by the portfolio's β, and then only there will be an arbitrage opportunity.
2. In an equilibrium market condition, the return of a zero-investment with zero-systematic risk portfolio is zero as the unique risks are diversified away.
3. Capital market is perfectly competitive with no restriction on short selling.
4. Investors always have a preference for more wealth to less wealth with certainty.
5. The relationship between asset returns and factors is linear.
6. Asset returns are influenced and generated by multiple factors. The stochastic process generating asset returns is expressed as a linear function of a set of *K* - multiple factors.

ARBITRAGE PRICING THEORY: STOCK SELECTION

With fewer assumptions in theory, APT has been arguably and considered more general than CAPM in the stock selection process. This observation can straight-forward understandable as APT itself has been structured in the way that more than 1 variable or multiple factors will be used in calculating and determining the asset's return, as oppose to CAPM which only rely on the beta. In other words, with the freedom to select factors without any restriction, APT allows the equilibrium return of an asset to be related and dependent on many factors, not just one. With that, APT allows multiple sources of risk, and without a doubt, these provide an explanation of what moves stock returns. What's more, APT can be applied to well-diversified portfolios and not necessarily to individual stocks. Under APT, it is probable for individual stocks to be miss-priced and not lie on the SML. Likewise, APT is more general than CAPM in the means that it gets to an expected return without the assumption of the

market portfolio. All these remarks have brought APT greater flexibility, higher suppleness, fewer restrictions, more realistic and greater accuracy in selecting a stock for an investment portfolio.

Additionally, in this concrete capital market, it is imperative to recognize that the performance of an asset could be linked and affected by the dividend yield and price-earnings ratio as well as the future profitability, not to mention the macro-environment factors such as interest rate, future economic conditions, market competitiveness, industry attractiveness and adverse movement in foreign exchange rates. Any change in interest rates will have an impact on the required rate of return which in turn inversely affects the value and the pricing of the asset. Interest rate will also have a significant influence on the stock market and its indices. The GDP of a nation will affect the earning power of a business organization and its expected future cash flows. The GDP will also determine whether a nation in which the asset is locating is currently in the period of economy booming or recession. Due to globalization, the performance of an asset is not only affected by domestic factors but in globally as well including change in international trade and global stock market performance. All these factors are decisive, crucial and affective in stock selection process and all should be priced in determining an asset's return, as be against to exclusively rely on beta which shown in CAPM framework.

ARBITRAGE PRICING THEORY: CRITICS AND LIMITATIONS

Ross's APT gives a sensible description of return and risk, together with conceivable and reasonable factors. The model was arising out of limitations of CAPM and arguably empirically testable. Nonetheless, one of the main problems with APT is that the model fails to identify the key macro-economic factors in the risk-return relationship. Factors are depends upon the risk-aversion of investors and those multiple factors are expected to have an impact on all assets. Conversely, APT does not mention what is the right or correct factor to use. One has to figure out the factors and what the returns are for the exposure to each factor. In addition to that, factors can change and unpredictable over time although there is a greater flexibility with lesser restriction on investors' preference.

Although APT can be testable but the testing on APT may be still inadequate. Calculating and estimating multi factors model such as APT will always require large data sets. The extent of computing the beta is still a problem. What's more, the testability problem of APT may well be that the arbitrage process presumed in the model which is difficult and impossible to implement on a practical

basis. Building a zero-investment portfolio will always involve equal investments in a short and a long position. Consequently, risk-free arbitrage with risky assets is impossible and unfeasible. One will find that it is impossible to create risk-free portfolios which comprised exclusively of risky assets only.

CAPITAL ASSET PRICING MODEL vs. ARBITRAGE PRICING THEORY

CAPM and APT shared a number of common characteristics as well as distinctions. The primary differences between the CAPM and APT are typified as below:

CAPM	**APT**
§ CAPM is a single factor model.	§ APT can be extended to multifactor model.
§ CAPM assumes one factor explains security returns - only beta is relevant.	§ APT assumes that multiple factors explain and have impact on security returns.
§ CAPM is based on investors' portfolio demand and equilibrium contexts.	§ APT is based on the factor model of returns and arbitrage contexts.
§ CAPM requires the mean-variance efficient portfolio.	§ APT does not require the mean-variance efficient portfolio.
§ CAPM assumes that the probability distributions for portfolio returns are normally distributed.	§ APT makes no assumption about the probability distribution of asset or portfolio returns.
§ CAPM requires that the market portfolio be efficient.	§ There is no special role for the market portfolio in the APT.
§ CAPM lumps all systematic risks collectively into one expression as a single risk premium.	§ In APT, there are K types of systematic risk and K types of risk premiums, one for each type of systematic risk.
§ CAPM is less flexible and more restrictive.	§ APT is more general and robust.
§ CAPM has been criticized in large for not testable.	§ APT is arguably testable.

CONCLUSION

It is apparent and clears from the above writings of this report that both CAPM and APT models by and large addressed the two same fundamental issues:

- How to measure the risk of a risky asset?
- How to compute the required return?

Conceptually advanced and sophisticated, APT can be considered as an improved version of the CAPM. Nevertheless, in real practice of the financial and investment management field, APT may not work better than CAPM as APT does not mention how many and what are the factors one should use. This will and can lead to higher estimation mistake and greater calculation error. In actuality, APT is more difficult to understand and harder to use.

In point of fact, CAPM is a very fundamental economic argument. It is simpler to understand and easier to use. Despite its shortcomings, CAPM is an accepted model in the financial industry and has been widely employed by the financial professionals. Because of the difficulty of determining what the factors are, Ross's APT is most likely to remain contentious and divisive among the communities but it has highly useful relevancies in investment management field.

In wrapping up this article, everyone should thoroughly understand the strengths and weaknesses of CAPM and APT, so that the most suitable asset pricing model can be used and be relied on when making financial decision.

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