Capital Asset Pricing Model and Arbitrage Pricing Theory: A Comparative Analysis

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Abstract

The study compares Capital Asset Pricing Model (CAPM) with Arbitrage Pricing Model (APT) as effective decision models in asset pricing with a view to identify the more appropriate and efficient one. CAPM and APT have emerged as two famous models that have tried to scientifically measure the potential for assets to generate a positive or negative return. Both of them are based on the efficient market hypothesis, and are part of the modern portfolio theory. The methodology of the study is basically on theoretical review of extant literatures. Findings indicate that the major flaws of the CAPM are that it is based on several simplifying assumptions which appear to be unrealistic in real world. Moreover, CAPM is said to be incorrect in respect of its description of expected returns, and also that its' market proxies are not mean-variance efficient; therefore, a multi-factor model like APT offers a better explanation. APT provides a better warning of asset risk and estimates of required rate of return compared to CAPM which uses beta as the only market risk. APT remains the newest and most promising explanation of relative returns as it gives a more complete description of returns, hence, is said to naturally out-perform CAPM. The study recommends that investors rely more on the APT model because it is based on a simple and intuitive concept and has shown to be more efficient in asset pricing.

Keywords: Arbitrage Pricing Model, Capital Asset Pricing Model, Asset Pricing.
1. Introduction

Asset prices are universally believed to react sensitively to economic news. Every day experience seems to carry the view that individual asset prices are influenced by a broad variety of unpredictable events and that some events have a more pervasive outcome on asset prices than others (Chen et al, 1986). Thus, various asset pricing models can be used to determine equity returns.

The Capital Asset Pricing Model (CAPM) and the Arbitrage Pricing Theory (APT) have emerged as two models that have tried to scientifically measure the potential for assets to generate a return or a loss. Both of them are based on the efficient market hypothesis, and are part of the modern portfolio theory. CAPM by Sharpe (1964) and Lintner (1965) symbolises the birth of asset pricing theory. The CAPM is still widely used in applications such as estimating the cost of capital for firms and evaluating the performance of managed portfolios (Black, et al, 1972).

The CAPM model assumes investors are risk averse and, when choosing among portfolios, they care only about the mean and variances of their one-period investment return (Markowitz, 1959). As a result, investors choose “mean-variance-efficient” portfolios: firstly, to reduce the discrepancy of portfolio return, given expected return, and secondly, to maximise expected return, given the variance. Thus, the Markowitz approach is often called a “mean-variance model.”

APT is an asset pricing model which uses one or more common factors to price returns hence, a multifactor model with more factors (Devinaga and Peongkwee, 2011). Primarily, Ross (1976a, 1976b) developed the APT. It is a one-period model in which every investor believes that the stochastic properties of returns of capital assets are consistent with a factor structure. Ross (1976) argues that if equilibrium prices offer no arbitrage opportunities over static portfolios of the assets, then the expected returns on the assets are approximately linearly related to the factor loadings. The factor loadings or betas are proportional to the returns’ co-variance with the factors.

According to Azhar (2011), the equilibrium-pricing model using APT has developed into one of the modern financial theory. However, its use in determining the factors which influences expected returns is too general. APT is often viewed as a substitute to the CAPM. Market’s expected return is used in the CAPM formula, while APT uses risky asset’s expected return and the risk premium.
APT model are used by arbitrageurs to profit by taking benefit of mispriced securities (Azhar, 2011). A mispriced security will have a price which is different from the model predicted hypothetical price.

APT is seen as an alternative to CAPM as it has the potential to overcome CAPM’s weaknesses (Devinaga and Peongkwee, 2011). It requires less and more realistic assumptions to be generated by a simple arbitrage argument and its explanatory power is potentially better since it is a multifactor model. The APT relates the expected rate of return on a sequence of primitive securities to their factor sensitivities, suggesting that factor risk is of critical importance in asset pricing (Gilles and LeRoy, 1990). It tries to capture some of the non-market influences that cause securities to move together.

APT rests on the hypothesis that the equity price is influenced by limited and non-correlated common factors and by a specific factor totally independent from the other factors. The main empirical strength of APT is that it permits the researcher to select whatever factors and provide the best explanation for the particular sample at hand (Groenewold and Fraser, 1997).

Objectives and Research Question of the Study

In view of the limitations of CAPM, the study examines APT and compares both models with a view to identify which is more appropriate as a decision model in asset pricing.

The basic question in this study is: is APT an improvement on; and therefore, more effective than CAPM as a decision model in asset pricing?

The study theoretically reviews both models with a view to identify their strength and weakness as decision models in asset pricing. The rest of the paper is organised as follows. Section two reviews the existing literature on both models while section three compares CAPM with APT and section four concludes the paper.

2. Literature Review

APT and CAPM are two influential theories on asset pricing. APT differs from the CAPM in that it is less restrictive in its assumptions. It allows for an explanatory (as opposed to statistical) model
of asset returns and assumes that each investor will hold a unique portfolio with its own particular array of betas, as opposed to the identical market portfolio, suggested by CAPM.

APT has the potential to overcome CAPM weaknesses: it requires less and more realistic assumptions to be generated by a simple arbitrage argument and its explanatory power is potentially better since it is a multifactor model. However, the power and the generality of APT are its main strength and weakness. APT permits the researcher to choose whatever factors and provide the best explanation for the data but it cannot explain variation in asset return in terms of a limited number of easily identifiable factors. In contrast, CAPM theory is intuitive and easy to apply (Devinaga and Peongkwee, 2011).

2.1 Conceptual Framework

2.1.1 Measuring Risks and Returns with the CAPM

Measuring risk is not an easy task, partly because of the many factors to be considered. The mathematics of risk includes knowledge of probability theory and understanding of how portfolio risks and returns are brought together into a meaningful model. Attempts have been made to simplify the measurement of risk, and one of the more successful efforts has been the development of the CAPM. This is a model that relates predicted undiversifiable risks to the expected returns of a project. Although, CAPM is more readily applicable to security analysis, it can be employed to evaluate the risk/return merits of investments and assets at the corporate level (Richard and Ronald, 2011).

CAPM start by dividing risk into two major components: diversifiable risk and non-diversifiable risk. The premise is that there is a close relationship between the returns of individual securities and capital gain plus dividend yields. It has been established by academicians that the stock market is a highly efficient vehicle because it quickly incorporates all available information. Therefore, the volatility of the market provides a common denominator for evaluating the degrees of risk of individual assets and securities. This degree of risk is determined by finding out how sensitive the returns of a stock are to the returns of the market (Alike and Sun, 2011).
Against this background, investors employ a common index that measures the sensitivity of the individual stock against a common index namely the market. If a stock return move up and down more than the market returns, the stock is said to be more risky than the market but when a stock’s returns move up and down less than market returns, the stock is said to be less risky than the market. It is possible, therefore, to classify the risks of different securities simply by relating them to the common market index (Alike and Sun, 2011). It is evident therefore, that the CAMP provides an easy way to compare the various risk levels of individual stocks. CAPM furnishes an alternative measure of risk in contrast to standard deviation. The model is a highly useful tool for evaluating securities because it supplies a required rate of return (discount rate) that can be employed to determine the value of securities. The rate of return supplied by the model serves as the discount rate to adjust future returns for risk (Richard and Ronald, 2011).

2.1.1.1 Assumptions and Criticism of CAPM

CAPM is based on several simplifying assumptions and because most of these assumptions appear to be unrealistic in the real world, it has been argued that they are the cause of its flaws (Watson and Head 1998; Harrington 1987). Several of the CAPM assumptions have been criticised. For instance, the assumptions that there are no taxes and no transaction costs do not conform to reality. In addition, the assumption of homogeneous expectations is also open to doubt, because investors usually have divergent expectations, apply various investment holding periods and differ in respect of their decision-making processes (Levy and Solomon, 2000).

Furthermore, CAPM assumes that the systematic or market risk of any security is captured by only one risk factor; it’s Beta. It also assumes that asset returns are multivariately normally distributed and that firm specific or diversifiable risk is not relevant, since it is easily eliminated. Some researchers suggest that CAPM is incorrect in respect of its description of expected returns and that a multi-factor model offers a better explanation. CAPM has run into several roadblocks such as Roll’s (1977) suggestion that it is not a testable scientific theory but a plethora of empirical anomalies which provide empirical evidence that the usual market proxies are not mean-variance efficient.
2.1.2 Arbitrage Pricing Model

APT is a general theory of asset pricing that holds that the expected return of a financial 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-specific beta coefficient. The model-derived rate of return will then be used to price the asset correctly - the asset price should equal the expected end of period price discounted at the rate implied by the model. If the price diverges, arbitrage should bring it back into line (Devinaga and Peongkwee, 2011).

2.1.2.1 Assumptions of the APT

APT has two assumptions (Devinaga and Peongkwee, 2011). Firstly, only the systematic risk is relevant in determining expected returns which is similar to CAPM. However, there may be several non-diversifiable risk factors different from CAPM, (since CAPM assumes only one risk factor) that are systematic or macroeconomic in nature and thus affect the returns of all stocks to some degree. Secondly, in relation to firm specific risk, since it is easily diversified out of any well-diversified portfolio, it becomes irrelevant in determining the expected returns of securities (similar to CAPM).

2.1.2.2 Criticisms Against APT Model

Morel (2001) observes that the most disappointing feature of APT is that it does not identify the common factors (or even their number). It is not also supported by the theoretical foundations of the CAPM that describes the investors' behaviour. Moreover, Gilles and LeRoy (1990) states that APT contains no useful information about prices, because they think that APT does not include any clear restrictions and it can be thought as a too general asset pricing model.

Gilles and LeRoy (1990) further argues that many economists have all along been skeptical about the content of APT, because they believe that APT should depend on the validity of assumed restrictions on preferences and technology. Furthermore, the tendency of factors to increase cannot be explained by “priced” and “non-priced” risk factors. This problem arises because the theory in itself does not identify relevant factors (Dhrymes, et al, 1984).
The major assumption of APT model is that asset returns are linearly related to a set of unspecified common factors and that there are no arbitrage opportunities. This generality of the theoretical APT has turned out to be a major weakness for the empirical APT (Koutmos, et al. 1993). There is also a great deal of skepticism about the test methods of the APT. Cheng (1996) states that the method of Chen, et al. (1986) is very sensitive to the number of independent variables included in the regression. Cheng (1996) also note that when a researcher is testing the APT, a factor may be significant in one multivariate analysis and then will not be significant when testing in a univariate model. The multi-collinearity among economic variables presents another drawback of this approach (Paavola, 2006).

2.2 Empirical Review

CAPM has been tested extensively, for over three decades, in various forms primarily in developed capital markets and to some extent in developing markets. Early work in this area including Black, Jensen and Scholes (1972), Fama and MacBeth (1973) and Blume & Friend (1973) supports the standard and zero beta model of CAPM. However Banz (1981), Reinganum (1981), Gibbons (1982), Shanken (1985a) and Fama & French (1992), highlights the danger of focusing exclusively on mean-beta space. These studies found that the return generation process also depends on other variables like size, book to market ratio and earnings price ratio.

Others, such as Maheshwari and Vanjara (1989), Madhusoodanan (1997), Sehgal (1997), Vipul (1998) and Dhankar and Singh (2005b) all sighted in Devinaga and Peongkwee, (2011) found that CAPM was not suitable for describing the Indian market. A great deal of research work on APT has been undertaken in developed markets, particularly in the U.S. market using two approaches. Roll and Ross (1980), Chen (1983) and Dhrymes, et al. (1984) used the first approach, namely factor analysis. The drawback of this approach is that it is difficult to interpret the statistically derived factors in economic terms.

Chen, Roll and Ross (1986) found that four macroeconomic factors have a significant explanatory influence on returns. Yield differential between long and short term treasury bonds, inflation rate, yield differential between bb rated corporate and treasury bonds, and growth rate in industrial production. In another study of CAPM vs. APT using principal component analysis, Dhankar and Singh (2005a) sighted in Devinaga and Peongkwee (2011) found that monthly and weekly returns gave
almost similar results, but weekly results showed APT in a more favorable light than monthly results. A study by Singh (2008b) as sighted in Devinaga and Peongkwee (2011) shows that beta varies considerably from year to year and also varies with the interval between data points (daily, weekly, monthly). Similarly, Singh (2008a) also found some evidence of non-stationarity of beta between bull and bear periods and stationarity between bull periods.

3. Comparing APT with CAPM

APT and CAPM are two influential theories on asset pricing. APT differs from CAPM in that it is less restrictive in its assumptions and allows for an explanatory (as opposed to statistical) model of asset returns. It assumes that each investor will hold a unique portfolio with its own particular array of betas, as opposed to the identical “market portfolio”. In some ways, the CAPM can be considered a “special case” of the APT in that the securities market line represents a single-factor model of the asset price, where beta is exposed to changes in value of the market (Gur and Zhenyu, 2005).

In addition, APT can be seen as a “supply-side” model, since its beta coefficients reflect the sensitivity of the underlying asset to economic factors. Thus, factor shocks would cause structural changes in assets’ expected returns, or in the case of stocks, in firms’ profitabilities. On the other side, CAPM is considered a “demand side” model. Its results, although similar to those of the APT, arise from a maximization problem of each investor’s utility function and from the resulting market equilibrium - investors are considered to be the “consumers” of the assets (Burmiester and McElroy, 1988).

3.1 Arguments in Favour of APT’s Superiority

Over CAPM

Paavola (2006) argues that APT naturally out-performs CAPM in a statistical sense for two reasons: APT permits more than a single factor and constructs the factors to best fit data whereas CAPM uses a single factor clearly defined by the theory. If a researcher includes another variable to explain returns, $R^2$ can never be smaller with the added variable (Groenewold and Fraser, 1997).
Burmiester and McElroy (1988) concluded that CAPM can be rejected in favour of their APT model which included factors like default premium and time premium.

Some common limitations about the CAPM are seen in the evidence, that it takes more than one factor to explain the shared, or systematic risk in securities, discredits the CAPM (Paavola, 2006) and in demonstrating that the risk premium on an asset depends only on its systematic factor loadings. The APT provides investors with a result of great practical value that the CAPM does not provide (Treynor, 1993).

According to Gur and Zhenyu (2005), APT is commonly put forward as a superior alternative to the criticised but widely used CAPM. The alleged weakness of CAPM, its baggage of “unrealistic assumptions” and its empirical shortcoming, are well known. Test of the CAPM typically display poor explanatory power as well as overestimating the risk-free rate and underestimating the market risk premium. The main criticism is particularly the use of betas to predict an asset’s return – returns on high-beta stocks will tend to be overestimated and vice versa for low-beta stocks (Groenewold and Fraser, 1997).

The advances of APT over CAPM according to Elton, et al (2003) are that the APT makes no assumptions about the empirical distribution of asset returns. Secondly, the strong assumptions made about utility theory in deriving CAPM are not necessary. APT also admits several risk sources and therefore, can be more operational and has a better forecasting ability than the CAPM. There is no special role for the market portfolio in APT, whereas CAPM requires that the market portfolio is efficient. APT is also easily extended to a multi-period framework (Morel, 2001).

Several rigorous assumptions have to be made when deriving CAPM such as there are no market frictions, e.g., short selling is unrestricted, investors can borrow and lend at risk-free rate and there are no taxes. There are numerous securities so that idiosyncratic risk can be diversified away and Investors are risk-averse and seek to maximise their wealth (Devinaga and Peongkwee, 2011).

Chen et al (1986) concludes that APT model is better explaining equities returns than CAPM and that at one percent significance level, CAPM model can be rejected in favour of APT model. Dhankar and Esq (2005:12) sighted in Devinaga and Peongkwee (2011) concludes that “APT provides a better warning of asset risk and estimates of required rate of return compared to CAPM which uses beta
as the only market of risk.” Elton, et al (2003) states that APT remains the newest and most promising explanation of relative returns as it gives a more complete description of returns than CAPM model. Both models assert that every asset must be compensated only according to its systematic risk. In CAPM, the systematic risk is the co-variation of the asset with the market portfolio and in APT; it is the co-variation with a number of factors.

3.2 Testability of APT Model

There had been a lot of tests of the APT (Chen et al, 1986; Burmeister and McElroy, 1988) for the United States, (Beenstockand and Chan, 1988; and Clare and Thomas, 1994) for the United Kingdom. It is well known that the macroeconomic variables chosen by Chen, et al (1986) has been the foundation of APT. According to Paavola (2006), it is worth pointing out, why these variables could affect equities' returns. First, Inflation: Inflation impacts both the level of the discount rate and the size of the future cash flows. Secondly, Term structure of interest rates: Differences between the rate on bonds with a long maturity and a short maturity affect the value of payments far in the future relative to near-term payments. Thirdly, Risk premium: Differences between the return on safe bonds (AAA) and more risky bonds (BAA) are used to measure the market's reaction to risk. And fourthly, Industrial production: Changes in industrial production affect the opportunities facing investors and the real values of cash flows.

4. Conclusion

CAPM and APT have emerged as two famous models that have tried to scientifically measure the potential for assets to generate a return or a loss. Both of them are based on the efficient market hypothesis, and are part of the modern portfolio theory. In an economy with a large number of available assets, a linear factor model of asset returns implies that particular risk is diversifiable and that the equilibrium prices of securities will be more or less linear in their factor exposures.

This idea has spawned a literature which has pushed the scientific frontiers in several directions and led to econometric insights about what constitutes a factor model, and how to efficiently estimate factor models with large cross-sectional data sets. One of the more successful efforts at simplifying the measurement of risk has been the development of the CAPM. The model relates predicted undiversifiable risks to the expected returns of a project. Although, CAPM is more
readily applicable to security analysis, it can be employed to evaluate the risk/return merits of investments and assets at the corporate level.

The APT which is based on a simple and intuitive concept has shown to be more efficient in asset pricing. When comparisons across models are made, the APT has tended to do well against the competing models. APT is commonly put forward as a superior alternative to the criticised but widely used CAPM. The alleged weakness of CAPM, is its baggage of "unrealistic assumptions" and its empirical shortcoming. Test of the CAPM typically display poor explanatory power as well as overestimating the risk-free rate and underestimating the market risk premium.

The main criticism is particularly the use of betas to predict an asset's return - returns on high-beta stocks will tend to be overestimated and vice versa for low-beta stocks. The advances of APT over CAPM are that the APT makes no assumptions about the empirical distribution of asset returns. It also admits several risk sources and therefore, can be more operational and has a better forecasting ability than the CAPM. APT provides a better warning of asset risk and estimates of required rate of return compared to CAPM which uses beta as the only market of risk. APT remains the newest and most promising explanation of relative returns as it gives a more complete description of returns than CAPM model.
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