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Introduction

The establishment of an empirically-verified model of risk-return relationships in the capital market continues to be an important issue in finance and economics. One important theory of the capital markets is Breeden's (1979) Consumption Risk Model (CRM), which Mankiw and Shapiro (1986) and others have stated to be preferable on theoretical grounds to competing models. The CRM hypothesizes that wealth is more highly valued in periods of low consumption, and that required returns on assets should be a positive linear function of the covariance of the assets' returns with changes in real aggregate consumption.

Since its original development, the CRM has been subjected to rigorous empirical examination. Several studies, such as Hansen and Singleton (1983), Dunn and Singleton (1983, 1986), Jagannathan (1985), and Ferson and Merrick (1987), have focused on the theory's implications for macroeconomic relationships such as the marginal rate of substitution between investment returns and consumption. Other researchers, such as Hazuka (1984), Mankiw and Shapiro (1986), and Breeden, Gibbons, and Litzenberger (1987), have examined the cross-sectional relationship between asset returns and CRM risk. Although the empirical findings have not been wholly supportive of the theory, Ferson and Merrick (1987) have found the results to be materially affected by different assumptions concerning parameter stationarity. In addition, Dunn and Singleton (1986) have shown that failure to include the consumption flow of durables into the time-series consumption estimate can have an adverse impact on the empirical findings. Similarly, Mankiw and Shapiro (1986) have noted that general errors in measuring the consumption variable can distort empirical tests of the CRM.

This paper complements previous empirical research on the CRM by utilizing different econometric techniques and data to test the precise risk-return implications of the theory. In particular, this research uses a large-scale cross-sectional sample, explicitly addresses the important problems of parameter non-stationarity and errors in variables, and explicitly includes a measure of the consumption flow of durables into the time-series consumption estimate. The testable implications of the CRM and general econometric problems are discussed, followed by a description of the testing procedure and data used in the research, an explanation of the results of the test, and a summation of the findings.

The Testable Hypothesis of the CRM and Econometric Problems

With respect to the risk-return tradeoffs existing in the capital markets, the CRM implies that, for any three assets j, f, and m,

$$(u_j - u_f)/(B_j - B_f) = (u_m - u_f)/(B_m - B_f), \tag{1}$$

where u denotes the expected instantaneous real return on the subscripted asset, and B (the consumption beta) represents the contribution of the subscripted asset to aggregate real consumption risk. Consumption betas for any asset k are measured by the equation

$$B_k = \mathrm{Cov}(\tilde{R}_k, \tilde{C})/\mathrm{Var}(\tilde{C}), \tag{2}$$

where ~ denotes a random variable, and R_k and C are the logarithmic real return on asset k and the logarithmic change in aggregate real consumption, respectively.

To preclude possible division by zero, (1) can be rearranged to yield the equation

$$(\overline{R}_j - \overline{R}_f)(B_m - B_f) = g_0 + g_1(\overline{R}_m - \overline{R}_f)(B_j - B_f), \tag{3}$$

where ‾ denotes an average value, and the CRM implies that the parameters g_0 and g_1 should conform to the restrictions

$$g_0 = 0, \text{ and} \tag{4}$$
$$g_1 = 1. \tag{5}$$

To test the joint CRM hypothesis in (4,5), average returns and betas for a set of different assets can be estimated in the first stage using time-series data, and the g parameters can be estimated in the second stage using the cross-sectional parameter estimates. This two-stage process is similar to that employed to test the risk-return implications of other models of capital market equilibrium (Black, Jensen, and Scholes, 1972).

To estimate consumption betas in the first stage of a CRM test, the time-series of logarithmic real asset returns can be regressed on the corresponding logarithmic changes in aggregate real consumption. Because the independent variable in the first stage (changes in aggregate real consumption) is measured with extraordinary error (Morgenstern, 1963), however, the regression suffers from the obvious problem of errors in variables (Judge et al., 1982:531-534). In addition, Ferson and Merrick (1987) and Cornell (1981), respectively, have indicated that problems of autocorrelation and beta nonstationarity may also exist in consumption beta estimation.

Statistical problems exist in the second stage of the test as well. For instance, because the independent variable in the second stage includes betas which are measured with error in the first stage, the second-stage regression also suffers from the problem of errors in variables. These various problems associated with asset-pricing tests are addressed in the next section.

Addressing the Econometric Problems of the Test

The existence of an unobservable independent variable results in errors in variables and biased parameter estimates if Ordinary Least Squares (OLS) is used. Nevertheless, consistent parameter estimates are obtainable if Instrumental Variables (IV) estimators are employed (Judge et al., 1982:534-548). An IV estimator requires specification of an instrument which has a high correlation with the true independent variable but which is not correlated with the errors in variables, i.e., is not correlated with the vector of differences between the proxy and the true independent variable.

An IV estimator, which is well-accepted in the econometric literature as a consistent and fairly efficient estimator, is the 3-group method (Johnston, 1984). This estimator utilizes an instrumental variable which has a value of 1, 0, and −1 for observations where the proxied independent variable has a value which, by relative magnitude, is in the upper, middle, and lower third of all observations, respectively (Kmenta, 1986).

Addressing the problem of parameter non-stationarity, Murphy (1984) has proven that, if the time-series variation in parameter values is uncorrelated with the time-series variation in other model parameters, average parameter estimates can be validly employed to test the linear risk-return implications of asset pricing-models. When estimating the average value of the beta parameters, however, non-stationarity can cause heteroskedasticity relative to the independent variable in the first stage (Judge et al., 1982:503-505).

To determine whether heteroskedasticity relative to the independent variable in the first stage is present, a Goldfeld-Quandt (GQ) test can be conducted (Judge et al., 1982:421-422). In this test, the sum of the squared residuals from the observations with the highest squared logarithmic changes in real consumption is divided by the sum of the squared residuals from the observations with the smallest squared logarithmic changes in real consumption to compute an F-statistic. If it can be inferred from the F-test that heteroskedasticity exists, then a Generalized Least Squares (GLS) estimator, which weights the observations by the absolute value of the inverse of the logarithmic change in aggregate real consumption, can be used.

To test monthly returns for autocorrelation, Durbin-Watson (D-W) statistics can be utilized. If a sufficient number of D-W values are significant, it may be appropriate to employ a GLS adjustment for autocorrelation.

Even with consumption betas estimated consistently and efficiently, errors in variables will still exist in the second stage, since the true betas are unobservable. This study employs the 3-group method to consistently estimate the g parameters. In addition, because the consumption betas are measured with different degrees of accuracy in the first stage of the test, heteroskedasticity might exist in the second stage relative to the standard error of these first-stage beta estimates, and a GLS adjustment migbt be appropriate.

Data

To conduct the test, the assets j, f, and m in equation (3) must be specified. Although the choice is somewhat arbitrary, this study will utilize for asset j a portfolio consisting of a long position on a stock and a short position on the risk-free, one-month T-bill. The nominal return on this portfolio j represents the excess return on the stock commonly employed in empirical research of asset-pricing theories (Miller and Scholes, 1972). Assets f and m for the test are specified to be the risk-free T-bill and a market portfolio proxy, respectively, with $\overline{R}$ and $\overline{B}$ for these assets being estimated using the same time horizon as employed for the stock-bill portfolio.

Individual stock returns are obtained from the Center for Research in Security Prices (CRSP) Monthly Stock Returns File. All observations on each of the 2043 stocks with more than 60 observations over the 1959-84 interval are included in the sample.[1] For the market portfolio proxy, a long position with a 60% equity (NYSE value-weighted), 30% corporate bond (CRSP long-term high-grade), and 10% Treasury bond (CRSP long-term U.S. government) weighting is combined with a short 100% T-bill position. The nominal return on this portfolio represents the excess return on a market index similar to that used by Friend, Westerfield, and Granito (1978) in previous asset-pricing research. Return data for the various components of the market portfolio proxy, as well as data on the Consumer Price Index (CPI) inflation rate (the logarithmic of which is subtracted from nominal logarithmic returns to compute logarithmic real returns for each asset), are obtained from the CRSP Indices File.

For measurement of the monthly changes in aggregate real consumption, data from the Citibank Economic Database (CITIBASE) is employed. Because government-reported aggregate consumption includes expenditures for durables and clothing, this variable is not an accurate measure of true consumption. Instead, real consumption is computed by adding the real expenditures on non-durables (not including clothing) to the real consumption of durables and clothing. For this study, real consumption of durables (clothing) is assumed to occur at a monthly rate equal to 3% (12.5%) of the previous month's stock of unconsumed real durables (clothing), with 10% (25%) of durables (clothing) being consumed in the month of expenditure and with stocks of real unconsumed durables (clothing) being computed prior to 1959 using quarterly data on durables (clothing) expenditures beginning in 1947. Although U.S. government records (such as those of the Bureau of Economic Analysis) on stocks of durables often assume consumption over a shorter life (like 3 years) using straight-line depreciation methods, Dunn and Singleton (1986) have shown that accelerated consumption over longer lives is a theoretically more justified procedure.

In an efficient market (Muth, 1961), price will incorporate the best theoretical forecast of consumption. To compute the covariance in (2), consumption changes or deviations should therefore be measured from this expectation. Although Breeden (1980) has suggested the expectations of professional economists as the best forecast, such forecasts are not broken down by durables and clothing category and are not available for monthly forecasts. In addition, since it is not always clear that economists' forecasts are superior to naive forecasts (Cooper, 1972, and McNees, 1979), this research estimates betas using changes in real consumption as opposed to deviations from economists' expectations.[2]

Comparison to Other Cross-Sectional Tests

The testing methodology employed in this study differs from other cross-sectional tests of the CRM both in terms of the sample size and the econometric procedure employed. In particular, other cross-sectional tests have utilized considerably smaller sample sizes, with the samples of Hazuka, (1984), Mankiw and Shapiro (1986), and Breeden, Gibbons, and Litzenberger (1987) including only, respectively, several futures contracts, the 464 stocks which were continuously listed on the NYSE between 1959 and 1982, and a small number of portfolios. In addition, unlike this research, each of these other cross-sectional studies failed to incorporate a measure of the consumption flow of durables into the time-series consumption data when estimating consumption betas. Finally, none of these studies explicitly addressed the econometric problems of heteroskedasticity and errors in variables in consumption beta estimation.[3] Through utilization of a different sample and testing procedure, the results of this research should contribute significantly to the empirical evidence on the CRM.

The Results

The results of the first-stage D-W tests revealed that only 4.60% (2.69%) of the 2043 first-stage D-W statistics were significant using the upper (lower) bound of D-W tables. Because these findings provide little evidence of autocorrelation, a GLS adjustment for autocorrelation is not made.

On the other hand, 39.70% of the first-stage GQ F-statistics were found to be significant at the .05 level. Such evidence implies the existence of heteroskedasticity relative to the square of the logarithmic changes in real consumption and is consistent with the hypothesis that consumption betas for many stocks are non-stationary. The results also indicate that a GLS adjustment for heteroskedasticity may be appropriate.[4]

Table 1 displays the results of the second-stage tests when betas are estimated using the IV estimator with and without the first-stage GLS adjustment for heteroskedasticity. As can be seen from the F-statistics, the CRM is rejected in each case at the .01 level. The g_1 parameter estimate is significantly positive as predicted, but it is significantly less than the predicted value of 1.0. Further testing revealed (not shown) that use of a GLS adjustment for second-stage heteroskedasticity relative to the standard error in estimating individual consumption betas would not materially affect these findings.[5]

These results for the CRM are similar to those found by Hazuka (1984), Mankiw and Shapiro (1986), and Breeden, Gibbons, and Litzenberger (1987) using different testing procedures and samples. All of the studies have found evidence of a positive relationship between CRM risk and return, but it has not been of the exact magnitude implied by the theory. This research adds

TABLE 1
Second-Stage Test Results[a]

$$(\overline{R}_j-\overline{R}_f)(\overline{B}_m-\overline{B}_f) = g_0+g_1(\overline{R}_m-\overline{R}_f)(\overline{B}_j-\overline{B}_f)$$

(1) Beta Het. Adj.[b]	(2) g_0	(3) (t^c)	(4) g_1	(5) (t^d)	(6) F^e
No	−.0025	(7.3956*)	.2363	(11.9662*)	1663.6107*
Yes	.0059	(4.0212*)	.0739	(4.8690*)	5818.9780*

*Significant at the .01 level.
[a]Uses the three group method to estimate the g parameters.
[b]This column denotes whether the betas employed in the second stage are estimated with an adjustment for first-stage heteroskedasticity or not.
[c]Tests the Ho: $G_0=0$.
[d]Tests the Ho: $g_1=0$.
[e]Tests the joint CRM Ho: $g_0=0$ and $g_1=1$.

to the existing evidence on the CRM by achieving similar results in spite of the utilization of a larger and different sample than the other studies and in spite of the use of a different procedure for estimating consumption betas.

The results of this study's CRM test are also similar to those found when a competing theory of the capital markets, Sharpe's (1964) Capital Asset Pricing Model (CAPM), is tested. Like the findings for the CRM in this research, typical empirical tests of the CAPM find a positive association between returns and the CAPM beta risk measure (Stambaugh, 1982), but the exact linear relationship implied by the CAPM is invariably rejected (Gibbons, 1982, and Shanken, 1987).[6]

Summary

Empirical verification of a general model of the risk-return tradeoffs in the capital markets would represent an important step in our understanding of economics and finance. Although a statistically significant, positive association between return and consumption betas is discovered, the exact CRM relationship indicated in (1) is found to be inconsistent with the empirical evidence. The finding of a relationship between model risk and return that has the correct sign but the incorrect magnitude is similar to the finding in other tests of the CRM as well as in tests of another popular theory, the CAPM.

The rejection of the CRM in this study lends support to previous research which has uncovered other empirical evidence which is not wholly consistent with the CRM. Discovering additional deviations from the CRM, as well as the factor(s) causing the deviations, represents a fertile area for future research. For example, a comparative testing of the risk-return implications of the 3-moment consumption risk model developed by Kraus and Litzenberger (1983) might represent a particularly important research topic. In addition, further refinements in measuring the consumption variable, such as the Mankiw and Shapiro (1986) suggestion of using only the consumption of stockholders, if obtainable, might also prove fruitful.

Footnotes

[1]For stocks whose returns were not available from CRSP for every month in the 1959-84 interval, months of missing observations were ignored for purpose of estimating the first-stage parameters.

[2]The use of expectations not conditioned on ex-ante information or forecasts implicitly assumes that the time-series expected value for consumption equals the average sample ex-post value. Grossman and Schiller (1982) have shown that, in general, the CRM risk-return relationships should hold for these unconditional expectations.

[3]It should be noted, however, that the Mankiw and Shapiro (1986) study did implicitly address the errors in variables issue by using ratios of betas in the second stage of the test.

[4]Without the GLS adjustment, the beta estimates averaged 2.76 and ranged between −9.51 and 17.51, with 12.09% of the betas being negative and with 80% of the beta estimates falling between −0.24 and 6.03. These consumption beta ranges are similar to those found by Breeden, Gibbons, and Litzenberger (1987) for entire portfolios. The ranges were somewhat larger when the GLS adjustment was employed.

[5]Further testing (not shown) was also conducted to determine the effect of other econometric problems, but the overall findings were not materially affected. For instance, because consumption is measured over a month's time interval instead of at discrete time points, Breeden, Gibbons, and Litzenberger (1987) have shown that estimated betas are biased and should be multiplied by 4/3. Such an adjustment was attempted, but neither the sign nor the significance of the second-stage parameter estimates or test statistics were affected.

[6]Although most previous tests of the CAPM have utilized somewhat different testing procedures, Murphy (1987) has shown the results to be largely unaffected by the methodology employed in this research to adjust for the first-stage problems of errors in variables and parameter non-stationarity in large-scale, cross-sectional CAPM tests. Comparative tests of the CAPM and the CRM by Mankiw and Shapiro (1986) and Breeden, Gibbons, and Litzenberger (1987) using different testing procedures have yielded mixed results on the issue of which model is more consistent with the empirical data.

References

F. Black, M. Jensen, and M. Scholes. "The Capital Asset Pricing Model: Some Empirical Findings." **Studies in the Theory of Capital Markets** ed. by M. Jensen, New York: Praeger (1972), pp. 79-124.

D. Breeden. "An Intertemporal Asset Pricing Model with Stochastic Consumption and Investment Opportunities." **Journal of Financial Economics** 7 (1979), 265-296.

_______. "Consumption Risk in Futures Markets." **Journal of Finance** 35 (1980), 503-520.

_______, M. Gibbons, and R. Litzenberger. "Empirical Tests of the Consumption-Oriented CAPM." Research Paper No. 879R, Stanford University (1987).

R. Cooper. "The Predictive Performance of Quarterly Econometric Models of the United States." **Econometric Models of Cyclical Behavior**, New York: NBER (1972), pp. 813-947.

B. Cornell. "The Consumption Based Asset Pricing Model." **Journal of Financial Economics** 9 (1981), 103-108.

K. Dunn and K. Singleton. "An Empirical Model of the Pricing of Mortgage-Backed Securities." **Journal of Finance** 38 (1983), 613-623.

_______ and _______. "Modelling the Term Structure of Interest Rates Under Non-Separable Utility and Durability of Goods." **Journal of Financial Economics** 17 (1986), 27-55.

W. Ferson and J. Merrick. "Non-Stationarity and Stage-of-the-Business-Cycle Effects in Consumption-Based Asset Pricing Relations." **Journal of Financial Economics** 18 (1987), 127-146.

I. Friend, R. Westerfield, and M. Granito. "New Evidence on the Capital Asset Pricing Model." **Journal of Finance** 33 (1978), 903-920.

M. Gibbons. "Multivariate Tests of Financial Models." **Journal of Financial Economics** 14 (1982), 3-27.

S. Grossman and R. Schiller. "Consumption Correlatedness and Risk Measurement in Economies with Non-Traded Assets and Heterogeneous Information." **Journal of Financial Economics** 10 (1982), 195-210.

L. Hansen and K. Singleton. "Stochastic Consumption, Risk Aversion, and the Temporal Behavior of Asset Returns." **Journal of Political Economy** 91 (1983), 249-265.

T. Hazuka. "Consumption Betas and Backwardation in Commodity Markets." **Journal of Finance** 39 (1984), 647-655.

R. Jagannathan. "An Investigation of Commodity Futures Prices Using the Consumption-Based Intertemporal Capital Asset Pricing Model." **Journal of Finance** 40 (1985), 175-191.

J. Johnston. **Econometric Methods**, New York: McGraw Hill (1984), 430-431.

G. Judge, C. Hill, W. Griffiths, H. Luetkepohl, and T. Lee. **Introduction to the Theory and Practice of Econometrics**, New York: John Wiley (1982).

J. Kmenta. **Elements of Econometrics**, New York: Macmillan (1986), 361-362.

A. Kraus and R. Litzenberger. "On the Distributional Conditions for a Consumption-Oriented Three Moment CAPM." **Journal of Finance** 38 (1983), 1381-1391.

G. Mankiw and M. Shapiro. "Risk and Return: Consumption Beta Versus Market Beta." **Review of Economics and Statistics** 47 (1986), 452-459.

S. McNees. "The Forecasting Record for the 1970's." **New England Economic Review** (September/October 1979), 33-53.

M. Miller and M. Scholes. "Rates of Return in Relation to Risk: A Reexamination of Some Recent Findings." **Studies in the Theory of Capital Markets** ed. by M. Jensen, New York: Praeger (1972), pp. 47-78.

O. Morgenstern. **On the Accuracy of Economic Observations**, Princeton: Princeton University Press (1963).

A. Murphy. "Risk-Return Tradeoffs on Commodity Futures Contracts with the Second Nearest Delivery Date." Dissertation: University of Georgia (1984).

________. "An Econometric Solution to Testing the CAPM." Presented at the 1987 Eastern Finance Association meeting.

J. Muth. "Rational Expectations and the Theory of Price Movements." **Econometrica** 29 (1961), 315-355.

J. Shanken. "Multivariate Proxies and Asset Pricing Relations." **Journal of Financial Economics** 18 (1987), 91-110.

W. Sharpe. "Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk." **Journal of Finance** 19 (1964), 425-442.

R. Stambaugh. "On the Exclusion of Assets from Tests of the Two-Parameter Model." **Journal of Financial Economics** 10 (1982), 237-268.

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