THE CAPITAL ASSET PRICING MODEL VERSUS THE THREE FACTOR MODEL: A United Kingdom Perspective

Chandra Shekhar Bhatnagar
Department of Management Studies,
The University of the West Indies, St. Augustine,
Trinidad (West Indies)

Riad Ramlogan
Intercommercial Bank Limited,
Trinidad (West Indies)

ABSTRACT

The Sharpe (1964), Lintner (1965) and Black (1972) Capital Asset Pricing Model (CAPM) postulates that the equilibrium rates of return on all risky assets are a linear function of their covariance with the market portfolio. Recent work by Fama and French (1996, 2006) introduce a Three Factor Model that questions the "real world application" of the CAPM Theorem and its ability to explain stock returns as well as value premium effects in the United States market. This paper provides an out-of-sample perspective to the work of Fama and French (1996, 2006). Multiple regression is used to compare the performance of the CAPM, a split sample CAPM and the Three Factor Model in explaining observed stock returns and value premium effects in the United Kingdom market. The methodology of Fama and French (2006) was used as the framework for this study. The findings show that the Three Factor Model holds for the United Kingdom Market and is superior to the CAPM and the split sample CAPM in explaining both stock returns and value premium effects. The "real world application" of the CAPM is therefore not supported by the United Kingdom data.

Keywords: Capital Asset Pricing Model, Mult-factor CAPM, Three Factor Model, Stock market

1. INTRODUCTION

Sharpe (1964), Lintner (1965) and Black (1972) developed the Capital Asset Pricing Model (CAPM). Several authors inclusive of Fama and French (2004) suggest that the CAPM marks "the birth of Asset Pricing models". Its main prediction is that a market portfolio is mean-variance efficient resulting in a linear cross-sectional relationship between mean excess returns and exposures to the market factor (Fama and French, 1992). The CAPM is defined by the following equation:

$E(R_i) = R_f + \beta_i[E(R_m) - R_f],$ [1]

where

$E(R_i)$ = The expected return of stock i.

$\beta_i = \frac{\sigma_{im}}{\sigma_m^2}$

R_f = The risk free rate of return

$E(R_m)$ = The expected return of the market

Studies in the 1980's identified other factors that influence average stock returns. Banz (1981) and Rosenberg, Reid and Lanstein (1985) find that market equity and a firm's book value to market equity (BE/ME) ratio impact on average return. Basu (1983) finds that low earnings-price ratios (E/P) stocks explain US stocks returns while high (E/P) stocks experiencing lower returns could be explained by the CAPM. DeBondt and Thaler (1985) find that stocks with abnormally low long-term returns (average returns in three years) experience abnormally high long term future returns (average returns in the next three years) and vice versa. Bhandari (1988) finds a positive link between leverage and average return. Lakonishok, Sheifer and Vishny (1994) find a strong positive relationship between average returns and BE/ME and cashflow/price ratio (C/P).

Fama and French (1993) find that two (2) factors; firm Size and BE/ME portfolios explain the differences in the average returns of stocks. Fama and French (1996) also find that two variables, SMB (Small Minus Big- Size proxy) and HML (High Minus Low- BE/ME proxy), inclusive of the market factor, explain significant return patterns[1]. Fama and French (1998) observe that value stocks outperform growth stocks based on an international Size effect. The resultant model is being coined the Fama and French Three Factor Model (TFM).

Value stocks are aligned with financial distress.[2] Fama and French (1993, 1996) identify that value stocks have high BE/ME ratios while growth stocks have low BE/ME ratios. High BE/ME ratios are identified to have a higher than average value premium in US stocks after 1963. Fama and French (2000) document a value premium effect by extending the study from 1926 – 1995.

Loughran (1997) finds that the BE/ME ratio has no major significance on realized return during 1963 - 1995. Value based strategies produce higher returns because some investors overreact to good or bad news and the prices adjust by more than what is justified by fundamentals.[3]

Fama and French (2006) report that evidence for a weak value premium among large firms is special to US stocks between the period of 1963 – 1995. They identify that the CAPM's general problem goes unrewarded throughout the 1926 – 2004 sample period. Multiple regression is used to compare the performance of the CAPM, a split sample version of the CAPM and the TFM in explaining (1) the observed stock returns and (2) the value premium effects in the UK market. The Fama and French (2006) methodology was used as the framework for this study.

Kothari, Shanken and Sloan (1995) re-examine the results presented by Fama and French (1993) and conclude that the results are likely influenced by a combination of survivorship bias. Additionally, Black (1993) and Mackinlay (1995) suggest that the results may be based on data snooping. Daniel and Titman (1997) and Daniel, Titman and Wei (2001) find that characteristics rather than pervasive factors explain the cross section variation in stock returns.

Several studies have also validated the results of Fama and French (1993, 1996). Barber and Lyon (1997) suggest that to overcome data snooping claims different time periods of observations and different countries, or a hold out sample can be used. Chan, Hamao and Lakonishok (1991) find a strong relationship between BE/ME and average return in Japanese stocks. Connor and Sehgal (2001) examined the Indian market and find evidence for pervasive Market, Size and BE/ME factors. Drew, Tony and Veeraragavan (2005) find that firm Size, BE/ME, the Market factor as well as idiosyncratic volatility are priced risk factors.

[1] Lakonishok, Shleifer, and Vishny (1994) portfolios are formed on earnings/price, cash flow/price and sales growth.
[2] See among others, Chan and Chen (1991) and Cochrane (2001)
[3] See Kothari (2000), Lee and Swaminathan (2000), Hirshleifer (2001), and Hong and Stein (1999).

1.1 The Three-Factor Model in the United Kingdom

BE/ME is the dominant variable in explaining variation in the UK stock returns.[4] Strong and Xu (1997) find that average returns are significantly positively related to beta, book-to-market equity and market leverage, and significantly negatively related to market value and book leverage.

Dimson, Nagel and Quigley (2003) find a strong value premium effect for stocks within the small cap and large cap universe in the UK market. Horani, Pope and Stark (2003) tested the UK Market and find that there is strong evidence that the Fama and French (1993, 1996) factors capture the variation in returns that are associated with RD activity. Malin and Veeraraghavan (2004) investigated the TFM on three major European markets. Their results however, contradict value effect as no evidence of a value effect was identified in any of the markets.

The results of the Malin and Veeraraghavan (2004) paper support the conclusions of Al-Horani, Pope and Stark (2003) who suggest that the CAPM β does not appear to have significant explanatory power for the cross section of UK stock returns. They comment that while the UK results of Chan and Chui (1996) and Strong and Xu (1997) support the results of the TFM, the absence of a consistently significant firm size effect is inconsistent with the US market findings.

2. DATA AND MODELS

The behavior of the underlying factors in the UK market was identified by studying the returns of all UK stocks in the FAME database[5]. For this study, data were gathered during April 2000 to June 2007. The period after 2007 was not considered to prevent the adulterating effect of the financial crises on the results. Data considerations can be segregated into two (2) main categories:

- Category one (1): Monthly Stock returns.[6]
- Category two (2): Company Accounting data.

Stock and share price data consist of month-end adjusted share prices of all companies over the sample period. Companies included in the sample are listed on the LSE. Data for both financial and non-financial firms are used. Accounting data consist of market value per share and book value per shareholder's equity. The market return variable (R_{Mt}) is the value-weighted portfolio of all stocks under consideration. For this study the UK Three (3) month Treasury bill rate is used as the risk free rate proxy[7].

2.1 The Models

2.1.1 The CAPM Model

It is defined by equation [1] where β is held constant over time and market information is perfect.

[4] See Chan and Chui (1996)
[5] The Fame Database is part of the Amadeus database group.
[6] The adjusted share price series have been converted into return series logarithmic returns also know as continuously compounded return. The logarithmic return is defined as $Return_{log} = ln\left(\frac{P_{t+1}}{P_t}\right)$, where Pt+1 is equal to Stock Price in period t+1 and where Pt is equal to Stock Price in period t. The return calculations have been done using the capital gain component only.
[7] Information for the one (1) month Treasury Bill rate was not used in this study due to lack of resources in obtaining such data. See http://www.bankofengland.co.uk/statistics/index.htm

2.1.2 The Split Sample CAPM Models

Jagannathan and Wang (1996) dispute that the relative risk of a firm's cash flow is likely to vary over the business cycle. Keim and Stanbough (1986) and Fama and French (1989) show that βs can vary. Ferson and Harvey (1991) and Chen (1991) show that variations in β occur as a result of movement in economic activity. A split sample CAPM can help to determine whether β is the only explanatory variable for excess market returns and whether the CAPM explains the value premium in average returns for the UK market.

In this study, the method of Fama and French (2006) has been followed. The full period dataset has been split into two (2) equal periods to allow for a single break in β in June 2004:

- Sample 1 considers the CAPM over the period May 2001 – May 2004 ***(CAPMS1)***.
- Sample 2 considers the CAPM over the period June 2004 – June 2007 ***(CAPMS2).***

2.1.3 The Value Premium CAPM and Split Sample Value Premium CAPM Models

To measure the ability of the CAPM to capture the Value Premium effect ***(VCAPM)*** in the UK market, equation [1] has been modified. The dependent variable of R_m has been replaced by the value proxy, HML[8] (See equation 2 below). The regressions of *HML* returns on the excess market return test whether the CAPM can explain value premiums (Fama and French, 2006).

$HMLt = R_f + \beta_i[E(R_m) - R_f],$ [2]

Where

HML = High Minus Low (proxy for BE/ME)

The methodology applied for the split sample of the CAPM has also been applied for the split sample of the VCAPM where the full period dataset has been split into two (2) equal periods.

- Sample 1 considers the VCAPM over the period May 2001 – May 2004 ***(CAPMS1)***.
- Sample 2 considers the VCAPM over the period June 2004 – June 2007 ***(CAPMS2).***

2.1.4 The Fama and French Three Factor Model (TFM)

The TFM of Fama and French (1996) uses the standard multiple regression approach. It is expressed via equation three (3) below:

$R_{it} - R_{ft} = \alpha_{it} + \beta_{iM}(R_{Mt} - R_{ft}) + \beta_{is}SMBt + \beta_{ih}HMLt + \varepsilon_{it}$ [3]

where

R_{it} = Average monthly return of portfolio i

R_{ft} = *R*isk free rate observed at the end of each month

$\beta_{iM} = \frac{\sigma_{im}}{\sigma_m^2}$

R_{Mt} = Expected Market Return

SMB = Small Minus Big (proxy for company Size)

HML = High Minus Low (proxy for BE/ME)

β_{is} & β_{ih} = Factor loadings also represent the slope(s) in the time series regression.

α_{it} & ε_{it} = These represent the intercept of the regression and the error term respectively.

Equation [3] can be used to estimate the CAPM by imposing the restriction $\beta_{is} = \beta_{ih} = 0$ for all i.

2.2 Portfolio Formation

LSE stocks were ranked as listed in the FAME database on Size (market price times outstanding shares) in May of each year "t" from 2001 – 2007. The data were split into two portfolios: stocks with an ME below the median (Small) and stocks with an ME above the median (Big).

[8] The definition of the HML variable is discussed in Section 2.2

The LSE stocks were broken into three BE/ME groups for the bottom 30% (Low, 'L'), middle 40% (Medium, 'M') and the upper 30% (High, 'H'). The Fama and French (1992) and Dimson, Nagel and Quigley (2003) approaches were used, where BE/ME is the book common equity for the firm's fiscal year ending t-1 divided by market equity at the end of December of t-1. Negative BE/ME firms were not included when calculating breakpoints for BE/ME.

Six (6) portfolios were constructed based on the two Size and three BE/ME portfolios: S/L, S/M, S/H, B/L, B/M and B/H. The S/L portfolio consisted of firms small in Size and low in BE/ME. The S/M portfolio consisted of firms small in Size and medium in BE/ME. The S/H portfolio consisted of firms small in Size and high in BE/ME. The B/L portfolio consisted of firms big in Size and low in BE/ME. The B/M portfolio consisted of firms big in Size and medium in BE/ME. The B/H portfolio consisted of firms big in Size and high in BE/ME. For each portfolio there was a total of six (6) years of 12 monthly returns, generating seventy-two (72) returns.

The monthly value weighted returns on the six portfolios were calculated from June of year "t" to May of year "t+1" and the portfolios were re-formed in June of year "t+1". The returns were calculated from June of year "t" to ensure investors know the book equity (BE) for year "t-1" by the time of the portfolio formation.

3. FINDINGS

Table I shows the summary statistics for the monthly excess returns (R_{mt} -R_{ft}), the SMB portfolio returns and the HML portfolio returns over the period 2001 – 2007. Figure 1depicts a bar chart presentation for the mean returns of the Small Cap versus Large Cap Portfolios while Figure 2 depicts a bar chart presentation of the mean returns of Low BE/ME portfolios versus Medium BE/ME portfolios versus High BE/ME portfolios.

Table 1

Summary Statistics for Monthly Returns on Size and Value Factors and the Size-*B/M* Portfolios Used to Construct Them

Book equity is Fame Database's Book Value per Share for the specific period multiplied by the Shares Outstanding for the specific period. In the *B/M* sorts in June of year *t*, book equity is for the fiscal year ending in the preceding calendar year, *t* − 1, and market equity is market cap at the end of December of that calendar year. The size premium, *SMB* (small minus big), is the simple average of the returns on the three small stock portfolios minus the average of the returns on the three big stock portfolios. The value premium, *HML* (high minus low), is the simple average of the returns on the two high portfolios minus the average of the returns on the two low portfolios. *RMt-RFt* is the difference between the value-weight market return (LSE) and the Bank of England three (3) month Treasury Bill Rate. The table shows means, standard deviations (*SD*).

	Average/Mean Returns	**Standard Deviation**
S/L	-1.52%	6.19%
S/M	-0.11%	4.87%
S/H	0.77%	3.99%
B/L	-0.04%	5.59%
B/M	0.68%	4.78%
B/H	1.07%	4.81%
SMB	-2.57%	5.66%
HML	3.40%	4.80%
RMt - Rft	-0.23%	4.76%

Figure 1

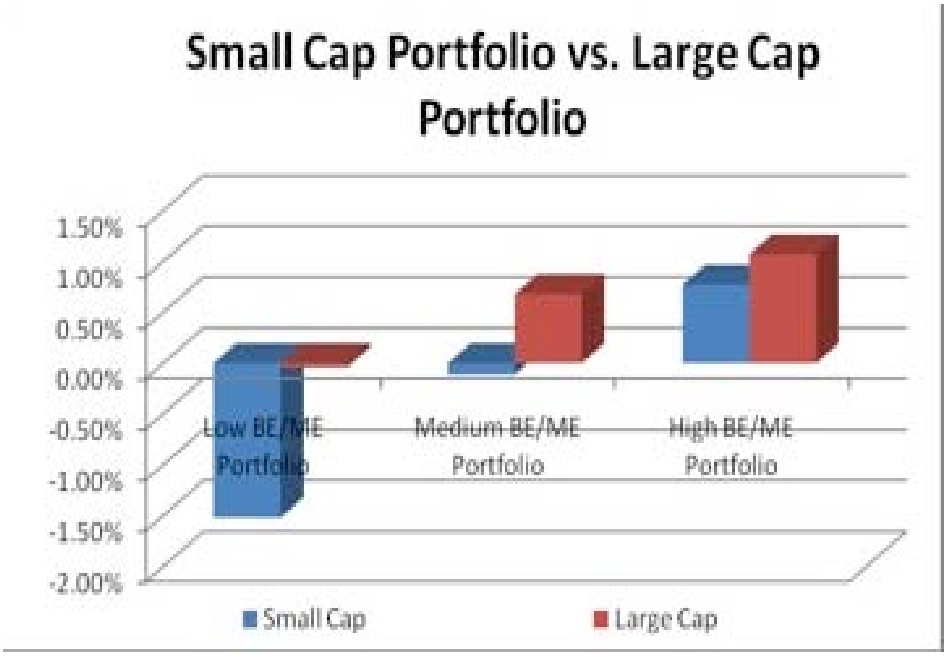

Figure 2

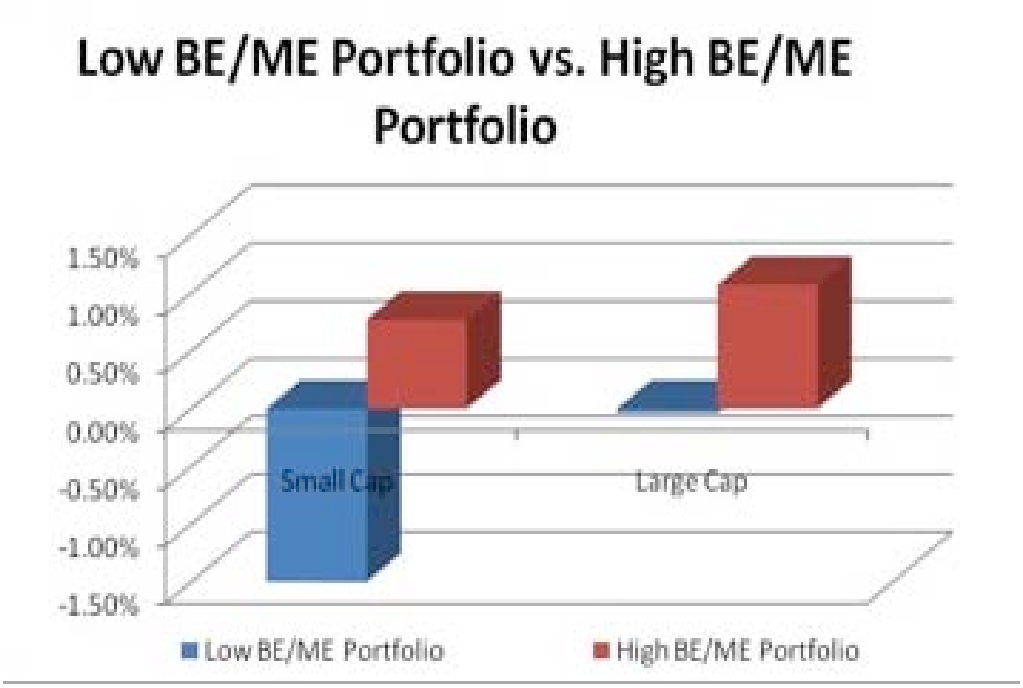

Table I shows that SMB has a negative average return of -2.57%. Both Table 1 and Figure 1 show ***that higher cap stocks produce higher than average returns in the UK market, representing a big firm effect.*** This challenges the Fama and French (1993, 1996) findings for the US Market but is consistent with UK Market findings of Malin and Veeraraghavan (2004).

The HML has a positive average return of 3.40% and a standard deviation of 4.80%. Figure 2 shows that stocks with higher BE/ME outperforms stocks with lower BE/ME in both the large cap and small cap portfolios. ***This suggests that there exists a value premium effect in the UK market over the sample period.*** This result is consistent with the findings of Fama and French (1993, 1996) and Dimson, Nagel and Quigley (2003) of the US and UK markets respectively.

3.1 Multifactor CAPM from 2001 – 2007

Table 2 shows that four (4) of the six (6) intercepts are significantly different than zero (0) at the 5% level. This implies that the portfolios of S/L, S/H B/M and B/H earn a return over and above the CAPM predicted return. Of course, we are working with estimates of the intercept and beta and not their true values. This can cause a bias in the beta estimate and may cause the intercept to be different from zero. The R Square (R^2) statistics range between 87% and 94%.

Table 2

CAPM Regressions to Explain Monthly Returns for May 2001 to June 2007
The CAPM regression is ***Rit – Rft = αit + βiM (RMt – Rft),*** where *Rit* is the return on one of the six size-*B/M* portfolios in excess of the 90 day Treasury bill rate, *Rft* is the bill rate, and *RMt* is the value weight market (LSE) return.

Multifactor Regression for Portfolios Formed on Size and Book-to-Market Equity Ratios Rit – Rft = αit + βiM (RMt – Rft) May 2001 - June 2007							
SIZE PORTFOLIOS		**BOOK TO MARKET EQUITY PORTFOLIOS**					
		Low	**Medium**	**High**	**Low**	**Medium**	**High**
		α coefficient			P Value		
Small		-0.016	0.005	0.005	0.000	0.167	0.000
Big		-0.001	0.005	0.009	0.420	0.000	0.000
		βi coefficient			P Value		
Small		1.213	0.975	0.802	0.000	0.000	0.000
Big		1.133	0.975	0.956	0.000	0.000	0.000
			R^2				
Small		0.871	0.907	0.918			
Big		0.930	0.944	0.897			

3.2 Split Sample CAPM (CAPMS1 & CAPMS2)

CAPMS1 regression results (Table 3) show that four (4) of the six (6) intercepts are significantly different than zero (0) at the 5% level. CAPMS2 (Table 4) shows deteriorating evidence for the CAPM's ability to fully explain the market returns of the UK market by having five (5) out of the six (6) intercepts that are significantly different than zero (0) at the 5% level.

Table 3

CAPMS1 Regressions: May 2001 to May 2004

Multifactor Regression for Portfolios Formed on Size and Book-to-Market Equity Ratios **Rit – Rft = αit + βiM (RMt – Rft)** **May 2001 - May 2004**							
SIZE PORTFOLIOS		**BOOK TO MARKET EQUITY PORTFOLIOS**					
		Low	**Medium**	**High**		**Low**	**Medium**	**High**
		α coefficient				P Value		
Small		-0.018	-0.002	0.009		0.005	0.491	0.001
Big		-0.006	0.005	0.008		0.050	0.014	0.012
		βi coefficient				P Value		
Small		1.219	0.952	0.817		0.000	0.000	0.000
Big		1.135	0.961	0.951		0.000	0.000	0.000
			R^2					
Small		0.891	0.918	0.937				
Big		0.943	0.961	0.914				

Table 4

CAPMS2 Regressions: June 2004 to June 2007

Multifactor Regression for Portfolios Formed on Size and Book-to-Market Equity Ratios **Rit – Rft = αit + βiM (RMt – Rft)** **June 2004 - June 2007**							
SIZE PORTFOLIOS		**BOOK TO MARKET EQUITY PORTFOLIOS**					
		Low	**Medium**	**High**		**Low**	**Medium**	**High**
		α coefficient				P Value		
Small		-0.013	-0.004	0.003		0.002	0.062	0.031
Big		0.004	0.005	0.010		0.027	0.005	0.000
		βi coefficient				P Value		
Small		1.127	1.120	0.770		0.000	0.000	0.000
Big		1.023	1.053	0.962		0.000	0.000	0.000
			R^2					
Small		0.741	0.875	0.835				
Big		0.886	0.866	0.797				

3.3 Full Period versus Split Sample CAPMS: Does Beta Vary?

Using the CAPMS1 as the base period, the S/M portfolio had the largest variation in β with a -17.61% change between split sample periods. Five (5) of the six (6) portfolios have percentage changes over the 5% mark. The most stable β portfolio is the B/H portfolio with the smallest percentage change of -1.13%.

3.4 Three Factor Model (TFM)

The results in Table 5 show that the intercept is not statistically different from zero for all six (6) portfolios at the 5% level. ***This suggests the TFM's risk factors are adequately priced leaving no abnormal returns to the portfolio.*** Table 5 also shows that βi is close to one and significant at the 5% level for all portfolios which implies all stocks move in step with the market.

The β coefficient is positive and significant at the 5% level for the three (3) small portfolios but negative and significant at the 5% level for the three (3) big portfolios. These results are consistent with the findings of Fama and French (1993, 1996) who report that small firms load positively on the SMB portfolio. ***The size premia[9] however shows a growth effect where large ME firms outperform small ME firms given the negative return attached to the SMB factor.***High BE/ME stocks (value stocks) have a positive coefficient on the HML portfolio.

For Low BE/ME stocks (growth stocks) βih is positive for the S/L portfolio and negative for the B/L portfolio.The βih coefficient is significant for all portfolios except the B/M portfolio at the 5% significance level. The parameter estimates for the HML portfolio are consistent with the findings of Fama and French (1993, 1996). ***The value premia shows that high BE/ME stocks outperform low BE/ME stocks, i.e., a value premium effect is identified for the UK market.***

[9] The size and value premia are taken as the product of the factor returns and the corresponding coefficients for each portfolio

Table 5

Three Factor Model (TFM) Regressions: May 2001 to June 2007

Book-to-Market Equity Ratios							
Rit – Rft = αit + βiM (RMt – Rft) + βisSMBt + βihHMLt +εit							
May 2001 - June 2007							
SIZE PORTFOLIOS		**BOOK TO MARKET EQUITY PORTFOLIOS**					
		Low	**Medium**	**High**		**Low**	**Medium**	**High**
		α coefficient				P Value		
Small		0.000	0.001	0.000		0.919	0.931	0.130
Big		0.000	0.002	-0.002		0.200	0.530	0.964
		βim coefficient				P Value		
Small		1.017	1.036	0.943		0.000	0.000	0.000
Big		0.974	0.977	1.047		0.000	0.000	0.000
		βis coefficient				P Value		
Small		0.179	0.199	0.112		0.000	0.000	0.001
Big		-0.210	-0.157	-0.144		0.000	0.000	0.000
		βih coefficient				P Value		
Small		0.355	0.080	0.226		0.000	0.013	0.000
Big		-0.246	0.024	0.173		0.000	0.260	0.000
			R^2					
Small		0.963	0.958	0.976				
Big		0.989	0.981	0.955				

The TFM has R^2 values ranging from 96% to 99%. A comparison of R^2 for each of the three models used indicates that the TFM has greater explanatory power. It can be concluded that the TFM explains the variance in the return of UK stocks better than the full period and conditional CAPM models.

3.5 Value Premium and the CAPM in the United Kingdom

To test the VCAPM's ability to explain value premiums in the UK market, we examine the following relationship:

$$HMLt = \alpha_{it} + R_f + \beta_i[E(R_m) - R_f], \qquad [2]$$

For the VCAPM to explain a value premium effect, the intercept (α_{it}) of equation [2] should be equal to zero, that is, there exists no pricing error in the model's specification (Fama and French 2006). Table 6 shows that the full period VCAPM as well as both split sample VCAPMS have intercepts significant at the 5% level. ***These results easily reject the VCAPM's and split sample VCAPM's ability to explain value premiums in the UK market.***

Table 6
VCAPM, VCAPMS1 & VCAPMS2 Regressions: May 2001 to June 2007

The VCAPM regression is

HMLt = αit + ßiM(RMt – Rft)

where the value premium, *HML* (high minus low), is the simple average of the returns on the two high portfolios minus the average of the returns on the two low portfolios, *RFt* is the 3 month Treasury bill rate, and *RMt* is the value weight market (LSE) return.

		α coefficient	**βi coefficient**	**p Value (α)**	**p Value (βi)**	R^2
VCAPM		0.03	-0.58	0.00	0.00	34.00%
VCAPMS1		0.04	-0.58	0.00	0.00	37.60%
VCAPMS2		0.02	-0.42	0.00	0.02	13.70%

4. CONCLUSIONS

This study had two (2) main objectives:
1. To provide an out of sample test for the TFM in the UK market over the period 2001 – 2007.
2. To empirically examine whether the market β's of the (1) full period CAPM and (2) split sample CAPM can explain observed value premium effects for the UK market.

Objective 1
OLS regression results indicated that the TFM outperformed both the full period CAPM and Split Sample CAPMs in explaining UK stock market returns. Inspection of the TFM output revealed no pricing errors in asset return explanation. The study identified a Big firm and Value premium effect for the UK market. It suggests that investors who hold stocks in firms with large Market Equity generate superior returns. This result challenges the findings of Fama and French (1993, 1996) that identify small firm effect findings for the US Market but is consistent with findings of Malin and Veeraraghavan (2004) for the UK market. This study also shows that investors who invest in value stocks will generate higher returns than those who hold growth stocks. This result is consistent with the findings of Fama and French (1993, 1996) and Dimson, Nagel and Quigley (2003) of the US and UK markets respectively.

Objective 2
The CAPM and its split sample versions do not describe Value Premium effects in the UK market. Intercepts of the regressions estimates are shown to contain pricing errors. The low R^2estimates (average of 28% for CAPM and Split sample CAPMs) signal that there exists further explanation of the HML (Value) variable which is not captured by the three CAPM models.

Evidence provides support for the TFM and it superior ability over the CAPM to explain returns and value premiums. This study also shows the variation of β over time through the use of a split sample CAPM. This result has implications for investors and portfolio managers who maintain the use of the traditional full period CAPM. It affords the opportunity for such persons and institutions to recognize time varying component of β as it relates to systematic risk and return.

There are, however, areas of research left unanswered by this study. For instance, the implications of industry classification on the TFM and CAPM or whether additional pervasive factors explain stock

returns were not examined. This study also did not examine more complicated versions of the CAPM such as the Inter-temporal CAPM and its ability to explain returns in the UK.

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