An Empirical and Theoretical Analysis of Capital Asset Pricing Model

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ABSTRACT

The problem addressed in this dissertation research was the inability of the single-factor capital asset pricing model (CAPM) to identify relevant risk factors that investors consider in forming their return expectations for investing in individual stocks. Identifying the appropriate risk factors is important for investment decision making and is pertinent to the formation of stocks' prices in the stock market. Therefore, the purpose of this study was to examine theoretical and empirical validity of the CAPM and to develop and test a multifactor model to address and resolve the empirical shortcomings of the single-factor CAPM. To verify the empirical validity of the standard CAPM and of the multifactor model five hypotheses were developed and tested against historical monthly data for U.S. public companies. Testing the CAPM hypothesis revealed that the explanatory power of the overall stock market rate of return in explaining individual stock's expected rates of return is very weak, suggesting the existence of other risk factors. Testing of the other hypotheses verified that the implied volatility of the overall market as a systematic risk factor and the companies' size and financial leverage as nonsystematic risk factors are important in determining stock's expected returns and investors should consider these factors in their investment decisions. The findings of this research have important implications for social change. The outcome of this study can change the way individual and institutional investors as well as corporations make investment decisions and thus change the equilibrium prices in the stock market. These changes in turn could lead to significant changes in the resource allocation in the economy, in the economy's production capacity and production composition, and in the employment structure of the society.

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CHAPTER 1:

INTRODUCTION TO THE STUDY

Introduction

The pricing of assets like stocks and bonds that trade in the capital market is one of the most important areas of finance and investment and affects the economic life of both individuals and organizations. According to economic theory the value of any asset, including the value of assets trading in the capital market, depends on three components (a) the expected or future cash flows from the asset, (b) the timing of those expected cash flows, and (c) an expected or required rate of return that is used to discount all the expected future cash flows, the sum of which will be the basis of the asset's value (Cochrane, 2001, pp. 5-28). As future cash flows from assets are uncertain, and the extent of uncertainty of cash flows differs from asset to asset, investors' expected or required rates of return from assets differ across different assets or different asset classes. And this difference between required rates of return on different assets reflects varying degrees of risks that investors have to take when investing in different assets. Therefore, two assets that are similar in all aspects and the same pattern of cashflows are expected from them will trade at different prices in the market if investors assign different degrees of risk, or uncertainty of future cash flows, to them. This dependence of the expected rate of return of an asset on the risk embodied in the asset makes the expected rate of return concept and its relationship with some measures of risk the most fundamental issue, both theoretically and practically, for asset valuation. The capital asset pricing model (CAPM),

which is the subject matter of this dissertation, is the most referenced theory that tries to explain the relationship between risk and expected rate of return and thus provide a conceptual method to determine the most important component of the asset valuation problem.

The CAPM, which was independently developed by Sharpe (1964), Linter (1965), and Mossin (1966), makes certain assumptions about the behaviors of the investors and about the working of the capital market and on the basis of those assumptions derives a specific linear relationship between expected rate of return and risk; a relationship that according to CAPM should hold for every individual asset or any combination of individual assets in order for the capital market to be in equilibrium. The analytical findings of CAPM as wells as major empirical tests conducted for its validity will be discussed at length in the literature review section of this dissertation. As for this introduction it is pertinent to point out that the main finding of CAPM, which is the subject of most controversies and this author intends to make his contribution on the issue, is related to the concept of rate of return versus risk in the capital market.

Early empirical tests of the CAPM such as those by Linter (1965); Black, Jenson, and Scholes (1972); and Fama and MacBeth (1973) concentrated on the linearity of the relationship between rates of return and beta for cross section of securities. Later empirical tests of the model initiated by Fama and French (1992) focused on the anomalies in the CAPM framework. These tests tried to investigate whether other variables like size and book-to-market value ratio, besides the beta, could explain the variation of average rates of return for cross-section of securities. However, although at this point in the literature these new tests have provided overwhelming evidence that

more than one risk factor is at work explaining stock returns but most of the tests fail to justify that the variables they add to the model are really additional risk factors that investors want to be compensated for and, therefore, do not back their findings by a theoretical model. It is the contention of this author that the main reason for such shortcomings is that in the field of investment theory the concept of risk factor is treated in isolation from the perception of risk factor in the field of corporate finance theory.

Statement of the Problem

The question of what determines the equilibrium prices in the stock market, or what is the right price for an investor to buy or sell a stock in the stock market, leads to the question of what risk factors investors consider, or should consider, in determining their expected rates of return from the stocks. This highlights the need to have a suitable model that can identify such risk factors and explain how investors' expected rates of return are determined. The overextended stock prices in the second half of the 1990s which led to the stock market collapse of the year 2000 casts doubts on the ability of the single-factor CAPM to explain how investors' return expectations are formed and thus its inability to explain and predict stock prices. Therefore, the problem to be addressed in this study is the inability of the single-factor CAPM to identify relevant risk factors that investors consider in forming their return expectations and the relationships between those relevant risk factors and return expectations. Thus, in this study a multifactor model containing five risk factors is suggested and tested against empirical data to provide a better explanation of the factors that determine the stocks rates of return than the single-factor CAPM does.

The knowledge of what factors determine investors' return expectations enables investors to evaluate if at any particular point of time the stock or portfolio of stocks they are considering to invest in or are holding is undervalued, overvalued, or properly valued by the market and thus make the right buy, sell, or hold decision. As was mentioned in the introduction section, theory of investment posits that investors value any investment, including investment in the stocks of companies, by discounting expected or predicted future cash flows from that investment at a discount rate commensurate with the inherent risk of the investment. In the investment and finance literature, this discount rate that investors use to value a stock or portfolio, is referred to as the *expected rate of return* of the stock or portfolio. The problem of stock or portfolio valuation, therefore, leads to the following questions: (a) *how do investors form their return expectations from an investment* (b) *what is the relationship between the expected rate of return and the risk of investing in a stock or portfolio, and (c) are there other possible variables besides the risk that affect the expected rate of return of the investment*?

Background of the Problem

In today's U.S. society many people are directly or indirectly involved in the capital market. People might invest their surplus income through the stock market by themselves into individual accounts or into retirement accounts, like 401K or self-directed IRA's. Or they might put their savings into managed accounts like mutual funds or investment trusts. Institutional investors, like mutual funds, insurance companies, foundations, and charities, deal with huge amounts of money that they invest on behalf of their investors through the stock market in pursuit of specific objectives. It is now even advocated to privatize part of the Social Security Fund and let it be invested in the stock

market. In all these cases people or institutions are faced with a set of issues; how much of their funds to invest through the stock market, how to allocate those funds between broad investment classes like stocks and bonds, what specific stocks or bonds to invest in, and more importantly what is the correct price for buying or selling any specific stock, bond, or a portfolio of stocks and bonds. Individual investors who entrust their savings with mutual funds and other institutional investors need to have some criteria to assess if their savings have been well invested. Institutional investors need to regularly evaluate the performances of their fund managers and revise their fund manager selections. On the other side of the spectrum, when corporations issue new securities, especially when issuing new equities to finance new investment projects, need to know at what price to offer the new securities to the capital market; and the price at which those securities can be absorbed in the capital market affects their decisions to continue or not with the new investment projects. In certain industries, specifically in the regulated utilities industry, the price to be charged to the consumer is related to the price of the company's stock or bond in the capital market, which in turn determines the cost of capital for the utility company.

All of these important issues have one common denominator, and that is the problem of how securities are or should be priced in the capital market. The CAPM developed by Sharpe (1964), Linter (1965), and Mossin (1966), which has been subject to various empirical tests since its inception, addresses this problem through relating the expected rate of return of a security to its systematic risk. This study will differ from the standard CAPM and the previous tests of the model in two aspects. First, although theoretically the standard CAPM should hold for every individual security as well as for

any combination of securities, most tests of the standard CAPM concentrate on portfolios rather than individual securities. If it is empirically shown that CAPM holds for portfolios then its usefulness would be only in the domain of portfolio management, whereas if an investment theory works for individual securities it can be useful not only for portfolio management but also for individual investments, the cost of capital problem, the capital budgeting and capital structure decisions of corporations, and for all the other problems mentioned in the beginning paragraph of this introduction. Therefore, the first intention in this study would be to test the standard single-factor CAPM for individual securities over the sample period. Second, as the author's pilot study suggests, and is expected so from the test of hypotheses on single-factor CAPM, the systematic risk (beta) by itself has a very weak explanatory power and therefore there must be some other risk factors accounting for differences in average rates of return across securities. In Chapter 3 of this dissertation some specific risk factors, backed by both corporate finance theory and investment theory, will be suggested as additional risk factors and a multifactor model will be proposed and tested against empirical data.

Nature of the Study

This study is quantitative, explanatory, and uses available data to investigate correlations and examine regressions amongst variables. Therefore, the research design in this study would be casual-comparative. The reason for employing the causal-comparative design is that the independent variables of the study can not be manipulated experimentally and thus it is not possible to investigate the relationship between the dependent variable and the independent variables through experimental designs.

Purpose of the Study

The reason why this study is proposed is that in the second half of the 1990s, which was labeled as the era of *the new economy* and information communication revolution, the US stock market faced an unprecedented rise in the stock prices which was followed by the stock market crash in April of 2000. And not many tests have been done for post-1995, and in particular there seems to be no empirical study on CAPM distinctly covering and both the second half of the 1990s and post-2000 where general economic situations were different form pre-1995. Thus, this study will investigate the validity of both the standard CAPM and the multifactor model developed by the author for the whole time span of the research, January 1995 to December 2004.

Theoretical Basis of the Study

Modern investment theory started with Markowitz portfolio investment theory. This theory was developed by Harry Markowitz in 1952 and earned him the Nobel Prize in economics. Markowitz (1952) postulated that the rates of return of individual assets covary with one another, and there is a rather stable covariance, or correlation coefficient, between the rates of return of every two assets. Thus, he stated that it is theoretically possible to construct a variance-covariance matrix of all risky assets. Knowing the variance-covariance of returns for all risky assets makes it possible to mathematically compute the risk, defined as the standard deviation of returns, of any portfolio consisting of specific weights of each asset. Through a sophisticated mathematical analysis Markowitz proved that to achieve a desired or expected rate of return on a combination of risky assets there is a specific mix of those assets, or optimal weights, that carry a minimum risk. Putting it in another way, Markowitz showed that for any level of risk that

an investor can tolerate there is an optimal weight of assets that yields a maximum rate of return on the portfolio. Portfolios built with optimal weights of their constituent assets were called *efficient* portfolios by Markowitz. He further showed that, if the rates of return on different efficient portfolios are plotted against their risks on a two dimensional graph, the result would be a smooth curve which he called it *the efficient frontier*. To complete his portfolio selection model, Markowitz made the assumption that all investors are *risk-averse*, meaning that for a specific level of return they prefer the portfolio with the least risk or what comes to the same thing, for a given level of risk tolerance investors choose the portfolio with the maximum rate of return. This implies that every risk-averse investor will choose a portfolio on the efficient frontier that suits his or her risk-returns profile. The efforts of all investors to build their desired efficient portfolios lead them to buy or sell some securities in the capital market and the outcome of all these decisions is establishment of the equilibrium asset prices in the capital market.

Markowitz model, although is still regarded as a sound theory of investment, but at the time of its inception it was practically difficult, if at all possible, to be tested empirically or to be implemented by investment professionals. The model requires calculating the variance-covariance matrix of all risky assets which means, for example, for the stocks in the S&P 500 Index, ½*(500) (501) or 125,250 variances and covariances need to be calculated, a task that was not worthwhile before fast computers. The Markowitz model inspired other researchers to incorporate Makowitz's risk-return ideas into less complicated models. And, these efforts led to the development of the CAPM.

Theoretical foundation of capital asset pricing model was originally developed by Sharpe in 1963 and subsequently elaborated into the equilibrium model of the capital

market prices by Sharpe (1964), Linter (1965), and Mossin (1966). In the 1970s after techniques for estimating the required inputs to the model were elaborated, it was packaged and marketed as computer software to the mutual funds and other institutional investors. From there, modern investment theory took off in terms of practical applications and up to the present time many institutional investors and investment professionals adhere to the predictions of CAPM in making investment decisions and managing investment portfolios. However, with present computational capacity of computers, the Markowitz model is now implemented to allocate investments between classes of securities, such as, between stocks and bonds, and the CAPM is used to allocate funds between different stocks within the equity part of the portfolio.

The basic tenet in the CAPM is that the reason why rates of return of individual stocks covary with one another is because the rate of return of every stock or any portfolio of stocks varies with a common factor, and that common factor is the rate of return of the overall stock market. The overall market is the portfolio of all risky assets, in which every asset is weighted by the dollar market value of that asset relative to total market values of all assets. For practical implementation of the CAPM findings and for test of hypotheses purposes a broad value weighted index, like the S&P 500 Stock Index, is usually taken as the proxy for the overall market. With this idea and by making several assumptions regarding investors' behaviors and the working mechanism of the stock market, the CAPM derives the followings conclusions regarding the asset pricing in the capital market:

1. The rate of return of every individual stock is a linear function of the rate of return of the overall stock market. The line representing this relationship is called the

characteristic line of the stock. The slope of this line represents the sensitivity of the rate of return of a stock to the rate of return of the overall market and is denoted by β (beta) in the literature.

2 The beta of a stock represents the systemic risk of a stock. More precisely, the systematic risk of a stock is the square of its beta times the variance of the overall market rate of return. Systematic risk is the only risk that matters to the investors. Any variation in the rate of return of a stock in excess of its systematic risk is specific to the stock and can be eliminated through diversification.

3. If the rates of return of individual stocks are plotted against their betas, the result would be an upward-sloping line, called *the security market line*. The slope of the security market line is the rate of return of the market portfolio over the risk-free rate in the economy; and is called stock market risk premium. As long as the security market line stays stable, its slope which is the market risk premium will also remain constant.

4. The equilibrium price of a stock would be such that given the beta of the stock its expected rate of return would fall on the security market line. Therefore, if a stock is priced such that given its beta its expected rate of return is below the security market line, it is overpriced and investors should sell it, and the reverse holds if a stock's risk-return profile falls above the security market line.

5. The market portfolio itself, which has a beta of one, is an efficient portfolio and falls on the security market line.

Markowitz model and CAPM, together with their assumptions and implications, will be described in details in the literature review chapter. As the empirical validity of the above findings of the CAPM is still controversial, in this study they will be viewed as

hypotheses to be tested against empirical data. In Chapter 3 of this dissertation a research design for testing the standard CAPM hypotheses against recent data will be suggested and a multifactor CAPM will be proposed to be tested.

Definitions of Terms

Major terms that are frequently used in this study and their operational definitions are specified below. More technical terms that are related to some specific parts of the study will be defined as they are referred to.

Investment cash flows: The cash equivalent of benefits from an investment, measured in dollar terms.

Expected rate of return: Benefits required, in excess of the initial investment, from an investment expressed as the percentage of the initial investment and for a specific holding period. As for the common stock of a corporation, the expected rate of return of common stock at time *t* is measured by forecasting the price of the stock at time (*t+1*) and the dividends to be received at time (*t+1*) from owning the stock and dividing the sum of these two forecasts less the stock price at time *t* by the price of the stock at time *t*. Symbolically, this is written as:

$E(R_t) = \frac{E(P_{t+1} + D_{t+1}) - P_t}{P_t}$, where *E* stands for expectation, *R* stand for rate of return, *P* stands for price, *D* stands for dividend, and *t* stands for time.

Realized rate of return: The rate of return actually achieved on an investment over a specific holding period. For common stocks, the realized rate of return at time *t* is measured by: $R_t = \frac{(P_t + D_t) - P_{t-1}}{P_{t-1}}$.

Beta (β): In a single factor model, this is the sensitivity of the rate of return of an asset to the rate of return of the whole universe of the risky assets. However, for practical purposes usually a broad index like S&P 500 Stock Index is used as the proxy for the universe of risky assets. In a multifactor model there will be more than one beta, each of which measures the sensitivity of the rate or return of an asset to changes in some specific risk factor. For common stocks, the betas are measured by estimating the regression coefficients for time-series data relating the rates of return on the common stock to the relevant risk factors.

Risk or volatility of returns: The degree of variability of the rates of return of an asset and is measured by standard deviation of the rates of return of the asset through some time periods. The expected risk or volatility of a stock is measured by forecasting the distribution of future cash flows from the stock, computing the distribution of expected rates of return of the stock, and calculating the standard deviation of those expected returns. The actual risk or volatility of a stock is measured by calculating the standard deviation of its holding period rates of return for some historical time periods.

Implied volatility: Ameasure of expected or future volatility of a security's or of the whole stock market's rate of return derived from the Black-Scholes Option Pricing Model. Inclusion of this factor into modeling stocks' rates of return is this author's intended contribution to CAPM. This notion of implied volatility will be explained in more details in Chapter 3.

Risk-free rate: The rate of return with zero volatility which is earned on the risk-free asset. The proxy for the risk-free asset is US Government Treasury-Bills. The maturity

chosen will depend on the holding period chosen in the study. Therefore, the measure of risk-free rate would be the rate of return on the relevant Treasury-Bill.

Risk premium: Risk premium of a stock, also called stock's excess return, is defined as the holding period rate of return of the stock less the risk –free rate of the same holding period.

Market risk premium: Also called market excess return, is the holding period rate of return on the overall stock market less the risk-free rate of the same holding period.

Financial leverage: A company's degree of indebtedness, measured by dividing total long-term debts (debts over one year maturity) of the company by its total assets.

Operating leverage: A company's level of fixed costs in relation to total costs of operation. As fixed costs are directly related to fixed assets, in this study the operating leverage is measured through dividing net fixed assets by total assets.

Capital market: The market in which corporate equity and long-term debt securities (those maturing in more than one year) are issued and traded.

Assumptions

As the primary purpose of this study is to test the CAPM hypotheses, initially the study will start with the same assumptions as those made by the CAPM. Because the rates of return and variation in the rates of return of the stocks are the result of investors' actions in the capital market, the assumptions of CAPM are stated in relation to (a) the investors' behavior and (b) the structure of the capital market. The assumptions of CAPM are:

1. Like the Markowitz model, CAPM assumes that only two characteristics of investment in securities are of relevance to investors; the expected rate of return and

the risk of securities. The expected rate of return is defined as the forecast of future pay-off from the investment in excess of initial investment divided by the initial dollar value of the investment and risk is defined as the probability of actual returns being different from expected return, measured by standard deviation of returns. The CAPM, as well as the Markowitz model, assume that investment risk is viewed with this perspective. In this sense investment decisions are made on the basis of only the first two moments of the probability distribution function of returns; the first moment, which is the expected or average rate of return, and the second moment, which is the variance of rate of return reflecting the amount of risk in the investment.

2 Investments are made by rational mean-variance portfolio optimizer investors who use the Markowitz model to select an efficient portfolio from the efficient frontier.

3. Investments in securities are made by investors who all have a similar economic view of the world and analyze securities in the same way. Therefore, estimates of probability distribution of securities' returns and of the expected rates of return, expected variance and covariance of returns, and expected future cash flows of all securities are identical for all investors. This assumption implies that all investors envision the same Markowitz efficient frontier portfolios and price securities according to the same method and on the basis of the same inputs. This assumption is usually referred to as *homogenous expectations* or beliefs assumption.

4. Like any other perfectly competitive market, the capital market consists of many buyers and sellers of securities, called the investors. The wealth of each individual investor is small as compared to the total wealth of all investors and therefore each