Comparative Study on Asset Pricing Models in Explaining Cross Sectional Variation of Stock Returns in the Colombo Stock Exchange

M.I.M. Riyath* (*riyath*.i@*sliate*.ac.lk)
Sri Lanka Institute of Advanced Technological Education

P.D. Nimal (*pdnimal@sjp.ac.lk)*
University of Sri Jayewardenepura

Abstract
This study intends to identify the better model in explaining variations of average stock returns of listed companies in the Colombo Stock Exchange (CSE) when time series and cross sectional regressions are employed. The sample consists of all stocks listed in the main board of the CSE except Bank, Finance and Insurance Sector during the period from 1997 to 2014. The methodology used to form factor mimicking portfolios to estimate risk factors and portfolio returns is similar to the methodology of Fama and French 1993 and 2012 and to test the performance of asset pricing models Fama and MacBeth (1973) two step procedure is employed. The Gibbons, Ross, and Shanken (GRS) (1989) F-test reveals that the Capital Asset Pricing Model (CAPM) is a poor model whereas the Fama and French (1993) Three Factor Model (FF3FM) and Carhart (1997) Four Factor Model (C4FM) are better models in explaining the cross sectional variations of stock returns of the listed companies in the CSE when time series regressions are employed. Fama-Macbeth t-test reveals that the C4FM is the only valid model in the size-BM sorted portfolios. The C4FM is found to be a superior model and performs better than FF3FM, Reward Beta Model (RBM) and CAPM and also the explanatory power of the FF3FM is comparatively better than both CAPM and RBM in explaining the cross section of stock returns of listed companies in the CSE.

Keywords: CAPM, FF 3-Factor Model, C4-Factor Model, Time Series Regression, Cross Sectional Regression, Reward Beta Model

INTRODUCTION

The Capital Asset Pricing Model of Sharpe (1964), Lintner (1965) and Black (1972) states that there is positive relationship between market risk and expected return. The findings of early empirical studies such as Lintner (1965), Black, Jensen and Scholes (1972), Fama and MacBeth (1973) and Stambaugh (1982) support the positive relationship between expected return and market risk. However, subsequent empirical studies specially after Fama and MacBeth (1973) provide inconsistent evidences on the positive liner relationship between market risk and expected return. Fama and French (1992) find that the relationship between market risk and average return is flat and size and book to market ratio have power in explaining the variation of stock returns. Nimal and Horimoto (2005) (as cited in Nimal & Fernando, 2013) find that the relationship between beta (market Risk) and average return is insignificant in the Tokyo Stock Exchange. Nimal (1997) finds that the CAPM does not have ability to explain stock returns and beta is not positively related with stock return in the Colombo Stock Exchange (CSE). Samarakoon (1997) finds that a strong negative relationship between return and beta in the CSE. These findings suggest that the relationship between beta and return is either weak or inconsistent and there are other several factors which can explain the variations of stock returns. Consequently, many studies focus on identification of other factor models that have more power in explaining the variation of stock returns.

Considering the inability of CAPM and empirical findings of the existence of size and value (BM) effect, Fama and French (1993) develop a three factor model (hereafter FF3FM). Fama and French (1993) find that the explanatory power of FF3FM is much higher than the CAPM. Many empirical findings in many developed and emerging markets have supported the FF3FM. Nanayakkara (2008) and Abeysekera and Nimal (2016a) have studied the FF3FM and find supportive evidences in the CSE.

However, Fama and French (1993) find that except the momentum effect documented by Jegadeesh and Titman (1993) other anomalies are largely disappear in the FF3FM model. Carhart (1997) formulate Four Factor model (hereafter C4FM) which introduce a factor for momentum effect. Further, Bornholt (2007) introduces the Reward Beta approach for estimating expected return and cost of capital as an alternative model by criticizing CAPM and factor models. Bornholt (2007) considers size and value effects into the Reward Beta Model (hereafter RBM) directly through use of portfolios. There are studies that empirically test these models and compare performance of C4FM with FF3FM and CAPM in explaining cross sectional variations of stock reruns of capital markets. The study of Abeysekera and Nimal (2016a) find that C4FM performs better than FF3FM and CAPM in explaining cross sectional variations of stock reruns in the CSE.

The comparative validity and performance of the asset pricing models such as CAPM, FF3FM, C4FM and RBM are empirically evaluated in deferent developed and emerging markets in explaining the cross sectional variations of average stock returns and also there are studies performed on these models to test the ability of explaining cross sectional variations of stock returns using time series data Alles and Murray (2008), Nimal (1997), Samarakoon (1997), Nanayakkara (2008), Randeniya and Wijerathna (2012) Abeysekera and Nimal (2016a) and Abeysekera and Nimal (2016b). However, the published studies on the test of comparative validity and performance of the asset pricing models using time series and cross sectional regression are hard to find in the Sri Lankan context. Therefore, this research intends to test the comparative validity and performance of the CAPM, FF3FM, C4FM and RBM using time series and cross sectional regressions in explaining cross sectional variations of stock returns in the CSE. Accordingly, the following specific research objectives are formulated;

1. To identify the better asset-pricing model in explaining cross sectional variation of stock returns of listed companies in the CSE when time series regression is used.
2. To identify the better asset-pricing model in explaining cross sectional variation of stock returns of listed companies in the CSE when cross sectional regression is used.

METHODOLOGY

Sample

The sample consists of all listed companies of the CSE during the period from October 1997 to September 2014. Following studies such as; Fama and French (1992, 1993, 2012) and most of the studies carried out in the CSE such as; Samarakoon (1997) and Abeysekera and Nimal (2016a) Bank, Finance and Insurance Sector is excluded and also stocks with negative BM ratios are excluded from the sample of this study. The Bank, Finance and Insurance Sector firms often have different firm structures. The high leverage that is normal for financial companies probably does not have the same meaning as for nonfinancial firms, where high leverage more likely indicates distress (Fama & French, 1992). In addition to that, newly listed companies and de-listed companies during the study period are also dropped from the sample to maintain the consistency across the study period. The relevant market data are obtained from the official website of the CSE (www.cse.lk), CSE data library. The relevant accounting data to calculate book and number of shares of the company are taken from published financial statements of respective companies. The monthly return of stocks are calculated following Nimal (2006b).

Test Procedure

We follow the Fama and MacBeth (1973) two step procedure which is frequently used in the literature to test asset pricing models (Fernando & Nimal, 2009, 2014; Gregory, Tharyan & Christidis, 2009, 2013; Nimal, 2006a; Nimal & Fernando, 2013) for the analysis. In the first step, the time series regression is used to estimate coefficients of risk factors (β_i, s_i , h_i and m_i) of respective asset pricing models. In the second step, the estimated coefficients in the first step are used as explanatory variables in cross sectional regression.

First step: The Time Series Regression

The time series regressions are performed to achieve the research objective-01 of this study. The time series regression equation-1 is used to estimate the β_i of CAPM. We run the time series regression equation-2 which is the excess portfolio returns on R_m-R_f (excess market return), SMB (size factor) and HML (value factor) to test the FF3FM. We run the regression equation-3 which is the excess portfolio returns on R_m-R_f, SMB, HML and WML (momentum factor) factors to test the C4FM.

$$R_{it} - R_{ft} = \alpha_i + \beta_i \left(R_{mt} - R_{ft}\right) + \varepsilon_{it} \quad (1)$$

$$R_{it} - R_{ft} = \alpha_i + \beta_i \left(R_{mt} - R_{ft}\right) + s_i SMB_t + h_i HML_t + \varepsilon_{it} \quad (2)$$

$$R_{it} - R_{ft} = \alpha_i + \beta_i \left(R_{mt} - R_{ft}\right) + s_i SMB_t + h_i HML_t + m_i WML_t + \varepsilon_{it} \quad (3)$$

Where;

R_{it} is the return of portfolio i at time t,

R_{ft} is the risk-free rate of interest at time t,

R_{mt} is the return of the market portfolio at time t

SMB_t is the size factor (Small minus Big) at time t

HML_t is the BM factor (High minus Low) at time t

WML_t is the momentum factor (Winner minus Loser) at time t

α_i is the intercept of portfolio i

β_i, s_i, h_i *and* m_i are coefficients of market, size, BM and momentum factors of portfolio i at time t respectively

ε_{et} is the residuals of the portfolio i at time t

Since the use of the individual portfolio intercept (α) and associated t-tests are not enough to make statistical inference, the GRS F-test which is introduced by Gibbons, Ross and Shanken (1989) is used to make appropriate statistical inferences. As Cochrane (2009) explains the intercept (α) term of time series regression of asset pricing model indicates pricing error and ability of the model to explain cross sectional variations of expected return in the market and the intercept value of any asset-pricing model should not be different from zero to consider as a valid model.

Based on the GRS test value of intercept, the comparative validity of asset pricing models are evaluated in order to achieve research objective-01. Furthermore, the comparative performance of asset pricing models in explaining cross sectional variations of average stock returns is evaluated using the adjusted R^2 of the time series regressions of the respective asset pricing model.

We use the methodology applied by Bornholt (2007) to test the performance of Reward Beta Model. The RBM also is a single factor model like CAPM. The Reward Beta (β_{ri}) of the RBM is calculated using equation-4. Unlike other models, the β_{ri} (Reward Beta) is not an estimate of time series regression. The β_{ri} (Reward Beta) is the ratio between average excess (monthly) return of respective portfolio divided by the average excess (monthly) market return (Bornholt, 2007). As such, the GRS F test statistics is not applicable for RBM.

$$\beta_{ri} = \frac{(\bar{R}_i - \bar{R}_f)}{(\bar{R}_m - \bar{R}_f)} \tag{4}$$

Where;

β_{ri} is the Reward Beta

$\bar{R}_m$ is the average market return

$\bar{R}_i$ is the average return of portfolio i

$\bar{R}_f$ is the average risk free rate

Second step: The Cross Sectional Regression

The cross sectional regressions are performed according to the Fama and MacBeth (1973) procedure to achieve the research objective-02 of this study. Following Cavenaile, Dubois and Hlávka (2009), the excess return of portfolios are taken as dependent variable and the coeffcients of risk factors estimated in the first step, time series regressions are taken as independent variables for the cross-sectional regressions in the second step

$$R_{ti} - R_{ft} = \gamma_{0t} + \gamma_{1t}\,\hat{\beta}_i + \varepsilon_{ti} \tag{5}$$

$$R_{ti} - R_{ft} = \gamma_{0t} + \gamma_{1t}\,\hat{\beta}_i + \gamma_{2t}\hat{s}_i + \gamma_{3t}\hat{h}_i + \varepsilon_{ti} \tag{6}$$

$$R_{ti} - R_{ft} = \gamma_{0t} + \gamma_{1t}\,\hat{\beta}_i + \gamma_{2t}\hat{s}_i + \gamma_{3t}\hat{h}_i + \gamma_{4t}\hat{m}_i + \varepsilon_{ti} \tag{7}$$

$$R_{ti} - r_{ft} = \gamma_0 + \gamma_{rt}\,\hat{\beta}_{ri} + \gamma_{1\,t}\hat{\beta}_i + \varepsilon_{ti} \tag{8}$$

Where;

R_{it} is the rate of return on portfolio i at time t,

R_{ft} is the riskfree rate at time t,

$\hat{\beta}_i,\ \hat{s}_i, \hat{h}_i\ and\ \hat{m}_i$ are estimated from the time series regression for Market, size, value, momentum factor respectively

γ_{0t} is the intercept (constant) at time t

$\gamma_{1t}, \gamma_{2t}, \gamma_{3t}\ and\ \gamma_{4t}$ are coefficient of $\hat{\beta}_i, \hat{s}_i, \hat{h}_i$ and $\hat{m}_i$ respectively at time t

$\hat{\beta}_{ri}$ is the Reward Beta estimated in equation (5)

ε_{ti} is the residuals of the asset i at time t.

The equation-1 estimates β_i which is used in equation-5 for CAPM; the equation-2 estimates β_i, s_i and h_i which are used in the equation-6 for FF3FM; the equation-3 estimates β_i, s_i , h_i and m_i which are used in the equation-7 for C4FM in the second step cross sectional regresions. Further, the equation-1 estimates β_i and the equation-4 estimates β_{ri} which are used in equation-8 for RBM in the second step cross sectional regresion. The use of the individual value of cross sectional regression coefficient estimates ($\gamma_0, \gamma_1, \gamma_2, \gamma_3\ and\ \gamma_4$) and associated t-tests are not enough to make statistical inference. "Fama and MacBeth (1973) propose a method for addressing the inference problem caused by correlation of the residuals in cross-section regressions" (Fama & French, 2004, p. 31). Therefore, The statistical inference is done using the Fama and MacBeth (1973) approach to adjusted t-statistic as given in equation-9 and the statistical significance is determined by the t distribution critical value.

$$t(\overline{\gamma_k}) = \frac{\overline{\gamma_k}}{\frac{sd\,(\overline{\gamma_k})}{\sqrt{T}}} \tag{9}$$

Where;

$\overline{\gamma_k}$ is the average of kth coefficient estimate of cross sectional regression

$sd\ (\overline{\gamma_k})$ is the standard deviation of the γ_k

T is the number of time series observations.

According to Gregory et al. (2013) the value of intercept in the cross sectional regression of the asset pricing model should not be different from zero to consider that as a valid model. Based on the Fama and MacBeth (1973) adjusted t-statistic value of intercept, the comparative validity of asset pricing models are evaluated in order to achieve research objective 2. Furthermore, the comparative performance of asset pricing models in explaining the cross sectional variations of average stock returns are evaluated using adjusted R^2 of the cross sectional regressions of the respective asset pricing models. The conceptual framework of the study can be depicted in the Figure 1.

Conceptual Framework

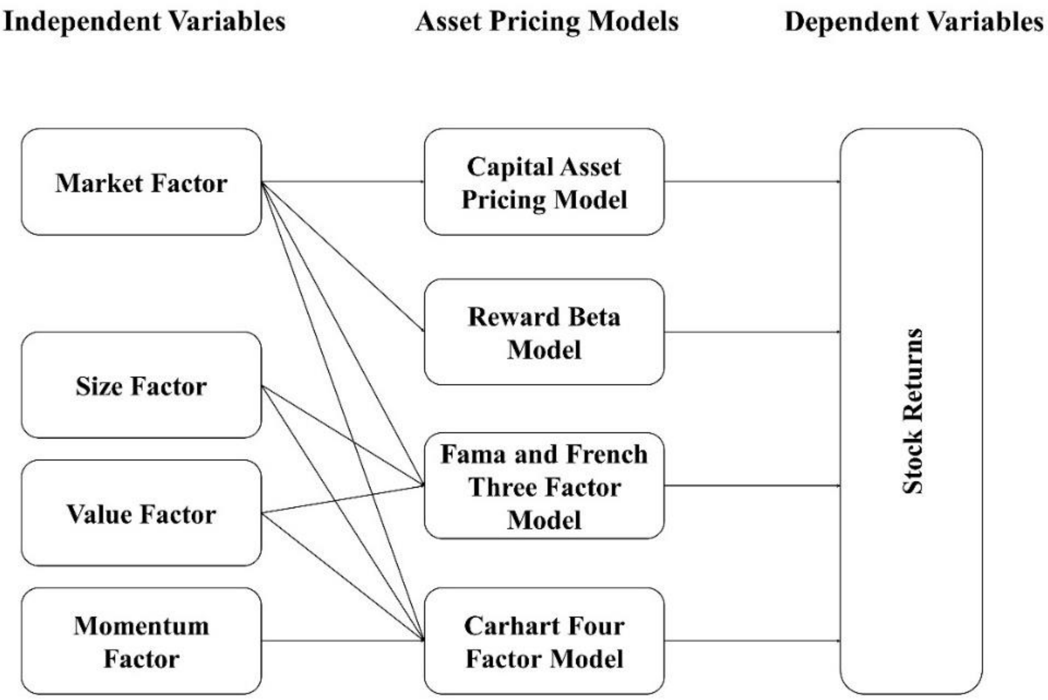

Figure 1: Conceptual Framework

Formation of Variable for Time Series Regression of step 1: The two set of six portfolios are formed based on Fama and French (1993, 2012) methodology in order to calculate the risk factors such as SMB, HML and WML as shown in Table-1, for the step 1 of the time series regressions. The first set of six portfolios (BH, BM, BL, SH, SM and SL) are formed at the end of September of each year t based on the intersection of two size and three BM sorted portfolios to calculate SMB and HML factors. The second set of six portfolios (BW, BN, BL, SW, SN and SL) are formed each month based on the intersection of two size and three momentum (past six months return) sorted portfolios.

Similar to Fama and French (1993) and Kongahawatte and Nimal (2015) the SMB (Small minus Big) is defined as the difference of the monthly returns between the portfolios of small stocks and big stocks. In order to construct the size portfolios, all sample of stocks are sorted based on the firm size in ascending order. Then, stocks are assigned into two groups such as Small (S) and Big (B) based on split point which is 50% in September of each year t. The size of the firm is measured in terms of market value. It means that market closing price (at last trading day of the month) times number of ordinary shares outstanding (Nanayakkara, 2008; Samarakoon, 1997; Titman, Wei & Xie, 2004).

Table 1: Factor Mimicking Portfolios

		BM			Momentum		
		High	Medium	Low	Winner	Neutral	Loser
Size	Big	BH	BM	BL	BW	BN	BL
	Small	SH	SM	SL	SW	SN	SL

The HML (High minus Low) denotes the BM related risk factor. In order to construct BM portfolios, the sample of stocks are independently sorted into three groups based on the BM ratio. Then, stocks are assigned into three groups such as Low (L), Medium (M) and High (H) based on 30^{th} and 70^{th} percentiles as the break points. The book value of a firm is the share capital plus reserve plus deferred tax. In order to measure the BM, book value of equity is divided by the market value of equity. The WML (Winner minus Loser) is the difference between the monthly returns of winner portfolios and the loser portfolios. In order to construct the momentum portfolios the sample of stocks are independently sorted into three portfolios based on the return of past returns. Considering the findings of Pathirawasam and Weerakoon Banda (2012, p. 30) and Anuradha and Nimal (2013) the momentum factor is formed based on average monthly return of past six month with a one month lag (i.e., t-7 to t-1). Then, split the stocks into three groups based on the break points such as 30^{th} and 70^{th} percentiles.

The size related risk factor, SMB is the difference of simple average return between the three small size portfolios (SH, SM, and SL) and the three big size portfolios (BH, BM, and BL). The BM related risk factor, HML is the difference of simple average return between the two high BM portfolios (SH and BH) and the two low BM portfolios (SL and BL). The momentum related risk factor, WML is the difference of simple average return between the two winner portfolios (SW and BW) and the two loser portfolios (SL and BL).

Following (Abeysekera & Nimal, 2016a; Kongahawatte & Nimal, 2015), this study measures the firm size at the end of September t to form size related portfolios and factors and the book value of equity of September of each year t is divided by the market equity as at the end of financial year t to calculate the BM ratio of firms. This study use All Share Price Index (ASPI) of the CSE as the proxy for market return and the 91days government Treasury bill rate as the risk free rate.

Formation of Variables for Cross Sectional Regressions of Step 2: This study also uses the same methodology used by Fama and French (1993, 2012) to make two set of sixteen portfolios. The market capitalization, Book to Market ratio and momentum return of sample companies are sorted on ascending order and divided into four equal size groups based on quartile. Then, a set of sixteen size-BM portfolios are constructed with the intersection of the four size and four BM sorted stocks. Another set of sixteen size-momentum portfolios are constructed with the intersection of the four size and four momentum sorted stocks. The equally weighted returns of each size-BM portfolio and each size-momentum portfolio are calculated after allocating stocks into portfolios. In this study, the size-BM portfolios are formed at the end of September in each year t and then calculated equally weighted monthly returns of each month from the October of year t to the September of year t+1. Following Abeysekera and Nimal (2016a) and Vosilov and Bergström (2010) these portfolios are reformed in September t+1 annually. However, as done by Abeysekera and Nimal (2016a) and Fama and French (2012) the size-momentum portfolios are formed on monthly basis to calculate equally weighted monthly returns of subsequent month.

ANALYSIS

Explanatory Returns

The descriptive statistics, i.e., mean of the excess market return, standard deviation and associated t statistics of four risk factors are presented in Table 2. It is evident that the average value of market factor of 0.458% (t=0.879) is insignificant during the study period. The average premium of size related factor, i.e., SMB is 1.039% (t=2.4) per month is significant. This finding is consistent with Carhart (1997), Czapkiewicz and Skalna (2010) and Fama and French (1993) who report postive significant average SMB factor, The study of Czapkiewicz and Wójtowicz (2014) Brailsford, Gaunt and O'Brien (2012) and Gregory et al. (2009) report negative insignificant size premium.

The BM factor (HML) produces average value premium of 0.694% (t=1.466) per month is not significant at 5% level. The study of Carhart (1997) Brailsford et al. (2012), Gregory et al. (2009), Czapkiewicz and Skalna (2010) and Fama and French (1993) report significant positive BM premium whereas Czapkiewicz and Wójtowicz (2014) report negative insignificant BM premium.

Table 2: Summary Statistics for Explanatory Returns

	R_m - R_f	SMB	HML	WML
Mean	0.458	1.039	0.694	0.958
Standard Deviation	7.447	6.186	6.761	8.034
t statistics	0.879	2.400*	1.466***	1.703**

Note: *, **, *** significant at 0.05, 0.10 and 0.15 level respectively.

Source: Authors' calculation.

The momentum factor (WML) produces premium of 0.958% (1.703) per month which is significant at 10% level. This finding is consistent with the finding of Carhart (1997), Czapkiewicz and Wójtowicz (2014) and Gregory et al. (2009) who report significant and positive momentum premium per month. Furthermore, Fama and French (2012) report significant momentum premium in North America, Europe, Asia Pacific and in Global whereas they report insignificant momentum premium in Japan.

Excess Returns of size-BM and size-momentum Portfolios

The average excess monthly return of each portfolio is tabulated in Table-3. It shows a weak size effect during the study period. Consistent with the literature, in general, the size effect shows a negative relationship between return and size. These findings are consistent with Abeysekera and Nimal (2016a) who report no persistent pattern related to size and return in the CSE.

It is also found that the average return is positively related with BM which supports for the existence of value effect in CSE during the study period. This finding is consistent with Abeysekera and Nimal (2016a), Kongahawatte and Nimal (2015) and Nanayakkara (2008) in CSE. Further, the finding of this study is consistent with findings of Fama and French (1992), Rouwenhorst (1999) and Lakonishok, Shleifer and Vishny (1994) in international markets.

Table 3: Summary Statistics for Mean Monthly Excess Returns of the two set of sixteen portfolios

	Mean Monthly Excess Return				t statistics			
Panel A: size-BM portfolios								
size	Book to Market				Book to Market			
	V1	V2	V3	V4	V1	V2	V3	V4
S1	2.757	2.061	2.352	4.725	1.652	2.257*	2.946*	3.899*
S2	1.702	1.464	1.637	2.028	1.825	1.789	2.424*	2.878*
S3	0.941	1.813	0.802	1.313	1.364	2.319*	1.382	1.849
S4	0.817	1.163	3.022	2.028	1.704	1.939	2.611*	2.186*
Panel B: size-momentum portfolios								
	Momentum				Momentum			
	M1	M2	M3	M4	M1	M2	M3	M4
S1	3.094	2.898	2.480	6.799	3.240*	3.210*	2.862*	2.160*
S2	1.101	2.092	2.163	1.648	1.417	2.496*	2.765*	2.340*
S3	0.909	0.638	1.125	1.854	1.167	1.123	1.724	2.452*
S4	0.752	0.968	1.400	2.511	1.025	1.626	2.429*	2.595*

Note: *- significant at 0.05 level

Analysis of this study reveals that the average return of four portfolios on each momentum quartile, tend to increase as momentum increases from loser to winner portfolios. This finding is consistent with Jegadeesh and Titman (1993, 2001), Chan, Jegadeesh and Lakonishok (1996) and Chui, Wei and Titman (2000) who report that winner stocks outperform loser stocks in the subsequent holding period. And also a considerable momentum effect is observed in biggest size quartile portfolios. However, it seems no regular pattern in other size quartile portfolios when momentum increases from loser to winner portfolios. This finding is consistent with Abeysekera and Nimal (2016a) who observe that the average return increases when moving from loser to winner portfolios in big size portfolios and seen contrarian pattern in small size portfolios.

Test of Time Series Regression

The Time Series Regression results of Asset Pricing Models is presented in Table 4. The GRS F statistic value of the CAPM are far into right side from zero in F distribution and the associated p value are less than significant value of 0.05. Hence, the hypothesis that intercepts of CAPM regression for all portfolios jointly equal to zero is rejected. Therefore, the CAPM is not a valid model in explaining cross sectional variations of average stock return in CSE when time series regression is applied. This finding is consistent with the finding of Abeysekera and Nimal (2016a), Shaker and Elgiziry (2014), Czapkiewicz and Skalna (2010), Czapkiewicz and Wójtowicz (2014) and Artmann et al. (2012) who performed GRS F test and report that the intercept values of CAPM are significant.

Table 4: Time Series Regression Summary of Asset Pricing Models

	Sixteen 4x4 size-BM portfolios			Sixteen 4x4 size-momentum portfolios		
Model	GRS		R^2	GRS		R^2
	F	P	AR^2	F	P	AR^2
CAPM	2.8618	0.04125*	0.4610	3.4884	0.02053*	0.4652
FF3FM	2.0245	0.11945	0.5677	2.5775	0.05817	0.5369
C4FM	1.8660	0.14864	0.5828	2.4149	0.07136	0.5783

AR^2 is the adjuded R^2 of regression model. F is the F statistics value of GRS test. The p value is associated to the GRS test.

Note: *- significant at 0.05 level

The analysis of the GRS F statistic value of FF3FM and C4FM suggest that the inclusion of additional factors in addition to market factor reduce considerable amount of asset pricing error and caused a substantial improvement of the model. The p-value of FF3FM and C4FM are higher than significant value 0.05. Therefore, the hypothesis that the intercepts of FF3FM and C4FM for all portfolios jointly equal to zero cannot be rejected. Therefore, the FF3FM and C4FM are valid models in explaining cross sectional variations of average stock return in the CSE in the time series regression.

The GRS F test of this study reveals that the intercept value of FF3FM is smaller than CAPM. Therefore, the FF3FM is a valid model and better than CAPM in explaining cross sectional variations of average stock return in CSE in the time series regression. The study of Abeysekera and Nimal (2016a), Czapkiewicz and Skalna (2010), Artmann et al. (2012) and Czapkiewicz and Wójtowicz (2014) report that FF3FM is better than CAPM. Furthermore, the C4FM is a valid model and better than FF3FM and CAPM in explaining cross sectional variations of average stock return in CSE in the time series regression. This finding is consistent with the study of Abeysekera and Nimal (2016a), Artmann et al. (2012) and Czapkiewicz and Wójtowicz (2014).

This study reports that the average adjusted R^2 of CAPM (size–BM portfolio) of the CAPM able to explain less than half of cross sectional variations of average stock return in the CSE using time series regression. Nartea, Ward and Djajadikerta (2009) also report smaller value of adjusted R^2 for CAPM and they state that the lower value of adjusted R^2 arises due to the small number of stocks listed in the New Zealand market.

The analysis of this study reports that there is an improvement of performance in the FF3FM. The improvement on adjusted R^2 suggests that the FF3FM performs better than CAPM in the CSE during the study period. This finding is consistent with Abeysekera and Nimal (2016a) in Sri Lanka and several studies in international markets.

Further improvement also can be observed in adjusted R^2 in C4FM than FF3FM of this study. The improvement can be observed in all sixteen both set of (size-BM and size-momentum sorted) portfolios. Therefore, the results suggest that the C4FM is able in explaining more variations of average return than FF3FM and CAPM. The finding of this study is consistent with the findings of Czapkiewicz and Wójtowicz (2014), Moez et al. (2013), Lam, Li and So (2010), Chen and Fang (2009) and Artmann et al. (2012).

Test of Cross Sectional Regression

The second step, cross sectional regression of Fama and Macbeth (1973) procedure results are summarized in table-4. The analysis of size-BM sorted portfolio shows that the cross sectional regression parameter $\overline{\gamma_0}$ of CAPM and FF3FM are negative and larger, but $\overline{\gamma_0}$ of RBM is positive and smaller. The comparison of $\overline{\gamma_0}$ of CAPM and RBM reveals that $\overline{\gamma_0}$ of RBM seems closer to zero than CAPM. It suggests that the RBM has lower asset pricing errors than CAPM. Therefore, the RBM is comparatively more effective model than CAPM in explaining cross sectional variation of stock return in the cross sectional regression.

Further, the $\overline{\gamma_0}$ of CAPM, FF3FM and RBM are statistically significant at 5% level in size-BM portfolios. As a result, the $\overline{\gamma_0}$ of CAPM, FF3FM and RBM are statistically different from zero. Hence, the hypotheses that $\overline{\gamma_0}$ is equal to zero is rejected. It suggests that the CAPM, FF3FM and RBM are invalid in explaining cross sectional variations of stock returns in cross sectional regression in the CSE. The study of Artmann et al. (2012), and Gregory et al. (2013) report that CAPM is a valid model, whereas Rogers and Securato (2007) report that

CAPM is an invalid model. The study of Gregory et al. (2013) reports that FF3FM is an invalid model but the study of Artmann et al. (2012), Hasnaoui and Ibrahim (2013) and Rogers and Securato (2007) report that FF3FM is a valid model.

Table 5: Fama and MacBeth Cross-Sectional Regression

Panel A: size-BM portfolios							
Model	$\overline{\gamma_0}$	$\overline{\gamma_r}$	$\overline{\gamma_1}$	$\overline{\gamma_2}$	$\overline{\gamma_3}$	$\overline{\gamma_4}$	R^2
CAPM	-3.424		5.259				10.61%
t statics	(-25.45)*		(35.79)*				
FF3FM	-2.494		4.150	0.781	0.485		26.70%
t statics	(-21.26)*		(31.825)*	(22.531)*	(11.953)*		
C4FM	-0.160		1.731	0.617	0.538	2.418	35.00%
t statics	(-1.574)		(15.130)*	(17.767)*	(13.275)*	(38.515)*	
RBM	0.906	0.458	0.00				18.82%
t statics	(6.294)*	(55.785)*	(0.001)				
Panel B: size-momentum portfolios							
Model	$\overline{\gamma_0}$	$\overline{\gamma_r}$	$\overline{\gamma_1}$	$\overline{\gamma_2}$	$\overline{\gamma_3}$	$\overline{\gamma_4}$	R^2
CAPM	-3.130		4.942				12.40%
t statics	(-16.52)*		(25.24)*				
FF3FM	1.004		0.419	1.298	-0.693		30.60%
t statics	(10.70)*		(4.11)*	(31.24)*	(-6.052)*		
C4FM	1.082		0.202	0.808	1.205	0.902	38.90%
t statics	(11.57)*		(2.00)*	(20.51)*	(12.182)*	(20.80)*	
RBM	0.906	0.458	0.000				21.20%
t statics	(5.94)*	(53.55)*	(0.001)				

Note: The analysis use all 204 monthly observations from October 1997 to September 2014 of monthly portfolio excess returns and coefficient of risk factors estimated in time series regression. The cross sectional regression test of asset pricing model is performed for all months on equation 5, 6, 7 and 8 respectively. The coefficient (γ) and significance of cross sectional regression of respective asset pricing models are presented in the table. The $\overline{\gamma}$ is the time series average of γ. The t statics is the Fama and Macbeth (1973) t statistics which is estimated in equation-9. The R^2 is the time series average of explanatory power of respective asset pricing model.

*significant at 0.05 level.

Source: Authors' calculation.

However, the $\overline{\gamma_0}$ of C4FM is smaller value which is statistically insignificant at 5% level. Hence, the hypothesis that $\overline{\gamma_0}$ is equal to zero cannot be rejected. Therefore, the C4FM is a valid model in explaining cross sectional variation of stock return in cross sectional regression of size–BM sorted portfolios. The finding of this study is consistent with the finding of Czapkiewicz and Wójtowicz (2014), Artmann et al. (2012), Gregory et al. (2013) and Hasnaoui and Ibrahim (2013) who report that C4FM is a valid model.

The analysis of size-momentum sorted portfolios reveals that the $\overline{\gamma_0}$ of cross sectional regression coefficient of all four models are statistically significant at 5% level. Hence, the $\overline{\gamma_0}$ is equal to zero is rejected. Therefore, none of the models is valid asset pricing model in explaining cross sectional variation of stock return in CSE when portfolios are sorted on size and momentum. The CAPM shows a negative $\overline{\gamma_0}$ but rest of the models show a positive $\overline{\gamma_0}$. The $\overline{\gamma_0}$ of RBM is closer to zero than rest of the models and the t statistics of RBM is closer to zero than rest of the models. Therefore, the RBM have displayed lower asset pricing errors than all other models in size-momentum portfolios in the CSE in the cross sectional regression.

The R^2 measures the performance of asset pricing model in explaining variations of portfolio return (Czapkiewicz & Wójtowicz, 2014). This analysis reports that the time series average of R^2 value of cross sectional regression of asset pricing models is lower for the both (size-BM and size-Momentum) set of portfolios. The finding is consistent with Fernando and Nimal (2009) who report that the R^2 of Fama and MacBeth (1973) cross sectional test of CAPM is less than 10% in Sri Lankan context. The R^2 value of the RBM is higher than that of the CAPM. Therefore, it suggests that the RBM performs better than CAPM in explaining cross sectional variations of average stock returns in cross sectional regression in CSE. This finding is consistent with the finding of Bornholt (2007), Gabriel and Rogers (2014) and Hernández and Cervantes (2010). However, this finding is inconsistent with the finding of Rogers and Securato (2007).

This study reports that the average R^2 of FF3FM is higher than both CAPM and RBM in both (size-BM and size-momentum) set of portfolios. It suggests that the FF3FM performs better than CAPM and RBM. This finding is consistent with the findings of Gabriel and Rogers (2014), Rogers and Securato (2007) and Hernández and Cervantes (2010) who state that the FF3FM performs better than CAPM and RBM in second step cross sectional regression. However, this finding of the study is inconsistent with the finding of Bornholt (2007) who reports that the average R^2 value of RBM is higher than FF3FM and CAPM. Furthermore, this study finds that the C4FM performs better than all models considered in this study in the second step cross sectional regression for both (size-BM and size-momentum) set of portfolios which is consistent with the finding of Czapkiewicz and Wójtowicz (2014), and Artmann et al. (2012). However (Gregory et al. (2013)) report that both the FF3FM and C4FM perform equally.

CONCLUSION

The conclusions are drawn in line with the research objectives of this study based on time series and cross sectional regressions on each asset-pricing model. Based on the GRS F test statistics and adjusted R^2 , the C4FM is found as the better asset-pricing model than FF3FM and CAPM in explaining cross sectional variations of average return of stocks listed in CSE in the time series regression. Based on the Fama-Macbeth t statistics and average R^2 value, the C4FM is found as the better asset-pricing model than FF3FM, RBM and CAPM in explaining cross sectional variations of average return of stocks listed in CSE in the cross sectional regression.

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