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PROBLEMS WITH TESTING THE CAPM IN THE PHILIPPINE SETTING

Rodolfo Q. Aquino*

The paper explores the problems associated with testing the Capital Asset Pricing Model (CAPM) particularly in the Philippine setting. CAPM tests have so far failed to provide convincing evidence of the validity of the model. This appears to be the main reason why the CAPM has not found wide usage in corporate financial practice, specifically in the estimation of the cost of equity capital for a company or a project. Using empirical data for 1996-2001, two major problems are identified. The first is that the usual market proxy used, which is the Philippine Stock Exchange Composite Index (Phisix), very likely is not representative of the true market portfolio. Given market imperfections, it could very well be that no portfolio with only positive holdings, as implied by the CAPM, can be mean-variance efficient. The second problem is that the assumption that a risk-free rate lending and borrowing rate exists, usually proxied by the interest rate on the 91-day treasury bill, is probably too restrictive for the Sharpe-Lintner-Mossin version of the CAPM to hold. While the Black version of the CAPM addresses this second problem, the empirical issue of the unobservable true market portfolio still has to be addressed.

I. INTRODUCTION

The capital asset pricing model, or CAPM, has many applications besides asset pricing. For example, it can be used in cost of capital estimation, portfolio benchmarking and event-study analysis. However, despite its simplicity, intuitive appeal and theoretical elegance, it has not found wide application in applied Philippine finance, particularly in estimating the cost of equity capital. Echanis and Kester (1997-98), in their survey of the use of quantitative techniques in the evaluation of capital expenditures by publicly listed firms, reported that about 73 percent or 30 firms of the 41 that responded indicated that they subjected all capital investment proposals to quantitative evaluation techniques. The techniques most commonly cited were the internal rate of return (IRR) and net present value (NPV) techniques. The hurdle rate used ranged from the cost of specific capital used for the project (29.3%), treasury bill rate plus a premium (24.4%), weighted cost of capital (12.2%), and multiple-risk adjusted (9.8%). The authors suggested that respondent firms that used risk adjusted discount rates were those that by nature of their businesses undertook heterogeneous investments that had different risk levels. Of these (total of 14 firms), only one responded to using the CAPM to determine project discount rates based on the estimated beta of each project. The authors suggested that "managers find the CAPM approach difficult to implement" and that "market imperfections makes CAPM infeasible." The first reason is a question of dissemination of theory into practice and the availability of benchmark data. The second reason can be due to the fact that the validity of the CAPM has not been demonstrated convincingly enough particularly for the Philippine situation.

Briefly, the aim of paper is to examine the mean-variance efficiency characteristics of Philippine stock returns using empirical data, and their implications on CAPM testing using

* *Professor of Accounting and Finance, College of Business Administration, University of the Philippines.*

Philippine data particularly in the context of Roll's (1977) celebrated critique of CAPM tests. Roll's point that the CAPM predictions represent a tautology as long as the market portfolio of all risky assets is mean-variance efficient means that the only testable proposition of the CAPM is that the unobserved market portfolio is indeed mean-variance efficient. Furthermore, according to Roll, traditional tests of the CAPM using imperfect proxies for the true market portfolio are flawed in the sense that they do not have sufficient power to reject the CAPM claims when they are in fact false (Type II error).

The remainder of this paper is organized as follows. Section 2 covers a brief review of CAPM theory and empirical testing. Section 3 looks heuristically at the empirical efficient frontier of Philippine stock returns based on 1996-2001 monthly returns. Section 4 looks at the implications of the characteristics of the *ex post* efficient frontier on CAPM testing. Section 5 concludes the paper.

II. BRIEF REVIEW OF CAPM THEORY AND TESTING

Modern portfolio theory started with the work of Markowitz (1952) that defined the so-called efficient frontier[1]. Let $\mathbf{R}$ be the N x 1 vector of expected returns on the N assets, $\mathbf{x}$ is the N x 1 vector of proportions of the total investible resources invested on the N assets, $\mathbf{i}$ is an N x 1 vector of ones, $\boldsymbol{\Sigma}$ is the N x N nonsingular covariance matrix of returns, R is the required expected return on the portfolio defined by $\mathbf{x}$, and σ^2 is the variance of the portfolio return. The efficient frontier can be obtained by solving the following optimization problem for various levels of R:

$$\text{(1)}\quad \begin{array}{ll} \text{Minimize} & \sigma^2 = \mathbf{x}^T \boldsymbol{\Sigma}\, \mathbf{x} \\ \text{Subject to:} & \mathbf{i}^T\mathbf{R} = R \\ & \mathbf{i}^T\mathbf{x} = 1. \end{array}$$

Given $\boldsymbol{\Sigma}$ nonsingular, the problem has closed-form solutions for various values of R yielding (R, σ) combinations tracing the efficient frontier. If short sales are not allowed, the vector $\mathbf{x}$ is restricted to be non-negative and the problem has to be solved using mathematical programming methods. Merton (1972) and Roll (1977) provide a rigorous comprehensive treatment of the mathematics of the efficient frontier which applies both in terms of *ex ante* and *ex post* returns and covariances. The succeeding discussion of efficient frontier mathematics follows that of Roll.

Defining the scalars $a = \mathbf{R}^T \boldsymbol{\Sigma}^{-1} \mathbf{R}$, $b = \mathbf{R}^T \boldsymbol{\Sigma}^{-1}\mathbf{i}$ and $c = \mathbf{i}^T \boldsymbol{\Sigma}^{-1}\mathbf{i}$, the global minimum variance can be shown as $\sigma_0^2 = 1/c$ with mean return $R_0 = b/c$ and investment proportions $\mathbf{x}_0 = \boldsymbol{\Sigma}^{-1}\mathbf{i}/c$.

Any efficient portfolio can be shown to be a linear combination of any two different efficient portfolios. Thus, the entire efficient frontier can be generated from these two efficient portfolios. One of these portfolios can be the global minimum variance portfolio whose mean, variance and investment proportion vector are easy to compute. Another is the one whose mean return is a/b and variance a/b^2. The investment proportions vector of this portfolio is $\boldsymbol{\Sigma}^{-1}\mathbf{R}/b$ which is also easy to compute. The portfolio orthogonal to this portfolio has a mean return of zero. As will be shown later, these properties were exploited by Jobson and Korkie (1980) to derive estimators for the efficient market portfolio.

The CAPM, jointly credited to Sharpe (1964), Lintner (1965) and Mossin (1966), introduces capital market equilibrium conditions into Markowitz' model. The assumptions underlying the CAPM are: (i) investors choose portfolios that maximize a derived utility function of the form $V(W, \sigma_W^2)$ where W and σ_W^2 are the mean and variance of end-of-period wealth and that the first derivatives $V_1 > 0$, $V_2 < 0$ and V concave, (ii) all investors have a common time horizon and homogeneous beliefs about returns and covariances of assets, (iii) each asset is infinitely divisible, and (iv) an investor may take a long or short position in unlimited amounts in any asset. In particular, any investor can borrow or lend any amount at the riskless rate of interest. Assumption (i) does not appear to be particularly restrictive if asset returns follow a normal distribution.[2] Lintner (1969) has also shown that assumption (ii) is not critical to the structure of the model. Furthermore, assumption (iii) applied to stocks seems innocuous. Thus, the most critical assumption is assumption (iv).

Define the Sharpe ratio for a portfolio *p* as:

$$(2)\quad \theta_P = \frac{E(R_P) - R_F}{\sigma_P^2}$$

where R_p is the portfolio return for the period and R_F is the return on the riskfree asset. The expected return-standard deviation locus of the portfolio that maximizes this ratio without violating the constraints in (1) is tangent to the efficient frontier. A line drawn from this tangency portfolio to the expected return axis crosses it at the riskfree rate. The CAPM states that under the assumptions just given this tangency portfolio is the market portfolio M and that the expected return on any financial asset for a single period can be expressed as:

$$(3)\quad E(R_i) - R_F = \beta_i[E(R_m) - R_F]$$

where R_i is the return on asset i for the period, R_m is the return on the market portfolio of all assets, and β_i the ith asset's sensitivity to the movements of returns on the market portfolio. β_i is the covariance of R_i with R_m normalized by dividing it by the variance of R_m. In the absence of a riskless asset, Black (1972) provided the following generalization now known as the Black CAPM or two-factor model:

$$(4)\quad E(R_i) - R_z = \beta_i[E(R_m) - R_z]$$

where R_z is the return on a portfolio whose return is uncorrelated with that of the market portfolio i.e., a zero-beta portfolio. If a riskless asset exists, then the Black model implies that $R_Z = R_F$.

If the Sharpe-Lintner-Mossin (SLM) CAPM is valid, relation (3) in real terms provides a simple but theoretically elegant way of estimating the expected return from any asset, particularly the cost of equity capital for a company or an investment project. The riskfree rate is usually assumed to be equal to the 91-day treasury bill rate after adjusting for inflation. The return on the market portfolio is also usually proxied by the return on the Philippine Stock Exchange composite index or Phisix unadjusted for dividend payments.

From equation (3), empirical tests of the SLM CAPM are usually based on the following hypotheses (Fama and MacBeth, 1973):

1. The relationship between the excess return on any asset and the return on the market portfolio is proportional;
2. The beta accounts for the entire cross-sectional variation of expected excess returns over the risk free rate; and
3. The market risk premium is positive (i.e., $[E(R_m) - R_F] > 0$).

Tests typically use either the cross-sectional or the time-series approach. Let R_P represent the return on the market proxy, **R** the N x 1 vector of returns on the N assets, and T the number of time series observations. Furthermore, let the excess returns on assets be defined as $R^e = R - R_F$ and $R_P^e = R_P - R_F$. Then, the parameters **a** and **B** and the residuals **ε** are estimated in the multivariate regression:

$$(5)\quad \mathbf{R}^e = \mathbf{a} + \mathbf{B} R_P^e \mathbf{i} + \boldsymbol{\varepsilon}.$$

Under the cross-sectional approach, a second regression is run with the mean return of individual assets as the dependent variable against the beta estimates. If condition (1) above is true, then the intercept in the cross-sectional regression should be zero. Although zero-intercepts already imply condition (2), factors other than beta (such as the standard deviation of the stock's own return) are sometimes added to the cross-sectional regression to verify whether they have additional explanatory power over returns. Finally, the slope coefficient in the cross-sectional regression should be positive if condition (3) is true. Under the time-series approach, the intercepts are tested whether they are uniformly zero. Assuming that the errors are normally distributed, the following test statistic is computed (also known as the GRS statistic, see Gibbons, Ross and Shanken, 1989):

$$(6)\quad F = \frac{T-N-1}{N}\frac{\hat{\mathbf{a}}^{T}\hat{\Sigma}_{\varepsilon}^{-1}\hat{\mathbf{a}}}{1+\hat{\theta}_{p}^{2}}$$

where θ_p is the Sharpe ratio for the market proxy as defined in (2) and $\hat{\Sigma}_{\varepsilon}$ is the covariance matrix of the residuals from regression (5). The "^" means that the sample estimate for the unknown parameter is used. If the p-value corresponding to this statistic is small enough, the hypothesis that the intercepts are uniformly zero is rejected. Then, the third condition is tested using estimated excess market return given by the sample mean of $R^{e}{}_{p}$.

In 1977, Roll published a paper casting doubt on the testability of the CAPM given available econometric techniques. Roll's point centers on the mathematical equivalence between mean-variance efficiency and beta/expected return linearity implied by equation (4). In essence, equation (4) holds for any efficient portfolio p, and its orthogonal portfolio z, even if p is not the market portfolio of all risky assets. Thus, the only hypothesis being tested by procedures along the framework just outlined above is whether the market portfolio is efficient or not.

Sensitivity analysis (see, for example, Miller and Scholes, 1972; and Stambaugh, 1982) suggests that inferences from traditional CAPM tests are not severely affected by errors in the choice of the market proxy if these are not too serious. Shanken (1987) estimated that if the correlation between the proxy and the true market portfolio is high (above 0.70), then the rejection of the CAPM using the proxy also implies rejection of the "true" CAPM. These results somewhat mitigate the problems raised by Roll provided that we are confident that the market proxy is sufficiently representative of the true market portfolio.

In the Philippines, there have been at least three comprehensive tests of the CAPM along this framework, that of Francisco (1983) and more recently, those of Yu (2002) and De Ocampo (2003). These studies give us deeper understanding of asset pricing relationships in the Philippine context although they do not provide convincing support for the CAPM. The tests of Yu and De Ocampo used the Phisix (to be described further below) to represent the market portfolio.[3] In both cases there was no examination of whether the market proxies used were representative of the unobserved market portfolio. Nevertheless, under the assumption that they were so, the negative test results cannot be interpreted in any way as rejecting the CAPM predictions. Such is the implication of Roll's critique.

III. HEURISTICS OF THE *EX POST* EFFICIENT FRONTIER

This section examines the *ex post* efficiency of the Phisix and alternative measures that can be used as market proxy. In essence, such an examination is only an indirect test of the CAPM since the CAPM as a theory is stated in *ex ante* terms.

The data used for the empirical investigation cover the simple monthly real returns of 131 stocks (except B shares) listed in the Philippine Stock Exchange with continuous trading from 1996-2001. Also used are the two aggregate indices commonly used to represent stock market conditions: the Phisix and the all shares index. The more popular Phisix is a market-value-weighted index of the A and B shares of 30 representative companies from different sectors of the local bourse. Each industry is represented by a company with the highest market capitalization within the industry. The remaining 15 of the 30 companies that compose the index were also chosen based on the market capitalization. The all shares index includes all shares traded in the PSE. However, this index only started to be reported in November 1996.

The *ex post* efficient frontier is generated using the procedures described in the previous section, both with and without short sales allowed.[4] Note that there are a total of T = 72 monthly returns for each stock. Since there are a total of 131 stocks, the covariance matrix of stock returns is singular (see Johnson and Wichern, 1992). Thus, some aggregation is unavoidable. The stocks are ranked according to the beta (i.e., slope coefficient of a simple regression) of their returns against the return on the portfolio represented by the Phisix. Then, except for individual stocks included in the Phisix, up to three stocks with the same beta (up to one decimal point) are grouped together in equally weighted portfolios. The number of stocks/portfolios is thereby reduced to N = 61. Figure 1 shows the efficient frontier lines with and without short sales allowed. The areas to the right of the lines are the opportunity sets under both conditions. It is seen that the opportunity set without short sales is well within that with short sales allowed and that the two efficient frontier lines do not touch.

The monthly mean return on the *ex post* minimum variance portfolio is 0.159 percent with standard deviation of 1.71 percent. (-0.128% and 4.62%, respectively with no short sales allowed). The mean of treasury bill 91-day rate in real terms is 0.359 percent on a monthly basis with standard deviation of 0.169 percent. If this is used as the riskfree rate, the result that it is higher than the return on the minimum variance portfolio can be interpreted as evidence against the Sharpe-Lintner-Mossin version of the CAPM since the minimum variance portfolio consists only of risky assets.

The mean monthly return on the Phisix portfolio over the 1996-2001 period is computed to be -2.38 percent with standard deviation of 9.85 percent. The return on the all shares index is -0.68 percent with standard deviation of 9.37 percent. The location of these two indices in the opportunity set can also be seen in Figure 1. Both are located near the negatively sloped portion of the no short sales allowed mean-variance frontier.[5] That the two are located near each other is explained by the fact that their returns are highly correlated with each other with an R^2 of 0.787 for 1997-2001. An additional proxy for the market portfolio is computed for this paper as the weighted average return with the weights as the relative share of the company's equity in total market capitalization for 1996-2001. The stocks included in this portfolio represent 70.9 percent of total market capitalization. The mean return is 1.44 percent and standard deviation of 12.2 percent. A regression of the average return on this market proxy with the return on the Phisix portfolio yields an R^2 of 0.710 and a slope coefficient of 1.046. Despite the high correlation, the mean return-standard deviation locus of this market proxy is quite far from that of the Phisix and deep inside the mean-variance opportunity set, as can be seen in Figure 1. These results, which can probably be explained by the extremely high volatility of the Philippine stock market, illustrate the difficulties of making statistical inference about stock returns.

To explore this point further, the tangency portfolio return can be estimated directly using the method developed by Jobson and Korkie (1980) and compared informally with those of the various market proxies. Using excess return over the riskfree rate R_F (proxied by the treasury bill 91-day rate) instead of gross return in optimization problem (1), the problem becomes one of finding the unknown investment proportions X_m and excess tangency portfolio return R_m that cuts through zero in the expected excess return axis in the excess return-standard deviation space. This portfolio is the one whose mean return is a/b, variance a/b^2 and investment proportions vector $\mathbf{\Sigma}^{-1}\mathbf{R}/b$. As mentioned in the previous section, the portfolio orthogonal to this portfolio has a mean return of zero. Thus, the beta-expected return relation (3) is met (if a riskfree rate does not exist, then R_z can be used instead). Then, in theory, this tangency portfolio and its parameters can be tested for equality with that of the market proxy. This test is equivalent to testing the validity of the CAPM. The parameters a and b can be estimated by its sample counterparts using the formulae in the previous section. Jobson and Korkie (1980) showed that the estimator $\hat{b} = \mathbf{R}^T \mathbf{\Sigma}^{-1}\, i$ is unbiased. However, in the case of a, the unbiased estimator is $\hat{a} = \mathbf{R}^T \mathbf{\Sigma}^{-1}\, \mathbf{R} - N/T$ where N is the number of assets and T is the number of time series observations. The estimated tangency portfolio excess return is then $\hat{a}/\hat{b}$ and variance $\hat{a}/\hat{b}^2$. The estimators resulted in unrealistic figures. With the correction for bias, the estimated efficient portfolio return is 57.7 percent per month with standard deviation of 36.0 percent. Although Jobson and Korkie (1980) themselves, using simulation results, stated that the estimators are very imprecise for T less than 300, this last result further highlights the difficulties involved in validating the CAPM using only market proxies.

Another approach in estimating the tangency portfolio from empirical data is to choose the portfolio that maximizes the Sharpe ratio as defined in (2) subject to the feasibility constraints in (1). Then, the resulting tangency portfolio results can be compared with those of the market proxies used for reasonableness. Unfortunately, the optimization procedure used failed to converge to a solution. The reason for this can be seen in Figure 2A. As Merton (1972) noted in his important paper cited above, when the riskfree rate is greater than the return on the global minimum-variance portfolio as has been noted previously for the 1996-2001 data, there is no tangency point on the positively sloped portion of the efficient frontier (although there is one on the negatively sloped portion). The intuitive reason for this is that, with the assumptions of a riskless asset and unlimited short selling, it is possible to lend unlimited amounts at the riskfree rate while shorting the risky assets. The unrealistic estimates for the parameters of the market portfolio using the estimators of Jobson and Korkie (1980) are consistent with this result.

IV. IMPLICATIONS FOR CAPM TESTS

Two observations stand out from the foregoing analysis. The first is that the riskfree rate surrogate is greater than the empirical global minimum-variance return. This indicates that either the surrogate chosen is wrong or the assumption of the existence of a riskless lending and borrowing rate is unrealistic. The second is that the assumption of unlimited shortselling is unrealizable. The fact that the empirical efficient frontier without short sales is well within that with short sales may indicate that no market proxy with positive holdings, like the Phisix or the all shares index, can be efficient. The implications of these two results for the testing of the CAPM are further explored. To do this, tangency portfolios under different assumptions are also derived. Figure 2B shows the results using the Black model (equation (3)) which relaxes the assumption of a riskless asset. The assumed market return here is 4.0 percent. Its orthogonal portfolio has a negative return of -2.56 percent and standard deviation of 2.24 percent. Figure 2C imposes the no short sales restrictions while maintaining the assumption that a riskfree asset (represented by the 91-day treasury bill) exists. The mean return on the derived market portfolio is 7.14 percent. The beta/return linearity implications of these two cases are shown in Figures 3A and B. As emphasized by Roll, exact linearity is implied by the Black model provided that a tangency portfolio (which need not be the market portfolio) is used. When the no short sales condition is imposed, close to perfect linearity is also achieved. However, the intercept is not even close to the riskfree rate as predicted by the SLM model. Figure 3C shows the results when the market proxy used is the Phisix. This result is typical of the usual CAPM tests using the cross-sectional approach. The slope is positive, indicating a positive market risk premium but the intercept is not even close to the riskfree rate. Furthermore, the significant but not quite so high R^2 indicates a good fit but also that other factors may also have significant effects on expected returns. In short, the data fall short of providing full support for the CAPM. Figure 3D shows the security market line when the alternative market proxy described previously is used. The results are similar to that in Figure 3C except that the fit is much better.[6] Relating these results with the opportunity sets depicted in Figures 1 and 2, it can be noted that the closer the market proxy is to the efficient frontier the better is the fit of the data to the security market lines.

Using the time-series approach, the GRS statistic in (6) applied to the 1996-2001 data with the Phisix as the market proxy has a p-value of 0.646. Thus, the null hypothesis that the intercepts are uniformly zero cannot be rejected. However, the sample mean excess return on the Phisix portfolio is negative, thus violating condition (3). Using the alternative market proxy, the p-value is 1.0.[7] The excess return on the market proxy is also positive. Thus, with the alternative market proxy, all the conditions necessary to support the CAPM are met. As in the cross-sectional test, support for the CAPM predictions improves as the market proxy is closer to the empirical efficient frontier. This indicates that tests of the CAPM are sensitive to the choice of the market proxy.

V. CONCLUDING REMARKS

The paper explores the problems associated with testing the CAPM, particularly in the Philippine setting. Thus far, CAPM tests in the Philippines have only shown that, at best, there is a direct relationship between expected return and risk. Other than that, the CAPM has not been able to offer a workable framework wherein the cost of equity capital for a company or a project can be worked out.[8] Using empirical data for 1996-2001, two major problems are identified. The first is that the usual market proxy used, which is the Phisix, very likely is not representative of the true market portfolio. Given market imperfections, it could very well be that no portfolio with only positive holdings, as implied by the CAPM, can be mean-variance efficient. The second problem is that the assumption of a riskfree rate lending and borrowing rate, usually proxied by the interest rate on the 91-day treasury bill, is probably too restrictive for the SLM version of the CAPM to hold. While the Black version of the CAPM addresses this second problem, the empirical issue of the unobservable true market portfolio still has to be addressed.

The failure of CAPM tests to support the model's validity can be due to two reasons. The first is that the model is wrong because of severe market imperfections. These imperfections could be due to asymmetry in information access, incomplete markets (as evidenced by the lack of a local options market or limitations on shortselling), limited institutional participation in the stock market, and constraints in the supply of traded shares to the public. These issues are discussed elsewhere (see for example, Saldaña, 2001) and are not the direct concern of this paper. The second is that the model is correct but that available econometric techniques are still not powerful enough to address the testing problems properly, particularly in the setting of a still-not fully developed asset market. It must also be noted that the tests considered here are tests of the unconditional version of the CAPM. More general forms of the model and their testing, such as those involving time-varying betas and conditional volatilities[9], are not considered, although the problems cited also apply equally in these cases. These are areas for further research.

NOTES

[1] In the sense that a portfolio is considered efficient if its expected return is the highest among those with the same or lower variance or the lowest variance among those with the same or higher expected return.

[2] For example, the Jarque-Bera test for normality on stock excess returns from a portfolio represented by the Phisix for 1996-2001 indicates that normality is attained rather quickly as returns are computed over a period of two months. The p-values are 0.0005 for monthly returns, 0.4158 for bimonthly returns and 0.8778 for quarterly returns.

[3] In the case of Francisco (1983), the Makati Stock Exchange composite index, which preceded the Phisix, was used.

[4] Using matrix algebra in the case with short sales and Microsoft Excel Solver in the case of no short sales allowed.

[5] Shanken's (1985) test for mean-variance efficiency of a particular market index implies that the index is located at least in the area above the line cutting through the minimum variance portfolio (Roll, 1985). Thus, both indices would implicitly fail Shanken's test.

[6] The intercepts in both cases are significantly different from zero and have negative signs. With the Phisix portfolio, $R^2 = 0.347$. The beta coefficient is highly significant with t-statistic of 5.650. Moreover, the intercept is also significant with t-statistic of -2.524 (p-value = 0.0136). Regression on the market proxy yields an $R^2 = 0.750$. The intercept is significant with a t-statistic of -2.608 (p-value = 0.0115).

[7] The intercepts for individual regressions are statistically different from zero for only four cases (at $\alpha = 0.05$). The beta coefficients are significant for all but 11 cases (of which one is significant at 0.10 and three at $\alpha = 0.05$).

[8] However, the CAPM, or more accurately, the single-index model (which does not assume market equilibrium conditions or require identification of the true market portfolio like the CAPM), can still be a useful tool for investment benchmarking and event studies.

[9] This was pointed out to the author by an unnamed reviewer of this paper.

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Figure 1: Efficient Frontiers: With and Without Short Sales

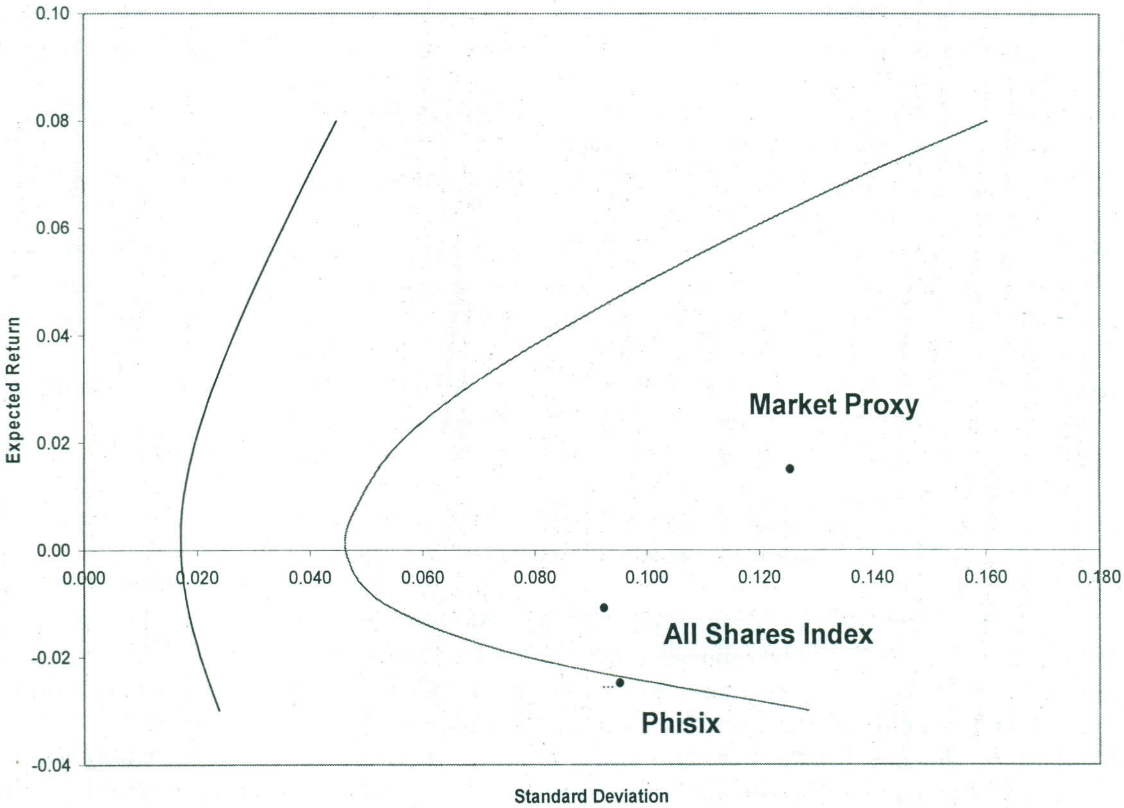
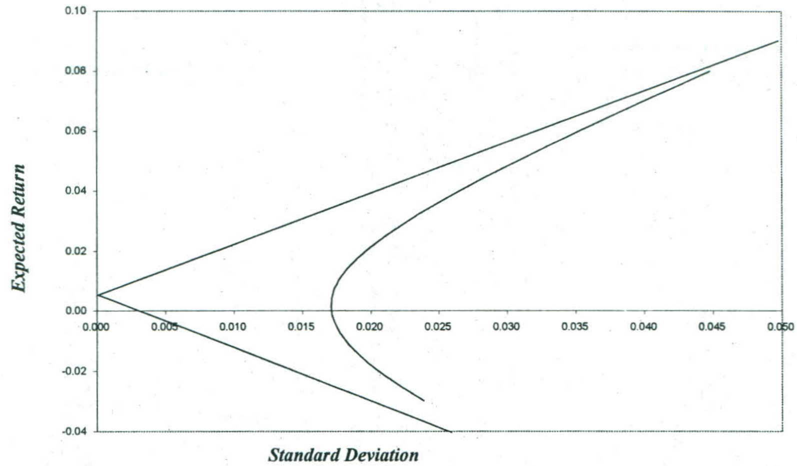
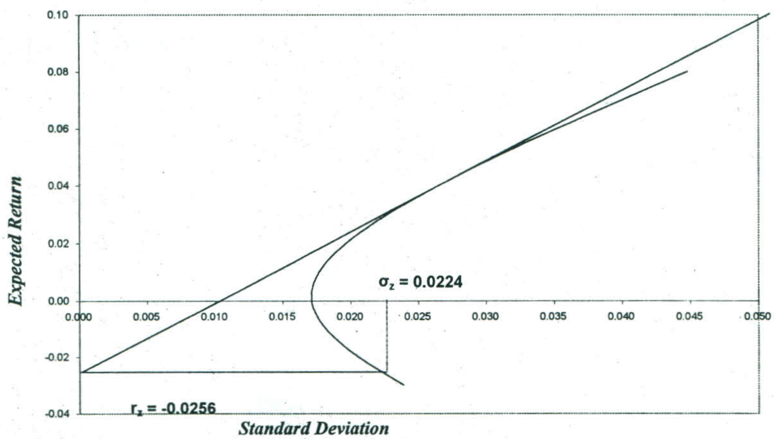


Figure 2: Tangency Portfolios

A: Efficient Frontier: Short Sales Allowed



B: Black CAPM
Short Sales Allowed with Market Return = 0.04



C: Sharpe-Lintner-Mossin CAPM
(No Short Sales Allowed)

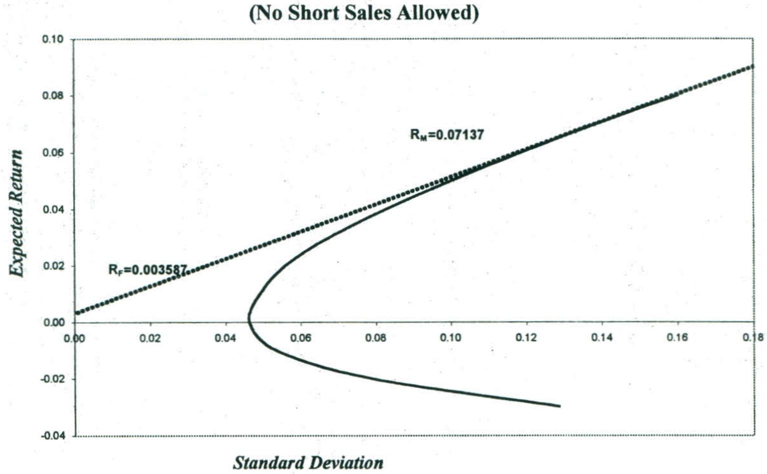
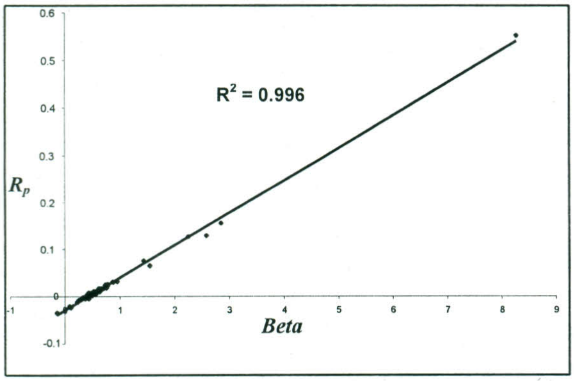
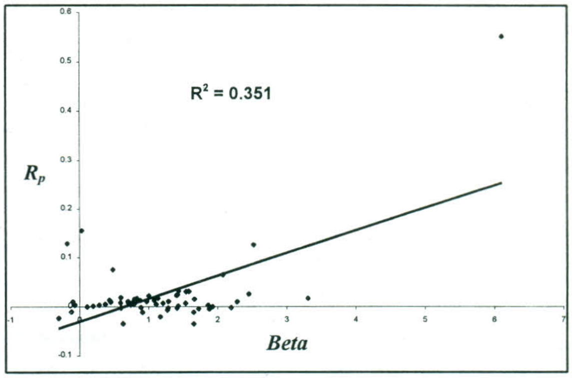


Figure 3: Security Market Lines

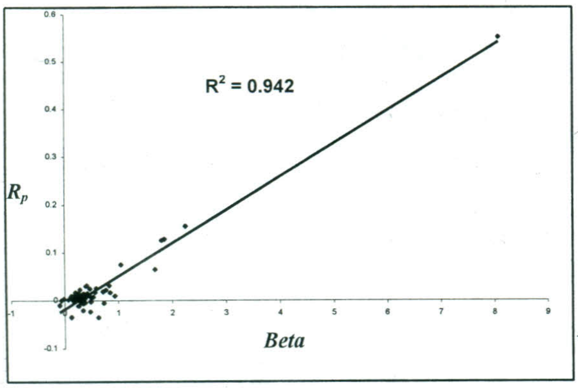
**A: Short Sales Allowed
(Assumed Portfolio Return at 4% per Month)**



C: Against Beta with Phisix Return



B: No Short Sales



D: Against Beta with Computed Market Portfolio