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A Test of Conditional CAPM

Preliminary Findings for the Thai Capital Market

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ABSTRACT

The study employs five Thai securities to test the conditional capital asset pricing model which allows expected returns to be time-varying but constrains market betas to be constant. It finds weak evidence against the proportionality restrictions implied by the model. But the zero-intercept conditions are strongly rejected.

Keywords : CAPM, Latent-Vatent-Variable Model, return predictability.

INTRODUCTION

Tests of the capital asset pricing model (CAPM) in both conditional and unconditional forms have been extensively performed. The results of the tests tend to suggest that the CAPM cannot provide a good description of the data. Nonetheless research in this area employing Thai data is minimal and limited to tests of the model in its unconditional form. For example, Sareewiwatthana and Maloné (1985) employ thirty most active stocks from December 1978 to November 1982 to test regularity conditions that the relationship between returns and market betas is linear and that the beta is the sole measure of risk. They reject both restrictions and argue the rejection may be due to the fact that Thai investors do not hold a diversified portfolio or that they take skewness into account when they make an investment decision. Recently, Priebjrivat (1991) uses monthly returns of sixty stocks from January 1985 to December 1989 to test the unconditional CAPM. Employing the classic two-pass procedure, she finds that the intercept and the slope coefficient of the second-pass regression are respectively much smaller than the average risk-free return and the average excess return on the market portfolio. She also rejects the linearity restriction between the returns and market betas. But she cannot reject the restriction in the subsample from January 1987 to December 1989. Priebjrivat argues that the rejection of the CAPM may be due to the structural change in the second period.

There is some evidence suggesting that expected returns of Thai stocks conditioned on available information are not constant. Sareewiwatthana (1986) finds that lagged returns can help to predict future returns. Khanthavit (1990) in addition, finds that lagged returns on the Thai and foreign market portfolios can improve predictability power. In this paper, we test the CAPM in its condi-

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tional form.[3] Expected returns conditioned on available information are allowed to be time-varying but market betas are constrained to be constant. The proportionality restrictions implied by the model are tested. Employing five stocks from December 1976 to October 1988, we find weak evidence against these restrictions. We also conduct the test of zero-intercept restrictions and find that they are strongly rejected. The CAPM tends to underprice the assets in the sample.

The organization of the paper is as follows ; Section I discusses the conditional CAPM and develops the statistical models for the tests. Section II briefly describes the data. Section III reports the results. Conclusions and discussions are in Section IV.

CAPM with Time-Varying Expected Returns

In this paper, we consider a conditional CAPM. The model states that the expected excess return on an asset i is linear in its market beta. That is,

$$E[R_{i,t} \mid \Omega_{t-1}] = \beta_{i,t} E[R_{m,t} \mid \Omega_{t-1}] \quad \ldots(1)$$

where

$E[\cdot \mid \cdot]$ = Conditional expectations operator

$R_{i,t}$ = Rate of return on asset i in excess of risk-free rate at time t

$R_{m,t}$ = Rate of return on the market portfolio in excess of risk-free rate at time t

Ω_{t-1} = Information set containing the information up to time t.

$\beta_{i,t}$ = Market beta of asset i at time t conditioned on Ω_{t-1}
$\equiv Cov[R_{i,t}, R_{m,t} \mid \Omega_{t-1}] / Var[R_{m,t} \mid \Omega_{t-1}]$.

$Cov[\Omega_{t-1}]$ and $Var[\cdot \mid \Omega_{t-1}]$ are respectively conditional covariance and variance operators conditioned on $\Omega_{t-1} \cdot \Omega_{t-1}$ is common to all investors. Since the model is ex ante and the expectations cannot be observed, we assume that the projections of expected excess returns onto information subset Z_{t-1} contained in Ω_{t-1} is linear[4], i.e.,

$$E[P_{k,t} \mid Z_{t-1}] = Z_{t-1}\gamma_k + V_{k,t} \quad \ldots(2)$$

Where Z_{t-1} is an $(1 \times M)$ instrument vector contained in Ω_{t-1} and γ_k is an $(M \times 1)$ projection vector. $v_{k,t}$ is the projection error. We further assume that the expectations are rational. That is,

$$R_{k,t} = E[R_{k,t} \mid Z_{t-1}] + e_{k,t}. \quad \ldots(3)$$

$e_{k,t}$ is orthogonal to Z_{t-1}. This assumption together with the linear projection in eq. (2) allows us to write the expected returns in terms of the observable as the following.

$$R_{k,t} = Z_{t-1}\gamma_k + \epsilon_{k,t} \quad \ldots(4)$$

where $\epsilon_{k,t} = v_{k,t} + e_{k,t}$ is orthogonal to Z_{t-1} (Cumby (1990)). Eqs. (1) and (4) imply the following statistical model of the CAPM.

$$R_{m,t} = Z_{t-1}\gamma_m + \epsilon_{m,t} \quad \ldots(5.1)$$

$$R_{i,t} = Z_{i,t}\gamma_i + \epsilon_{i,t} \quad \ldots(5.2)$$

with the restriction

$$\gamma_i = \beta_{i,t}\gamma_m. \quad \ldots(5.3)$$

By constraining the conditional beta $\beta_{i,t}$ to be constant over time, eq. (5.3) becomes the proportionality restriction of the CAPM (Gibbons and Ferson (1985)).

$$\gamma_i = \beta_i\gamma_m. \quad \ldots(5.3')$$

Employing eqs. (5.1), (5.2), and (5.3′), we can write the restricted model as follows :

$$R_{m,t} = Z_{t-1}\gamma_m + \epsilon_{m,t} \quad \ldots(6.1)$$

$$R_{i,t} = Z_{t-1}(\beta_i\gamma_m) + \epsilon_{i,t}. \quad \ldots(6.2)$$

We will employ Hansen's (1982) generalized method of moments (GMM) to estimate this

[3] The Sharpe-Lintner CAPM does not have a conditional form because it is a one-period model. The conditional CAPM that we test in this paper is the Merton-Breeden CAPM in which the investment opportunity set is constant or in which investors have log utility.

[4] This is obtained by taking iterative expectation of $E[R_{k,t} \mid \Omega_{t-1}]$ with respect to Z_{t-1} contained in Ω_{t-1}.

model. We use this method because it allows heteroscedastic and serially correlated ϵ_t. What it requires is only that ϵ_t is orthogonal to the information set Z_{t-1}. The system in (6) has MN moments and $M+N-1$ parameters, where M is the number of columns of Z_{t-1} and N is the number of equations in the system. This configuration constitutes $(M-1)(N-1)$ over-identification restrictions. The minimized value of the objective function can be used to test the restrictions implied by the model. Hansen shows that if the model is correct, the minimized objective value will be distributed as a chi-squared statistic with $(M-1)(N-1)$ degrees of freedom.

Harvey (1989) points out that the CAPM in (6) also implies that the intercept of asset i is zero. That is, if we rewrite (6) as

$$R_{m,t} = Z_{t-1}\gamma_m + \epsilon_{m,t} \quad \ldots(7.1)$$

$$R_{i,t} = I_i + Z_{t-1}(\beta_i\gamma_m) + \epsilon_{i,t} \quad \ldots(7.2)$$

we must have the intercept $I_i = 0$ if the CAPM is correct. Khanthavit (1992) finds that tests of zero-intercept conditions are much more powerful than tests of proportionality restrictions. We will employ the same GMM procedure to estimate and test the model in (7). The test of the zero-intercept conditions is carried out in two phases. First, we test if the model is consistent with the data by performing the test of overidentification restrictions implied by the model. The minimized value of the objective function in this case is distributed as a chi-squared statistic with (M-2) (N-1) degrees of freedom. The degrees of freedom are reduced by $N-1$ because of additional $N-1$ parameters introduced as the intercepts. Second, if the model passes the test, we further conduct a Wald test that the intercepts are jointly zero. Under the null hypothesis, the Wald statistic is distributed as χ^2 $(N-1)$.

The Data

We employ five assets from December 1976 to October 1988 in the study. The reference market portfolio is the country portfolio constructed by the International Finance Corporation. The four test assets consist of Bangkok Bank (BBL), Dusit Thani (DTC), Siam Cement (SCC) and Thai Glass Industries (TGI) whose returns are reported by the Stock Exchange of Thailand. We use these five test assets because they have long return series. And since they are large stocks, they should suffer less from the thin trading problem. All returns are monthly, continuously compounded capital gains plus dividend yields. The return on market portfolio is converted to the return measured in baht by the end-of-month spot exchange rate available from Citibase. The risk-free rate is the continuously compounded rate of return on one-month treasury bill reported by the Bank of Thailand.

Z_{t-1} consists of four instruments--a constant, February dummy, lagged inflation, and lagged dividend yields on the market portfolio. The inflation rate is available from **International Financial Statistics.** The February dummy is used to capture seasonality effects on returns.[5] The motivation to include lagged inflation is due to Fama and Schwert (1977), among others, who find a negative correlation between the expected inflation and stock returns. Lagged dividend yields are used because they have been found to predict excess returns in the U.S. (Fama and French, 1988).

[5] The January dummy was tried but it failed to predict returns. Foerster (1990) suggests that the February dummy corrects an improperly formulated regression model when the January dummy and market returns are regressors. We employ only the February dummy to keep a low number of regressors.

RESULTS

Tests of proportionality restrictions depend critically on predictability of returns. To test the predictability, we run ordinary-least-squares regressions of the excess returns on Z_{t-1}. Consistent covariance matrices of Hansen (1982) are used to compute T statistics reported in parentheses under the projection coefficients. We find that the February dummy has a negative relationship with the excess returns.[6] Like Fama and Schwert, we find that inflation has a negative effect on returns. The predictability power of lagged dividend yields is low and their coefficients are not significant. In all, the coefficients of determination (R^2's) are small ranging from .004 for BBL to .038 for DTC. We conduct Wald tests that projection coefficients are jointly zero and that the coefficients except the constant are zero. The results are reported in the columns labeled W_4 and W_3 respectively. We find that, except for BBL, the excess returns are predictable.

It should be noted that the rational expectations assumption is the key assumption to derive our model. An implication of this assumption is that the forecast errors are serially uncorrelated. To ensure that condition is satisfied, we perform ℓ tests, proposed by Cumby and Huizinga (1990), that the forecast errors are uncorrelated with their leg q, q = 1, ..., 12. Under the null hypothesis of no serial correlations, the ℓ statistic is distributed as a χ^2 (12). The results are reported in the column labeled ℓ_{12} of the table. The P values are in parentheses. At a conventional confidence level, the hypotheses cannot be rejected.

Table 1 Tests of predictability*

Asset	Constant	February	L Inflation	L Dividend	R^2	ℓ_{12}	W_4	W_3
Market	.020	−.026	−.949	−1.215	.019	9.825	7.203	7.197
	(.896)	(−2.229)	(−1.721)	(−.451)		(.631)	(.126)	(.066)
BBL	.003	.007	−.241	.674	.004	16.593	3.841	.777
	(.189)	(.543)	(−.518)	(.375)		(.166)	(.428)	(.855)
DTC	.060	−.031	−1.175	−5.309	.038	15.176	10.205	6.472
	(2.154)	(−1.279)	(−1.792)	(−1.592)		(.232)	(.037)	(.091)
SCC	.052	−.036	−1.514	−2.778	.024	9.313	13.368	8.069
	(1.755)	(−1.987)	(−2.255)	(−.760)		(.679)	(.010)	(.045)
TGI	.037	−.025	.998	−4.373	.027	13.197	9.606	9.597
	(1.493)	(−1.975)	(1.295)	(−1.162)		(.355)	(.048)	(.022)

* Projection parameters are obtained from ordinary-least-squares regressions. Consistent covariance matrices are used to compute T statistics reported in parenthesis. ℓ_{12} is the ℓ statistic of the joint test that projection error is uncorrelated with its lag q, q = 1, ..., 12. It has a χ^2 (12) distribution under the null hypothesis. Its P value is in parentheses. W_4 and W_3 are Wald statistics of the tests that the projection parameters and the projection parameters except the constant are jointly zero. They have χ^2 (4) and χ^2 (3) distributions. P values are in parentheses.

6 Hugh Thomas pointed out interestingly that the February effect may be due to the Chinese New Year.

Table 2 below reports the results of the proportionality restriction tests. If the CAPM is correct, β_i can be interpreted as the market beta of asset i. i = BBL, DTC, SCC and TGI. We can employ the minimized value of the objective function to test the model. Hansen (1982) shows that if the model is correct, the value of the objective function is distributed as a chi-squared statistic with degrees of freedom equal to the number of parameter restrictions. In the system with five stocks, we have 20 moments and 8 parameters. This constitutes 12 parameter restrictions. We find that the value of the objective function in this case is 19.349. The corresponding P value is .080. The finding offers weak evidence against the CAPM.

Note that the excess returns on the BBL stock are not predictable and, as a result, the restricted system cannot be interpreted. To examine the validity of the test, we estimate a system of four assets excluding BBL. In this case, we have 16 moments and 7 parameters, thus leaving us with 9 parameter restrictions. The value of the objective function is 14.367. Its P value is .109 which is of the same magnitude as that of the system with five assets.

Weak evidence against the CAPM suggests either that the CAPM can provide a fairly good description of the data or that our test has low power to reject the model. In their Monte Carlo simulation, Ferson and Foerster (1991) find that in a large system GMM tests are vulnerable to Type-II error. To ensure

Table 2 Tests of proportionality restrictions implied by CAPM*.

System	Const.	Febru.	L Inf.	L Div.	β_{BBL}	β_{DTC}	β_{SCC}	β_{TGI}	χ^2(k)
5 Assets	.035	−.012	−3.041	−.809	.445	1.613	2.170	.596	19.349
	(.018)	(.011)	(1.950)	(.351)	(.182)	(.581)	(.524)	(.495)	(.080)
4 Assets	.004	.002	−.390	−.039		15.217	12.051	7.863	14.367
	(.013)	(.008)	(1.369)	(.137)		(50.284)	(37.526)	(25.783)	(.109)
BBL	.001	−.001	−.095	−.012	−17.784				3.155
	(.006)	(.008)	(.999)	(.127)	(190.492)				(.368)
DTC	.021	.004	−1.859	−.521		2.443			2.173
	(.017)	(.011)	(1.778)	(.408)		(1.472)			(.537)
SCC	.005	.004	−.252	−.127			6.156		2.711
	(.008)	(.006)	(.541)	(.166)			(6.248)		(.438)
TGI	−.007	−.006	1.160	−.452				−2.982	2.020
	(.009)	(.010)	(1.351)	(.430)				(3.485)	(.568)

* Standard errors are under parameter estimates. The system with 5 assets uses all sample assets in the test. The system with 4 assets uses all sample assets except BBL. The remaining systems pair the market portfolio with an asset. χ^2 (k) is chi-squared statistic of over-identification test. k indicates degrees of freedom. k = 12 in the system with 5 assets, k = 9 in the system with 4 assets, and k = 3 in the systems which pair the market portfolio with a sample asset. P values are in parentheses.

that our weak rejection of the model is not due to the error, we estimate systems of two equations of the market portfolio and a test asset. The results are reported in the lower part of Table 2. At a conventional confidence level, we cannot reject the CAPM. The P values in these systems are much higher than those of the systems with 5 and 4 assets. An explanation of the findings is the following. The estimates of projection vectors of excess returns are random vectors. Suppose the projection vector of the market portfolio is approximately proportional to those of assets i and j. But those of assets i and j are not proportional. By pairing the market portfolio with either asset i or asset j, we would not be able to reject the model because their projection vectors are so similar. The test will have stronger power when all the assets are used.

The CAPM also implies that the intercepts in eq. (7) are zero. Tests of zero intercepts of the conditional model were suggested by Harvey (1989). Khanthavit (1992) finds that these tests are more powerful than the tests of proportionality restrictions. To test the zero-intercept conditions, we estimate the model given by eq. (7), employing five assets and four assets excluding BBL. The results are reported in Table 3. below.

From the table, in the system with 5 assets the overidentification test suggests that the model with intercepts can provide a good description of the data. The value of the objective function, which is a χ^2 (8), is 8.149 and its P value is .419. The intercepts of all test assets are positive. But only that of SCC is significant. The Wald test that the intercepts are jointly zero reports a Wald statistic of 16.899 and a P value of .002 which is highly significant. The overidentification test also suggests that the system with four assets fit the data well. The estimates of the intercepts are similar to those in the system with five assets and only the intercept of SCC is significant. The Wald statistic of the test that the three intercepts are jointly zero is 16.720. Its P value is .001. The findings lead us to conclude that the CAPM is not the correct model to describe the data.

CONCLUSION

In this paper, we examine the conditional capital asset pricing model which allows the expected returns to be time-varying but constrains the market betas to be constant. The proportionality restrictions and the zero-intercept conditions implied by the model are tested. We find weak evidence against the proportionality restrictions. But the hypothesis that the intercepts are jointly zero is rejected at a very high confident level.

In the theory, the market portfolio must include all assets in the economy. Since the true market portfolio cannot be observed, we employ the country portfolio as its proxy. Therefore it can be argued that, though the CAPM is correct, since the portfolio that we use lies so far away from the true market portfolio, the CAPM is rejected (Roll (1977)). However, this argument is not valid in this case because our test can be interpreted as a single-latent-variable test. That is, we can treat the country portfolio as the reference asset and reinterpret the betas as the ratios between the true but unobserved market betas of test assets and country portfolio. Since all single-beta pricing models imply the single-latent-variable model, the rejection of the single-latent-variable model provides sufficient evidence against the CAPM.

The rejection of the model may be due to the auxiliary assumption that market betas are constant over time. This assumption is inconsistent with Khanthavit (1991) who finds strong multivariate ARCH effects of Thai stocks. Recently, Khanthavit (1992) proposes

Table 3 Tests of zero intercepts implied by CAPM*.

Statistics	5 Assets	4 Assets
Constant	.005	−.002
	(.011)	(.012)
February	−.018	−.012
	(.012)	(.012)
L Inflation	.677	1.318
	(1.232)	(1.382)
L Dividend	−.862	−.871
	(.429)	(.481)
β_{BBL}	.199	
	(.298)	
β_{DTC}	.944	.846
	(.654)	(.682)
β_{SCC}	1.347	1.437
	(.403)	(.445)
β_{TGI}	−1.518	−1.695
	(1.223)	(1.375)
I_{BBL}	.004	
	(.003)	
I_{DTC}	.004	.005
	(.005)	(.005)
I_{SCC}	.015	.016
	(.004)	(.004)
I_{TGI}	.017	.011
	(.013)	(.813)
χ^2 (k)	8.149	6.930
	(.419)	(.327)
Wald	16.899	16.720
	(.002)	(.001)

* Standard errors are under parameter estimates. The system with 5 assets employs all sample assets for the estimation. The system with 4 assets employs all sample assets except BBL. χ^2 (k) is chi-squared statistic of test of over-identification. k indicates degrees of freedom. $k=8$ in the system with 5 assets and $k = 6$ in the system with 4 assets. Wald is Wald statistic of the test that the intercepts of test assets are jointly zero. It is distributed as a χ^2 (4) in the system with 5 assets and as a χ^2 (3) in the system with 4 assets. P values are in parentheses.

a model with time-varying first and second moments in a GARCH (1, 1) – M framework. The models with time-varying second moments tend to fit the data better. Whether they will be able to provide a good description of Thai stock returns is left for future research.

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