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AUTHORS

Hussein Mohammad Salameh  <https://orcid.org/0000-0001-6893-1862>

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Hussein Mohammad Salameh,
Associate Professor in Finance,
Researcher, Amman, Jordan.
(Corresponding author)



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Hussein Mohammad Salameh (Jordan)

APPLICATION OF ASSET PRICING MODELS: EVIDENCE FROM SAUDI EXCHANGE

Abstract

The Saudi Arabia Stock Exchange (Tadawul) is one of the biggest emerging Stock Exchanges in the Middle East region. Therefore, this research aims to apply Fama and French (2015) 5-factor model on Tadawul, and compares it with the Fama and French 3-factor model and CAPM to check the applicability of the models in Tadawul and the identity of the factors that can affect stock returns. Furthermore, the Generalized Method of Moments (GMM) regression has been implemented to examine the impact between the variables in the models. Empirically, the results show that Fama and French (2015) 5-factor model is the most consistent model in comparison to the other two models in terms of explaining the cross-section of average stock returns in Tadawul. However, it is not the best according to the intercepts results of all the regressions in 2x3, 2x2, or 2x2x2x2 sorts. Besides, Fama and French (2015) 5-factor model has the highest explanatory power in most of the portfolios based on the adjusted R² regardless of the sort (2x3, 2x2, or 2x2x2x2). Finally, the results conclude that Fama and French (2015) 5-factor model can be an applicable model in Tadawul but only market and size can affect the stock returns, while the value, profitability, and investment cannot. Accordingly, the author recommends that, as a continuation of this research, further research can be done, which investigates a model with additional factors like momentum and illiquidity.

Keywords

Tadawul, Fama and French, CAPM, returns, GMM

JEL Classification

G10, G11, G12, B23

INTRODUCTION

The Modern Portfolio Theory was established around 1950 by Markowitz. Its main objective was to consider the asset return through its risk adjustment. Markowitz's contributions paved the way to Sharpe and others to construct the famous Capital Asset Pricing Model (CAPM). This single index model describes the linear adjusted relationship between the asset or portfolio return and the market risk beta.

The Arbitrage Pricing Theory (APT) was introduced around 1970 by Ross and Roll. It was a multiple independent micro or macro variables model to present the asset return (R_i) without determining the identity of the variables. The Size factor presented by Banz (1981), Jegadeesh and Titman (1993) introduced the momentum factor. Fama and French (FF1992, FF1993) models were mainly concerned with the milestone models (market, size and book-to-market (B/M)). Carhart (1997) 4-factor model consisted of FF1993 3-factor model and momentum. Moreover, Amihud (2002) introduced the illiquidity factor. Denial and Titman (1996) tested the independent variables as a characteristic excluding risk factor. The Profitability factor was identified by Novy-Marx (2013). The Investment factor was documented by Alharoni et al. (2013). Consequently, Fama and

French introduced their new milestone Fama and French 5-factor model in 2015 (FF2015), adding two factors, profitability and investment, to FF1993 model. Therefore, this research aims to analyze the application of FF2015 on Tadawul.

The implementation of such models in a developed exchange in Tadawul is full of challenges and difficulties, such as the Islamic Culture (Zikaa not Taxes) and the lack of consensus about the numbers, and identification of factors that affect the stock returns (R_i). However, this research aims to empirically assess the accuracy of standard asset pricing models to the Saudi Arabia Stock Exchange (Tadawul). In particular, the 5-factor, 3-factor, and CAPM are tested.

The present and current author's research makes several major contributions. Firstly, during the study period, this paper was the first to apply FF2015 model in an emerging market such as Tadawul. A second contribution is that it checks the identity of the factors that can affect (R_i). A third contribution is that it finds if the applicable models employed in the developed markets explain the cross-sectional variations on (R_i) at Tadawul.

1. LITERATURE REVIEW

To begin with, Markowitz could show how to construct an efficient frontier of portfolios, while Sharpe developed the single index model in 1963 and CAPM in 1964 (Haugen, 1997). The introduction of the USA earliest articles concerning this topic was full of contradictions and agreements. Fama and Macbeth (1973) proved that the portfolio risk only affects the returns. On the other hand, Banz (1981) found that smaller firms had a higher "risk-adjusted returns on average" than large firms. Reinganum (1982) totally agreed with Banz. However, Horowitz, Loughran, and Savin (1996) and Roll (1981) came to a contradiction with Banz. From Roll's (1981) perspective, the problem with Banz's study was in the methods and ways used to measure riskiness of small firms.

Many debates were concerned with the microeconomic risks. This includes a couple of FF statements. In 1992, they stated that Size and B/M are used with market β to capture the variation in the returns. In 1993, they stated that stock returns have shared variation due to Market, Size, B/M factors. In 1995, they also stated that many anomalies disappeared in FF1993 model. On the other hand, Davis, Fama, and French (2000) showed that FF1993 model explains the value premium better than the hypothesis that B/M characteristic is compensated irrespective of risk loadings. In 2003, Fama and French indicated that CAPM has been widely used in multiple applications. In 2007, they provided a framework for the disagreement

among investors on probability distributions of future payoffs on assets. In 2012, Fama and French proved that there are value and momentum in average returns. As a result, a new milestone was introduced in FF2015 model by capturing size, value, profitability, and investment patterns in average stock returns. In 2017, Fama and French showed that average stock returns increase with B/M and profitability, and it is also negatively related to investment.

As a further contribution to the debate, Daniel and Titman (1997) indicated that the characteristics appear to explain the variation in returns, but not the covariance structure of returns. Daniel, Titman, and Wei (1999) could reject FF1993 model, but not the characteristics model. Also, Kim (1997) found that size, B/M, earnings price, and β s have explanatory power on the returns. In 2003, Gomes suggested that size and B/M can be consistent with conditional CAPM. However, Jegadeesh and Titman (1993) added the momentum factor. Jensen (1972) indicated that risk premium on an asset is not relative to its β . Griffin (2002) showed that the 3F model has the best performance on a country-specific basis and supported domestic factors. In contrast, Bartholdy and Peare (2005) found poor performance for CAPM and FF models. Liu (2006) showed that market and liquidity model explains returns effectively so as B/M. From his side, Chen, Novy-Marx, and Zhang (2011) explained that market, investment, and return-on-equity model reduce magnitude of abnormal returns to insignificance. Blitz (2016) il-

illustrated how FF2015 model improved explanatory power. Bianchi (2016) also showed that FF2015 is the best. Wahal (2017) showed that profitability is similar in magnitude in pre and post 1963 periods. He also observed no relation between investment and returns. Hühn (2016) supported momentum factor.

Similarly, in Europe, Bhatnagar and Ramlogan (2012) compared CAPM's performance and evaluation in the UK using different approaches than the previous FF. Staying in the UK, Gregory and Michou (2009) showed that FF1993 model is better than CAPM, and they proved that size and value factors have an +impact. In further discussions on this issue in Italy, Brighi et al. (2013) found that market and size are confirmed for local investor. On the contrary, value factor has a weak proof. Let us consider the same issue in Turkey. Eraslan (2013) found that large size firms have more excess returns than small firms. In general, low B/M firms have better performance than high ones. Staying in Turkey, Unlu (2013) indicated that CAPM, 3F, 4F, and 5F models are applicable. Furthermore, Faff and O'Brien (2001, 2007) supported FF1993 model in Australia.

Highlighting the Asian markets (Far East and China), Drew (2003) showed that B/M and size have a negative impact. In this regard, Wang and Di Iorio (2007), concluded that FF1993 model is superior to CAPM. Moving forward to Japan, Pham (2007) confirmed a reversal of size effect during post bubble period. Moreover, in India, Connor and Sehgal (2001) confirmed the effect of market and size. In Thailand, Homsud, Wasunsakul, Phuangnark, and Joongpong (2009) concluded that FF model verified the variations through explaining risk factor in form of stock return. Along with this, Hamid, Hanif, Malook, and Wasimullah (2012) indicated that FF explained many variations in returns in Pakistan firms. Tackling this issue in Tehran, Shams et al. (2014) showed that the influence of size and value factors was eliminated. Investigating this issue in Vietnam, Hoang et al. (2013) found that FF1993 model are superior to CAPM. Also, 4-factor model (FF1993 and liquidity) is superior. Moving on to Korea, Kim et al. (2012) found that FF1993 model performs most satisfactorily among the others.

Investigating the African exchanges, Bundoo (2008) confirmed that FF1993 model holds for a Mauritius Exchange. Naceur and Chaibi (2007) from Tunisia showed that Carhart model is the selected one. In Sudan, Khalafalla (2014) showed that APT outperformed FF and CAPM. Considering asset pricing models in Egypt (Shaker & Elgiziry, 2013, 2014), Shaker (2015) showed that FF model is the best. Tahaa and Elgiziry (2016) concluded that a model, which incorporates market, size, B/M, E/P, and liquidity factors, is the best.

Moving the discussion to Middle East, Al-Zubi and Salameh (2009) indicated that FF1993 model is applicable in Amman Stock Exchange, and they stated that market and size variables had a significant impact. Aldaarmi, Abbod, and Salameh (2015) also showed the same results in Tadawul, but only market variable had an impact. Staying in Saudi Arabia, Habib (2016) found that Proxy Asset Pricing specifications are scant due to a lack of theoretical frameworks and misguided significance tests of factor loadings. To best of our knowledge, this research definitely is one of few supervene researches that apply the FF2015 methodology in Tadawul among Arab exchanges.

2. METHODS

2.1. Data and sample

The period herein extended from January 2014 to August 2017, monthly stock prices of Tadawul firms were used (44 observations). The source of data is the Tadawul's website (<http://www.tadawul.com.sa/>).

2.2. Models

This author tested the factors of three models to find out if the factors in each model affect the portfolio returns. Moreover, the models were tested by using Generalized Method of Moments (GMM) regression (it does not need information about the exact distribution of the disturbances). In fact, many common estimators in econometrics can be considered as special cases of GMM, and time series (HAC) GMM is a robust estimate with regard to the heteroskedasticity and autocorrelation of unknown form was used to find out if the value of the intercept = 0, which means that the model cap-

tures the cross-sectional variation in stock returns. The models with the intercept that is closer to zero would capture the cross-sectional variation in the stock better than other models.

Fama and French 5-factor model (FF2015):

$$R_{pt} = a_p + b_p R_{mt} + s_p SMB_t + h_p HML_t + r_p RMW_t + c_p CMA_t + \varepsilon_{pt}.$$

Fama and French 3-factor model (FF1993):

$$R_{pt} = a_p + b_p R_{mt} + s_p SMB_t + h_p HML_t + \varepsilon_{pt}.$$

Capital Asset Pricing Model (CAPM):

$$R_{pt} = a_p + b_p R_{mt} + \varepsilon_{pt}.$$

2.3. Variables

According to Fama and French methodology

R_{it} : ($R_{it} - R_{ft}$): is the excess weighted average return for all the Tadawul's firms for several portfolios.

R_{mt} ($R_{mt} - R_{ft}$): is the excess weighted average return for all the stocks in the Tadawul.

SMB_t : is the difference between the return on portfolios of small and big size.

HML_t : is the difference between the return on portfolios of high and low B/M.

RMW_t : is the difference between the return on portfolios of robust and weak profitability.

CMA_t : is the difference between the return on portfolios of conservative and aggressive investment.

Risk-free rate R_{ft} : is the 4 weeks' interest rate on SAMA bills (Saudi Arabia Monetary Authority website).

2.3.1. Measurement of the variables and formation of the portfolios

2.3.1.1. Monthly return

The monthly return is a function of the price of the stock in the current month and the price of the

stock in the previous month and can be represented by the following equation:

$$R_{it} = \frac{P_{it} - P_{it-1}}{P_{it-1}}.$$

2.3.1.2. Methodology of forming the dependent variables portfolios

The FF2015 model methodology will be used in constructing the portfolios, the percentage average monthly returns for portfolios formed will depend on Size, B/M, OP, and Inv. from January 2014 to August 2017 (44 months). At the end of each December for a fiscal year ending in year $t-1$, stocks are allocated into two Size groups (Small (S) and Big (B)) using Tadawul cap median breakpoints). Besides, stocks are allocated independently into two B/M groups (Low (L) and High (H) using Tadawul value of the B/M median breakpoints). Moreover, the Operating Profitability (OP) of the sort of December of year t is measured with the accounting data of the fiscal year ending in year $t-1$, which is equal to the revenues minus cost of goods sold, selling, general, administrative expenses, interest expenses finally divide everything by the book assets. Based on that, stocks are allocated independently into two Operating profitability groups (Robust (R) and Weak (W) using Tadawul Operating Profitability ratio median breakpoints. Investment is the change in the total assets from the fiscal year ending in year $t-2$ to the fiscal year ending in $t-1$, divided by the total assets of the year $t-2$.

Accordingly, stocks are allocated independently to into Investment groups (Conservative (C) and Aggressive (A) using Tadawul rate of change in total assets in the two years' median breakpoints. The intersections of four sorts produce 16 dependent variables that depend on the size, value, OP, and Inv. portfolios: BHRA, BHRC, BHWA, BHWC, BLRA, BLRC, BLWA, BLWC, SHRA, SHRC, SHWA, SHWC, SLRA, SLRC, SLWA, and SLWC.

2.3.1.3. Methodology of forming the independent variables portfolios

To examine whether the specifics of factor construction are important to be used in the tests of asset pricing model, the author used three sets of factors to capture the patterns in average returns (depend-

ent variables). On the other hand, three approaches were used in constructing the independent variables: Size (*SMB*), Book-to-market (*HML*), Profitability (*RMW*), and Investment (*CMA*), which were used in three different sorts (2x2x2x2, 2x3, and 2x2), which were further described formally and in detail.

The author uses the independent sorts to assign stocks in different groups at each sort.

2x3 sort

Size: Tadawul median (Small (S) or Big (B))

B/M: 30th and 70th Tadawul percentiles (High (H), Neutral (N), or Low (L))

OP: 30th and 70th Tadawul percentiles (Robust (R), Neutral (N), or Weak (W))

Inv.: 30th and 70th Tadawul percentiles (Conservative (C), Neutral (N), or Aggressive (A))

Eighteen (18) portfolios were constructed and defined by the intersections of the groups are the building blocks for the factors: *SH*, *SN*, *SL*, *SR*, *SN*, *SW*, *SC*, *SN*, *SA*, *BH*, *BN*, *BL*, *BR*, *BN*, *BW*, *BC*, *BN*, *BA*. Therefore, the measurements of the independent variables are as follows:

$$\begin{aligned}
 SMB_{B/M} &= ((SH + SN + SL) / 3) - ((BH + BN + BL) / 3) \\
 SMB_{OP} &= ((SR + SN + SW) / 3) - ((BR + BN + BW) / 3) \\
 SMB_{Inv} &= ((SC + SN + SA) / 3) - ((BC + BN + BA) / 3) \\
 SMB &= (SMB_{B/M} + SMB_{OP} + SMB_{Inv}) / 3 \\
 HML &= ((SH + BH) / 2) - ((SL + BL) / 2) = [(SH - SL) + (BH - BL) / 2] \\
 RMW &= ((SR + BR) / 2) - ((SW + BW) / 2) = [(SR - SW) + (BR - BW) / 2] \\
 CMA &= ((SC + BC) / 2) - ((SA + BA) / 2) = [(SC - SA) + (BC - BA) / 2]
 \end{aligned}$$

2x2 sort

Size: Tadawul median (Small (S) or Big (B))

B/M: Tadawul median (High (H) or Low (L))

OP: Tadawul median (Robust (R) or Weak (W))

Inv.: Tadawul median (Conservative (C) or Aggressive (A))

Twelve (12) portfolios were constructed and defined by the intersections of the groups are the building blocks for the factors: *SH*, *SL*, *SR*, *SW*, *SC*, *SA*, *BH*, *BL*, *BR*, *BW*, *BC*, *BA*. Therefore, the measurements of the independent variables are as follows:

$$\begin{aligned}
 SMB &= ((SH + SL + SR + SW + SC + SA) / 6) - ((BH + BL + BR + BW + BC + BA) / 6) \\
 HML &= ((SH + BH) / 2) - ((SL + BL) / 2) = [(SH - SL) + (BH - BL) / 2] \\
 RMW &= ((SR + BR) / 2) - ((SW + BW) / 2) = [(SR - SW) + (BR - BW) / 2] \\
 CMA &= ((SC + BC) / 2) - ((SA + BA) / 2) = [(SC - SA) + (BC - BA) / 2]
 \end{aligned}$$

HML, *RMW*, and *CMA* from the 2x3 or 2x2 sorts weigh small and big stock portfolio returns equally; they are roughly neutral with respect to size. The *HML* is constructed without controls for OP and Inv.; however, it is not neutral with respect to Profitability and Investment. This likely means that the average *HML* return is a mix of premiums related to B/M, Profitability, and Investment. Similar comments apply to *RMW* and *CMA*.

2x2x2x2 sort

In this sort, the author should better isolate the premiums in average returns related to Size, B/M, OP, and Inv. The final candidate factors use the four sorts illustrated above to construct the dependent variables so that it can jointly control four variables. Further explanation of the methodology of *FF* in constructing the four independent var-

iables according to these sorts will be discussed further.

Size: Tadawul median (Small (S) or Big (B))

B/M: Tadawul median (High (H) or Low (L))

OP: Tadawul median (Robust (R) or Weak (W))

Inv.: Tadawul median (Conservative (C) or Aggressive (A))

Sixteen (16) portfolios formed for the dependent variables in the previous section were constructed using the following four sorts. The measurements of the independent variables are as follows:

$$\begin{aligned}
 SMB &= ((SHRC + SHRA + SHWC + SHWA + SLRC + SLRA + SLWC + SLWA) / 8) - \\
 &- ((BHRC + BHRA + BHWC + BHWA + BLRC + BLRA + BLWC + BLWA) / 8). \\
 HML &= ((SHRC + SHRA + SHWC + SHWA + BHRC + BHRA + BHWC + BHWA) / 8) - \\
 &- ((SLRC + SLRA + SLWC + SLWA + BLRC + BLRA + BLWC + BLWA) / 8). \\
 RMW &= ((SHRC + SHRA + SLRC + SLRA + BHRC + BHRA + BLRC + BLRA) / 8) - \\
 &- ((SHWC + SHWA + SLWC + SLWA + BHWC + BHWA + BLWC + BLWA) / 8). \\
 CMA &= ((SHRC + SHWC + SLRC + SLWC + BHRC + BHWC + BLRC + BLWC) / 8) - \\
 &- ((SHRA + SHWA + SLRA + SLWA + BHRA + BHWA + BLRA + BLWA) / 8).
 \end{aligned}$$

In 2x2x2x2 sort, *SMB* is equal to the weights high and low B/M, robust and weak OP, and conservative and aggressive Inv. portfolio returns. Thus, the Size factor is roughly neutral with respect to the value, profitability and investment, and this is what the author means by Size factor jointly controlling for the other three variables. Likewise, *HML* factor is roughly neutral with respect to the size, profitability, and investment, and similar comments could apply to *RMW* and *CMA*. As a comment, neutrality with respect to the characteristics does not imply low correlation between factor returns. Moreover, factor exposures are more important in the eventual inferences, since multivariate regression slopes measure marginal effects, the five factors slope for *HML*, *RMW*, and *CMA* produced by the factors from 2x3 or 2x2 sorts may isolate exposures to the value, profitability and investment effects in returns as effectively as the factors from the 2x2x2x2 sort.

3. RESULTS AND DISCUSSION

3.1. Descriptive statistics

Table A1 (Appendix A) shows that the Jarque-Bera's values for *BHRA*, *BHRC*, *BHWC*, *BLRA*, *BLRC*, *BLWC*, *SHRC*, *SHWA*, *SHWC*, *SLRA*, *SLRC*, *SLWA* are significantly not-normally distributed at 1%, *BHWA*, *SLWC* are significantly not-normally distributed at 5%, *BLWA*, *SHRA* are normally distributed. The R_m is normally distributed, *SMB222*, *SMB22*, *SMB23* are normally distributed, *CMA22*, *CMA222* are significantly not-normally distributed at 1%, *CMA23*, *HML22*, *RMW2222* are significantly not-normally distributed at 5%. Finally, *RMW22*, *RMW23*, *HML23*, *HML2222* are nor-

mally distributed. The variables' data should be normally distributed in order to have accredited regression results; using *GMM* regression, the author can skip some of not-normally distributed variables.

Further illustration of the correlation matrix results in 2x2x2x2 version in Tables (B1, B2, B3) in Appendix B (R_{RMW}^{2222} & R_{SMB}^{2222} , R_{RMW}^{2222} & R_m^{2222} , R_{SMB}^{2222} & R_m^{2222}) are correlated negatively and insignificantly, while (R_{HML}^{2222} & R_m^{2222} , R_{CMA}^{2222} & R_m^{2222} , R_{CMA}^{2222} & R_{SMB}^{2222} , R_{HML}^{2222} & R_{CMA}^{2222}) are correlated positively and insignificantly. (R_{HML}^{2222} & R_m^{2222} , R_{RMW}^{2222} & R_{CMA}^{2222}) are negatively correlated (sig. at 5%, 10%), respectively, and (R_{RMW}^{2222} & R_{HML}^{2222}) are positively correlated (sig. at 1%). Additionally, the correlation matrix in 2x2 version showed that (R_{RMW}^{22} & R_{CMA}^{22} , R_{RMW}^{22} & R_m^{22}) are correlated negatively and insignificantly, while (R_{HML}^{22} & R_m^{22} , R_{CMA}^{22}

& R_m , R_{CMA} & R_{SMB} are correlated positively and insignificantly. (R_{RMW} & R_{SMB} , R_{SMB} & R_m , R_{HML} & R_{SMB}) are negatively correlated (sig. at 10%, 5%, 1%), respectively. Finally, (R_{RMW} & R_{HML} , R_{CMA} & R_{HML}) are positively correlated (sig. at 5%, 10%), respectively.

Finally, the correlation matrix in 2x3 sort showed that (R_{RMW} & R_{CMA} , R_{HML} & R_m , R_{HML} & R_{CMA}) are correlated negatively and insignificantly, while (R_{HML} & R_{SMB} , R_{CMA} & R_m , R_{CMA} & R_{SMB} , R_{RMW} & R_{SMB} , R_{RMW} & R_{HML}) are correlated positively and insignificantly. (R_{RMW} & R_m , R_{SMB} & R_m) are negatively correlated (sig. at 5%, 1%), respectively.

The existence of multicollinearity (if correlation between independent variables is more than 0.70) distorts the regression coefficients. Tables B1-B3 (Appendix B) show that only 9 out of 30 values are significant, 8 values are between -0.461 and 0.558. Only 1 correlation value is -0.868. Accordingly, there is no multicollinearity problem.

3.2. Regressions details

3.2.1. Regressions results of 2x3 sort

Cross-section of stock returns: Table C1 in Appendix C shows that FF1993 and CAPM regressions do a better job in explaining the cross section of the average stock returns (R_i), which can be explained by the intercepts in all the regressions, which are insignificantly different from zero, but only in 14 regressions for FF2015 model, while *BHWC*, *BLRA* regressions are significant different from zero at 5% and 10%, respectively.

CAPM model: Table D1 in Appendix D shows that the adjusted R^2 are 0.0388-0.7036, which means R_m explains some of the variations in stock returns (R_i), but not all of them. The coefficients of R_m are (0.317-0.795), *BHWC*, *BLRA*, *BLWA* are significant at 1%, *BHRA*, *BHRC*, *BHWA*, *BLWC*, *SHWA*, *SLWC* are significant at 5%, *SHRA*, *SHRC*, *SHWC*, *SLRA* are significant at 10%, and *BLRC*, *SLRC*, *SLWA* are insignificant.

FF1993 model: Table D1 shows that the adjusted R^2 are 0.283-0.761, and 14 regressions have a higher adjusted R^2 than the CAPM, which means that

the FF1993 model explains more of the variations in stock returns (R_i), but not all of them. The coefficients of R_m are 0.539-2.003; 14 portfolios are significant at 1%, while *BHRC*, *BHWC* are significant at 5%. The coefficients for R_{SMB} are -0.048-1.608, 8 portfolios are significant at 1%, *BLRC*, *BLWA*, *BLWC* are significant at 5%, and *BHRC*, *BHWA*, *BHWC*, *BLRA* are insignificant. The value factor, the coefficients for R_{HML} are -1.010 to -0.036, *BLRC*, *SLRA*, *SLWA* are significant at 1%, *BHRA*, *BHWC*, *SLRC* are significant at 5%, *BHWA*, *SHRC*, *SHWA* are significant at 10%, and seven portfolios are insignificant.

FF2015 model: Table D1 shows that the adjusted R^2 are 0.263-0.794, and 11 out of 16 regressions have a higher adjusted R^2 , which means that the FF2015 explains more of the variations in stock returns (R_i) than the other models, but not all of them. The coefficients of R_m are 0.496-1.957, 15 portfolios are significant at 1%, and *BHRC* is significant at 5%. The coefficients for R_{SMB} are -0.047-1.565, 10 portfolios are significant at 1%, *BLWA* is significant at 5%, *BLWC* is significant at 10%, and *BHRC*, *BHWA*, *BHWC*, *BLRA* are insignificant. The coefficients for R_{HML} are -0.945 to -0.028, *BLRC*, *SLRA*, *SLWA* are significant at 1%, *BHRA*, *SLRC* are significant at 5%, *BHWA*, *BHWC*, *SHRC*, *SHWA* are significant at 10%, and seven portfolios are insignificant. The coefficients for R_{RMW} are -0.380-0.254, (*SLRA*, *SLWA*) are significant at 1%, and 14 portfolios are insignificant. The coefficients for R_{CMA} are -0.408-0.150, *SHRA*, *SLRA* are significant at 1%, *SLWA* is significant at 5%, and 13 portfolios are insignificant.

3.2.2. Regression results of 2x2 sort

Cross-section of stock returns: Table E1 (Appendix E) shows that the FF1993 and CAPM regressions do a better job in explaining the cross-section of average stock returns (R_i) since the intercepts in all the regressions are insignificantly different from zero, but only in 12 regressions for FF2015 model, while the intercepts in *SHRA*, *BHRC*, *SHWC*, *SHRC* regressions are significantly different from zero at 5% and 10%, respectively.

CAPM model: Table F1 (Appendix F) shows that the adjusted R^2 are 0.0388-0.7036, which means that R_m explains some of the variations in stock

returns (R_p), but not all of them. The coefficients of the R_m are 0.317-0.795, *BHWC*, *BLRA*, *BLWA* are significant at 1%, *BHRA*, *BHRC*, *BHWA*, *BLWC*, *SHWA*, *SLWC* are significant at 5%, *SHRA*, *SHRC*, *SHWC*, *SLRA* are significant at 10%, and *BLRC*, *SLRC*, *SLWA* are insignificant.

FF1993 model: Table F1 shows that the adjusted R^2 are 0.2159-0.6901, and 13 regressions have a higher adjusted R^2 than *CAPM*, which means that the FF1993 model explains more of the variations in stock returns (R_p), but not all of them. The coefficients of R_m are 0.2930-0.8975, 14 portfolios are significant at 1%, *BHWA* is significant at 5%, and *BLRC* is significant at 10%. The coefficients for R_{SMB} are 0.0062-1.5486, 9 portfolios are significant at 1%, *BHRC* is significant at 5%, and *BHWA*, *BHWC*, *BLRA*, *BLRC*, *BLWA*, *BLWC* are insignificant. The coefficients for R_{HML} are -1.3579 to 0.969564, *BLRC* is significant at 1%, *SLRC*, *SLWA* are significant at 5%, *BLWC*, *SHWA*, *SLRA* are significant at 10%, and 10 portfolios are insignificant.

FF2015 model: Table F1 shows that the adjusted R^2 are 0.2664-0.7329, and 14 regressions have a higher adjusted R^2 than the other models, which means that the FF2015 model explains more of the variations in stock returns (R_p), but not all of them. The coefficients of R_m are 0.2644-0.8967, 11 portfolios are significant at 1%, *BHRC*, *BHWA*, *BHWC*, *BLRC* are significant at 5%, and *BLRC* is significant at 10%. The coefficients for R_{SMB} are -0.0178 to 1.17055, 9 portfolios are significant at 1%, and *BHRC*, *BHWA*, *BHWC*, *BLRA*, *BLRC*, *BLWA*, *BLWC* are insignificant. The coefficients for R_{HML} are -1.9344 to 0.3767, *BLRC*, *SLWA* are significant at 1%, *SLRC*, *SLWC* are significant at 5%, *SHWA*, *SLRA* are significant at 10%, and 10 portfolios are insignificant. The coefficients for R_{RMW} are 0.0098-1.0308, *SHRA*, *BHRC* are significant at 5%, *BHRA*, *SLRA* are significant at 10%, and 12 portfolios are insignificant. Finally, the coefficients for R_{CMA} are -0.6298 to 1.7005, *BHRC*, *SLWC* are significant at 1%, *BLRC*, *SHWC* are significant at 5%, *BHRA*, *BHWC*, *SHRC* are significant at 10%, and nine portfolios are insignificant.

3.2.3. Regressions results of 2x2x2x2 sort

Cross-section of stock returns: Table G1 (Appendix G) shows that the *CAPM* regressions do a bet-

ter job in explaining the cross-section of average stock returns (R_p), since the intercepts in all the regressions are insignificantly different from zero, but only in 15 regressions for FF2015 and FF1993 models, while the intercepts of *BLWA* in FF2015 and *BLWC* in FF1993 are significantly different from zero at 5% and 10%, respectively.

CAPM model: Table H1 (Appendix H) shows that the adjusted R^2 are 0.0388-0.7036, which means that R_m explains some of the variations in stock returns (R_p), but not all of them. The coefficients of R_m are 0.317-0.795, *BHWC*, *BLRA*, *BLWA* are significant at 1%, *BHRA*, *BHRC*, *BHWA*, *BLWC*, *SHWA*, *SLWC* are significant at 5%, *SHRA*, *SHRC*, *SHWC*, *SLRA* are significant at 10%, and *BLRC*, *SLRC*, *SLWA* are insignificant.

FF1993 model: Table H1 shows that adjusted R^2 are 0.158685-0.700032, and 13 regressions have a higher adjusted R^2 , which means that the FF1993 model explains more of the variations in stock returns (R_p) than the *CAPM*, but not all of them. The coefficients of R_m are 0.2511-0.8161, 10 portfolios are significant at 1%, *BHWA*, *SHRA*, *SHWC*, *SLRA*, *SLWA* are significant at 5%, and *BLRC* is insignificant. The coefficients for R_{SMB} are -0.1410 to 1.3086, nine portfolios are significant at 1%, and *BLWC*, *BLWA*, *BLRC*, *BLRA*, *BHWC*, *BHWA*, *BHRC* are insignificant. The coefficients for R_{HML} are 0.6161 to -1.5522, *SLRC* is significant at 1%, *BLWC*, *SLWA* are significant at 5%, *BLRC*, *SHWA* portfolios are significant at 10%, and 11 portfolios are insignificant.

FF2015 model: Table H1 shows that the adjusted R^2 are 0.2832-0.6952, and 9 regressions have a higher adjusted R^2 , which means that the FF2015 model explains more of the variations in stock returns (R_p) than the FF1993 and *CAPM*, but not all of them. The coefficients of R_m are 0.3110-0.7984, 12 portfolios are significant at 1%, *BHWA*, *BLRC* are significant at 5%, and *SLWA*, *SHRC* are significant at 10%. The coefficients for R_{SMB} are -6.33E-05 to 1.3093, 9 portfolios are significant at 1%, and *BHRC*, *BHWA*, *BHWC*, *BLRA*, *BLRC*, *BLWA*, *BLWC* are insignificant. The coefficients for R_{HML} are -2.1711 to 0.2952, *SLRC* is significant at 1%, *BLRC*, *BLWC* are significant at 5%, and 13 portfolios are insignificant. The coefficients for R_{RMW} are -1.3003 to 0.8227, *BLWA* is significant at 1%,

and 15 portfolios are insignificant. Finally, the coefficients for R_{CMA} are -0.5958 to 1.5667 , $BLWA$, $SLRC$, $SLWC$ are significant at 1%, $BHRC$, $BLWC$, $SHWC$ are significant at 5%, and 10 portfolios are insignificant.

3.3. Discussion

FF2015 model does a better job in explaining the cross-section of average stock returns (R_i) but there is not clear evidence that it is the best in all sorts. Adjusted R^2 results showed that independent variables in the three models explain some of the variations in stock returns (R_i), but not all of them. Accordingly, famous financial models used in developed exchanges can be an applicable at Tadawul, and known omitted factors such as momentum and illiquidity should be included in the model to improve the explanation power. Other possible factors that might be added to regression model could be biased to Saudi's unique culture. R_m significantly affects R_i in 13 for CAPM, 16, 16, 15 for FF1993, 16 for FF2015 portfolios in 2x3, 2x2, 2x2x2x2 sorts, respectively. R_{SMB} significantly affects (R_i) in 12, 10, 9 for FF1993, 12, 9, 9) for FF2015 portfolios in 2x3, 2x2, 2x2x2x2 sorts, respectively. Accordingly, there is good evidence that R_m and R_{SMB} significantly affect (R_i). R_{HML} significantly affects (R_i) in 9, 6, 5 for FF1993, 9, 6, 3 for FF2015 portfolios for 2x3, 2x2, 2x2x2x2 sorts, respectively. R_{RMW} significantly affects (R_i) in 2, 4, 1 portfolios in 2x3, 2x2, 2x2x2x2 sorts, respectively. R_{CMA} significantly affects (R_i) in 3, 7, 6 portfolios for 2x3, 2x2, 2x2x2x2 sorts, respectively. Accordingly, there is no evidence that R_{HML} , R_{RMW} , and R_{CMA} significantly affect (R_i). The financial implications for the regressions results are: CAPM model variable the market significantly affects stock returns. Furthermore, the Market and Size variables in FF1993 significantly affect stock returns, while Book-to-market variable does not have any clear evidence of its significant effect. Finally, FF2015 model shows the same results for the Market and Size and Book-to-market variables; besides, does not provide any clear evidence of profitability and investment variables' significant effect.

2x3 sort

FF1993 model: For Size factor, $BLRA$ is the only one with a negative coefficient, while positive for

the others. In every Book-to-market quintile, the slopes on SMB increase from bigger to smaller size quintile. For Value factor, the sign of all coefficients is negative. In every size quintile of stocks, R_{HML} slopes increase from small values for the lowest B/M quintile to bigger values for the highest quintile that only applies for four cases, while the opposite happens for the other four cases ($BHRA$, $BLRA$ & $BHWA$, $BLWA$ & $BHWC$, $BLWC$ & $SHWC$, $SLWC$), regardless of the coefficient sign.

FF2015 model: For Size factor, $BLRA$ is the only one with a negative coefficient, while positive for the others. Mainly in every B/M, Profitability, Investment quintile, and slopes on SMB increase from smaller to bigger size quintile. For Value factor, the sign of all coefficients is negative. In every Size, Profitability, and Investment quintile of stocks, R_{HML} slopes increase from small values for the lowest B/M quintile to bigger values for the highest quintile only for five cases, while the opposite happens for other three cases ($BHRA$, $BLRA$ & $BHWA$, $BLWA$ & $BHWC$, $BLWC$ & $SHWC$, $SLWC$), regardless of the coefficient sign. For Profitability factor, the coefficients sign of the following portfolios' ($SLRC$, $SLRA$, $SHRA$, $BLRC$, $BHWA$, $BHRA$) are positive, while negative for the others. In every Size, Book-to-market, and Investment quintiles of stocks, RMW slopes increase from small values for the weak profitability quintile to bigger values for the robust profitability quintile only for seven cases, while the opposite happens for one case ($BHRC$, $BHWC$), regardless of the coefficient sign. For Investment factor, the sign of 14 coefficients is negative, except for two portfolios' coefficients ($SHRC$, $SLWC$) is positive. In every Size, Book-to-market, and Profitability quintiles of stocks, CMA slopes increase small values for the aggressive investment quintiles to bigger values for the conservative investment quintiles only for five cases, while the opposite happens for three cases ($BHWA$, $BHWC$ & $BLRA$, $BLRC$ & $SHWA$, $SHWC$), regardless of the coefficient sign.

2x2 sort

FF1993 model: For Size factor, the sign of the coefficients is positive for all the portfolios. In every Book-to-market quintile, the slopes on SMB decrease from smaller to bigger size quintile. For Value factor, the sign of all coefficients is negative,

except for *SHWC*, *BHRC* portfolio's coefficients. In every Size quintile of stocks, R_{HML} slopes increase from small values for the lowest B/M quintile to bigger values for the highest quintile only for six cases, while the opposite happens for two cases (*BLWA* & *BHWA*, *BLRA* & *BHRA*), regardless of the coefficient sign.

FF2015 model: For Size factor, the sign of the coefficient is negative only for *BHWC*, *BLRA*, *BLRC*, while positive for the others. In every Book-to-market, Profitability, and Investment quintile, the slopes on *SMB* increase from the bigger to smaller size quintile. For Value factor, the sign for 14 coefficients is negative, except for *BLRA*, *BLWA*. In every Size, Profitability, and Investment quintile of stocks, *HML* slopes increase from small values for the lowest B/M quintile to bigger values for the highest quintile only for six cases, while the opposite happens for two cases (*BHRA*, *BLRA* & *BHWA*, and *BLWA*), regardless of the coefficient sign. For profitability factor, the sign of following portfolios' (*BHRA*, *BHRC*, *BHWC*, *BLRA*, *BLRC*, *SHRA*, *SHRC*, *SHWA*, *SHWC*, *SLRA*, *SLWA*) coefficients are positive, while the others are negative. In every Size, Book-to-market, and Investment quintiles of stocks, R_{RMW} slopes increase from small values for the weak profitability quintile to bigger values for the robust profitability quintile regardless of the coefficient sign. For Investment factor, the sign of 14 coefficients is negative, while three portfolios' coefficients (*BLRA*, *BLWA*, *SHRA*) are positive. In every Size, Book-to-market, and Profitability quintiles of stocks, *CMA* slopes increase small values for the aggressive investment quintiles to bigger values for the conservative investment quintiles, regardless of the coefficient sign.

2X2X2X2 sort

FF1993 model: For size factor, the sign of the coefficient is negative only for *BHWA*, *BHWC*, *BLRA*, while positive for the others. In every Book-to-market quintile, *SMB* slopes decrease from smaller to bigger size quintile. For Value factor, the sign of all coefficients is negative, except for with *BHRC*, *SHRA*. In every Size quintile of stocks, *HML* slopes increase from small values for the lowest B/M quintile to bigger values for the highest quintile in all cases.

FF2015 model: For Size factor, the sign of the coefficient is negative only for *BHRC*, *BHWA*, *BHWC*, *BLRA*, while positive for the others. In all Book-to-market, Profitability, and Investment quintiles, *SMB* slopes increase from bigger to smaller size quintile. For Value factor, the sign of all coefficients is negative, except for *BHRC*, *BLWA*. In every Size, Profitability, and Investment quintiles of stocks, *HML* slopes increase from small values for the lowest B/M quintile to bigger values for the highest quintile only for six cases, while the opposite happens for two cases (*BLWA* & *BHWA*, *BLRA* & *BHRA*), regardless of the coefficient sign. For Profitability factor, the sign of following portfolios (*BHWA*, *BHWC*, *BLWA*, *BLWC*, *SHWA*, *SHWC*, *SLWA*, *SLWC*) is negative. In every Size, Book-to-market, and Investment quintiles of stocks, *RMW* slopes increase from small values for the weak profitability quintile to bigger values for the robust profitability quintile, regardless of the coefficient sign. For Investment factor, the sign of six coefficients (*BHWA*, *BLRA*, *BLWA*, *SHRA*, *SLRA*, *SLWA*) is negative, while it is positive for others. In every Size, Book-to-market, and Profitability quintiles of stocks, *CMA* slopes increase small values for the aggressive investment quintiles to bigger values for the conservative investment quintiles, regardless of the coefficient sign.

Finally, the author adds the following financial implications: the positive sign of Size variable in the paper contradicts FF2015 results. Fama and French illustrated the negativity of this variable as a result of neglected, mispriced, and insufficient analysis of small firms. The positive sign in Tadawul (the US's stocks are much larger than Tadawul) indicates a well-analyzed, not neglected, and correctly priced small firms. Moreover, the negative sign of Book-to-market variable in this study also contradicts FF2015 results. Fama and French illustrated the positivity of this variable due to making high Book-to-market firms have higher returns so that it protects the investors from high risk. The negative sign in Tadawul is forcing the CEOs to take financial, investment, and operational activities to raise the stock price since they are not facing enough corporate governance procedures from the board of directors. Furthermore, the sign of Profitability variable in this study does not have any clear indication; some portfolios are positive,

while others are negative and insignificant. Fama and French illustrated the positivity of this variable since robust profitability corporations have higher returns. The insignificant elusory sign in Tadawul is an indicator that robust profitability of the firms does not have any effect on raising the stock price because of poor implementation of corporate governance. Finally, the Investment variable sign in this study is also unclear same as profitability factor. Fama and French illustrated the positivity of this variable because conservative asset investments lead to higher returns. The positive insignificant sign in Tadawul also leads

to higher returns but it is not significant due to poor implementation of corporate governance procedures.

Adding *SMB*, *HML* and *SMB*, *HML* *RMW*, and *CMA* to FF1993 and FF2015 regressions, respectively, has an effect on the market β s for stocks. In some regressions, it collapses the β s for stocks toward 1.0, low β s move up, and high β s move down toward one. This behavior is due to correlation between market and *SMB* or *HML* and correlation between markets in FF1993 and *SMB* or *HML* or *RMW* or *CMA* in FF2015.

CONCLUSION

Finally, previous empirical studies concluded that it is difficult to apply the famous finance models on Tadawul due to the Islamic Sharia, which complicated identifying the returns' determinates. Therefore, this article showed the applicable models employed in developed markets and explained the cross-sectional variations on stock returns at Tadawul. When the author interpreted his results, he clearly indicated no clear evidence that the usage of FF2015 model leads to a better job than FF1993 and CAPM models in explaining the cross-section of average stock returns and it is also more adequate in explaining the variations in stock returns than other models since FF2015's adjusted R^2 values are higher in most of the portfolios. However, it does not clarify all of them since FF2015's adjusted R^2 values are less than 100%. Moreover, the regressions show good evidence that R_m and R_{SMB} significantly affect the stock returns, according to CAPM, FF1993, FF2015 results in all sorts. Secondly, there is good evidence that R_{HML} affects stock returns in 2x3 sort, while there is no evidence in other sorts. Finally, the results do not provide evidence that R_{RMW} and R_{CMA} variables affect stock returns. Based on these results, the author would like to conclude by giving a couple of important interpretations. First, there is no difference in the results between 2x3, 2x2, and 2x2x2x2 sorts. Second, FF2015 model do a great job in explaining the cross-section of average stock returns in Tadawul. However, it is not the best. Finally, the author concludes that FF2015 model can be an applicable model at Tadawul, but Saudi's unique culture affects the identity of its determinates.

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APPENDIX A

Table A1. Descriptive statistics

	Mean	Std. Dev.	Jarque-Bera	Prob.	Obs.
BHRA	-0.015	0.065	32.974	0.000	44
BHRC	-0.011	0.063	58.606	0.000	44
BHWA	0.002	0.050	7.160	0.028	44
BHWC	-0.010	0.054	39.224	0.000	44
BLRA	-0.014	0.062	25.629	0.000	44
BLRC	-0.013	0.050	12.456	0.002	44
BLWA	-0.007	0.073	0.089	0.957	44
BLWC	-0.017	0.078	62.188	0.000	44
SHRA	-0.004	0.058	3.574	0.167	44
SHRC	-0.006	0.080	50.502	0.000	44
SHWA	-0.007	0.071	28.675	0.000	44
SHWC	-0.008	0.079	15.874	0.000	44
SLRA	-0.012	0.069	72.294	0.000	44
SLRC	-0.011	0.073	20.757	0.000	44
SLWA	-0.012	0.087	12.656	0.002	44
SLWC	-0.010	0.089	6.918	0.031	44
RM2222	-0.007	0.068	1.031	0.597	44
SMB2222	-0.005	0.041	1.338	0.512	44
HML2222	-0.002	0.018	2.971	0.226	44
RMW2222	-0.008	0.020	7.966	0.019	44
CMA2222	-0.009	0.016	24.263	0.000	44
SMB22	-0.009	0.042	0.063	0.969	44
HML22	0.000	0.019	6.171	0.046	44
RMW22	-0.008	0.021	0.816	0.665	44
CMA22	-0.008	0.022	22.355	0.000	44
SMB23	-0.001	0.086	1.138	0.566	44
HML23	-0.003	0.030	3.812	0.149	44
RMW23	-0.006	0.043	3.815	0.148	44
CMA23	-0.013	0.043	6.126	0.047	44

APPENDIX B

Table B1. Correlations for 2x2 sort

Variables	RM2222	SMB22	HML22	RMW22	CMA22
RM2222	1.000	-0.383**	0.168	-0.188	0.228
Sig.		0.010	0.276	0.222	0.136
SMB22		1.000	-0.461***	-0.279*	0.058
Sig.			0.002	0.066	0.709
HML22			1.000	0.325**	0.399***
Sig.				0.031	0.007
RMW22				1.000	-0.149
Sig.					0.333
CMA22					1.000

Note: * significance at 10%, ** at 5%, *** at 1%.

Table B2. Correlations for 2x2x2x2 sort

Variables	RM2222	SMB2222	HML2222	RMW2222	CMA2222
RM2222	1.000	-0.104	0.097	-0.236	0.110
Sig.		0.503	0.530	0.123	0.476
SMB2222		1.000	-0.345**	-0.248	0.124
Sig.			0.022	0.106	0.423
HML2222			1.000	0.558***	0.095
Sig.				0.000	0.538
RMW2222				1.000	-0.268*
Sig.					0.079
CMA2222					1.000

Note: * significance at 10%, ** at 5%, *** at 1%.

Table B3. Correlations for 2x3 sort

Variables	RM2222	SMB23	HML23	RMW23	CMA23
RM2222	1.000	-0.868***	-0.187	-0.327**	0.229
Sig.		0.000	0.225	0.030	0.135
SMB23		1.000	0.179	0.151	-0.164
Sig.			0.245	0.328	0.287
HML23			1.000	0.203	-0.016
Sig.				0.186	0.919
RMW23				1.000	-0.233
Sig.					0.129
CMA23					1.000

Note: * significance at 10%, ** at 5%, *** at 1%.

APPENDIX C

Table C1. Intercepts: 2x3 factors sort on Size and B/M, Size and OP, Size and Inv

Model	a	t(a)	P-value	Model	a	t(a)	P-value
Dependent variable: BHRA				Dependent variable: SHRA			
FF2015	−0.0100	−1.3319	0.1908	FF2015	0.0016	0.2069	0.8372
FF1993	−0.0084	−1.1650	0.2509	FF1993	0.0039	0.5062	0.6155
CAPM	−0.0112	−1.2705	0.2109	CAPM	−0.0024	−0.2631	0.7937
Dependent variable: BHRC				Dependent variable: SHRC			
FF2015	−0.0108	−1.287847	0.2056	FF2015	0.0058	0.4626	0.6463
FF1993	−0.0079	−0.990534	0.3279	FF1993	0.0048	0.4754	0.6371
CAPM	−0.0072	−0.941600	0.3518	CAPM	−0.0031	−0.2686	0.7896
Dependent variable: BHWA				Dependent variable: SHWA			
FF2015	0.0043	0.5302	0.5991	FF2015	0.003	0.480	0.6334
FF1993	0.0049	0.6707	0.5063	FF1993	0.0038	0.6108	0.5448
CAPM	0.0050	0.6676	0.5080	CAPM	−0.0038	−0.4999	0.6198
Dependent variable: BHWC				Dependent variable: SHWC			
FF2015	−0.0116**	−2.1110	0.0414	FF2015	−0.0029	−0.4558	0.6511
FF1993	−0.0077	−1.3964	0.1703	FF1993	0.0022	0.3178	0.7523
CAPM	−0.0068	−1.1202	0.2690	CAPM	−0.0051	−0.5257	0.6019
Dependent variable: BLRA				Dependent variable: SLRA			
FF2015	−0.0106*	−1.8441	0.0730	FF2015	−0.0056	−1.0035	0.3220
FF1993	−0.0090	−1.3959	0.1704	FF1993	−0.0029	−0.4493	0.6557
CAPM	−0.0085	−1.5139	0.1375	CAPM	−0.0092	−1.0085	0.3190
Dependent variable: BLRC				Dependent variable: SLRC			
FF2015	−0.0115	−1.3696	0.1789	FF2015	−0.0004	−0.0674	0.9466
FF1993	−0.0113	−1.5343	0.1328	FF1993	−0.0022	−0.4485	0.6562
CAPM	−0.0111	−1.426373	0.1612	CAPM	−0.0089	−1.2006	0.2366
Dependent variable: BLWA				Dependent variable: SLWA			
FF2015	−0.0040	−0.5291	0.5998	FF2015	−0.0072	−0.9902	0.3283
FF1993	0.0003	0.0464	0.9632	FF1993	−0.0007	−0.0902	0.9286
CAPM	−0.0012	−0.1741	0.8626	CAPM	−0.0103	−1.0075	0.3195
Dependent variable: BLWC				Dependent variable: SLWC			
FF2015	−0.0126	−1.4637	0.1515	FF2015	0.0017	0.1799	0.8582
FF1993	−0.0101	−1.0848	0.2845	FF1993	0.0032	0.340	0.7356
CAPM	−0.0131	−1.3234	0.1929	CAPM	−0.0064	−0.6227	0.5368

APPENDIX D

Table D1. Coefficients: 2x3 factors sort on Size and B/M, Size and OP, Size and Inv

D.V.	Model	b	P-value	s	P-value	H	P-value	r	P-value	c	P-value	Adj. R ²
BHRA	FF2015	1.305***	0.000	0.714***	0.000	-0.709**	0.043	0.202	0.311	-0.291**	0.048	0.536
	FF1993	1.145***	0.0001	0.642***	0.0002	-0.670**	0.024					0.498
	CAPM	0.496**	0.018									0.257
BHRC	FF2015	0.497**	0.015	0.030	0.845	-0.304	0.517	-0.188	0.407	-0.117	0.463	0.264
	FF1993	0.561**	0.011	0.073	0.622	-0.348	0.440					0.283
	CAPM	0.510**	0.014									0.289
BHWA	FF2015	0.705***	0.002	0.236	0.149	-0.477*	0.085	0.171	0.309	-0.180	0.157	0.402
	FF1993	0.584***	0.001	0.179	0.162	-0.442*	0.062					0.381
	CAPM	0.425**	0.014									0.322
BHCW	FF2015	0.615***	0.009	0.140	0.437	-0.572*	0.075	-0.148	0.194	-0.240	0.123	0.503
	FF1993	0.634**	0.013	0.164	0.369	-0.609**	0.049					0.486
	CAPM	0.504***	0.003									0.388
BLRA	FF2015	0.723***	0.002	-0.047	0.791	-0.028	0.918	-0.027	0.768	-0.122	0.466	0.682
	FF1993	0.709***	0.0004	-0.048	0.781	-0.036	0.891					0.690
	CAPM	0.765***	0.000									0.704
BLRC	FF2015	0.691***	0.001	0.427***	0.007	-0.892***	0.007	0.234	0.118	-0.189	0.336	0.408
	FF1993	0.539***	0.009	0.353**	0.011	-0.844***	0.003					0.365
	CAPM	0.221	0.190									0.070
BLWA	FF2015	1.072***	0.000	0.291**	0.015	-0.300	0.244	-0.234	0.248	-0.211	0.150	0.595
	FF1993	1.138***	0.000	0.339**	0.017	-0.356	0.165					0.588
	CAPM	0.795***	0.000									0.549
BLWC	FF2015	1.223**	0.014	0.570*	0.085	-0.500	0.186	-0.142	0.543	-0.119	0.578	0.401
	FF1993	1.265***	0.002	0.600**	0.034	-0.534	0.139					0.423
	CAPM	0.651**	0.011									0.307
SHRA	FF2015	1.415***	0.000	0.944***	0.000	-0.283	0.150	0.198	0.240	-0.355***	0.009	0.595
	FF1993	1.244***	0.000	0.869***	0.000	-0.246	0.270					0.515
	CAPM	0.311*	0.095									0.113
SHRC	FF2015	1.803***	0.000	1.247***	0.000	-0.684*	0.065	-0.001	0.997	0.089	0.637	0.639
	FF1993	1.823***	0.000	1.253***	0.000	-0.682*	0.057					0.655
	CAPM	0.504*	0.060									0.166
SHWA	FF2015	1.669***	0.000	1.145***	0.000	-0.530*	0.098	-0.043	0.813	-0.037	0.783	0.682
	FF1993	1.682***	0.000	1.154***	0.000	-0.541*	0.075					0.697
	CAPM	0.461**	0.033									0.179
SHWC	FF2015	1.623***	0.000	1.132***	0.000	-0.625	0.154	-0.289	0.186	-0.244	0.221	0.609
	FF1993	1.708***	0.000	1.193***	0.000	-0.693	0.104					0.595
	CAPM	0.456*	0.081									0.136
SLRA	FF2015	1.765***	0.000	1.162***	0.000	-0.744***	0.001	0.222*	0.085	-0.408***	0.000	0.767
	FF1993	1.571***	0.000	1.077***	0.000	-0.703***	0.0001					0.686
	CAPM	0.447*	0.079									0.176
SLRC	FF2015	1.670***	0.000	1.249***	0.000	-0.895**	0.014	0.254	0.334	-0.032	0.829	0.640
	FF1993	1.542***	0.000	1.179***	0.000	-0.840**	0.014					0.637
	CAPM	0.317	0.125									0.068
SLWA	FF2015	1.957***	0.000	1.566***	0.000	-0.941***	0.004	-0.258*	0.079	-0.389**	0.028	0.795
	FF1993	1.996***	0.000	1.609***	0.000	-1.010***	0.002					0.761
	CAPM	0.314	0.292									0.039
SLWC	FF2015	1.789***	0.000	1.298***	0.000	-0.484	0.396	-0.380	0.140	0.151	0.497	0.628
	FF1993	2.003***	0.000	1.409***	0.000	-0.565	0.327					0.607
	CAPM	0.504**	0.046									0.131

Note: * significance at 10%, ** at 5%, *** at 1%.

APPENDIX E

Table E1. Intercepts: 2x2 factors sort on Size and B/M, Size and OP, Size and Inv

Model	a	t(a)	P-value	Model	a	t(a)	P-value
Dependent variable: BHRA				Dependent variable: SHRA			
FF2015	0.0086	0.8159	0.4196	FF2015	0.016**	2.189703	0.0348
FF1993	-0.0050	-0.6817	0.4994	FF1993	0.006	0.772723	0.4442
CAPM	-0.0114	-1.2705	0.2109	CAPM	-0.0024	-0.263146	0.7937
Dependent variable: BHRC				Dependent variable: SHRC			
FF2015	0.0149*	1.8628	0.0702	FF2015	0.0218*	1.9696	0.0562
FF1993	-0.0045	-0.5515	0.5843	FF1993	0.0106	0.8545	0.3979
CAPM	-0.0072	-0.9416	0.3518	CAPM	-0.0031	-0.2686	0.7896
Dependent variable: BHWA				Dependent variable: SHWA			
FF2015	0.0054	0.5551	0.5821	FF2015	0.0118	1.5576	0.1276
FF1993	0.0055	0.7267	0.4717	FF1993	0.0074	1.2064	0.2347
CAPM	0.0050	0.6676	0.5080	CAPM	-0.0038	-0.4999	0.6198
Dependent variable: BHWC				Dependent variable: SHWC			
FF2015	-0.00257	-0.3556	0.7241	FF2015	0.0166*	2.0118	0.0514
FF1993	-0.0062	-1.2172	0.2307	FF1993	0.0083	0.9356	0.3551
CAPM	-0.0068	-1.1202	0.2690	CAPM	-0.0051	-0.5257	0.6019
Dependent variable: BLRA				Dependent variable: SLRA			
FF2015	-0.0054	-0.8022	0.4274	FF2015	0.0085	1.1185	0.2704
FF1993	-0.0084	-1.4388	0.1580	FF1993	0.0001	0.0161	0.9872
CAPM	-0.0085	-1.5139	0.1375	CAPM	-0.0092	-1.0085	0.3190
Dependent variable: BLRC				Dependent variable: SLRC			
FF2015	0.0024	0.2419	0.8102	FF2015	0.0016	0.1887	0.8513
FF1993	-0.0101	-1.4395	0.1578	FF1993	0.0013	0.2068	0.8372
CAPM	-0.0111	-1.4264	0.1612	CAPM	-0.0089	-1.2006	0.2366
Dependent variable: BLWA				Dependent variable: SLWA			
FF2015	-0.0065	-0.8198	0.4174	FF2015	0.0098	1.1898	0.2415
FF1993	0.0020	0.3206	0.7502	FF1993	0.0038	0.5187	0.6068
CAPM	-0.0012	-0.1741	0.8626	CAPM	-0.0103	-1.0075	0.3195
Dependent variable: BLWC				Dependent variable: SLWC			
FF2015	-0.0092	-1.0223	0.3131	FF2015	0.0171	1.6044	0.1169
FF1993	-0.0087	-1.0523	0.2990	FF1993	0.0095	0.9727	0.3365
CAPM	-0.0131	-1.3234	0.1929	CAPM	-0.0064	-0.6227	0.5368

Note: * significance at 10%, ** at 5%, *** at 1%.

APPENDIX F

Table F1. Coefficients: 2x2 factors sort on Size and B/M, Size and OP, Size and Inv

D.V.	Model	b	P-value	s	P-value	H	P-value	r	P-value	c	P-value	Adj. R ²
BHRA	FF2015	0.672***	0.001	0.572***	0.010	-0.905	0.131	0.934*	0.073	0.745*	0.099	0.453
	FF1993	0.654***	0.001	0.604***	0.001	-0.221	0.595					0.390
	CAPM	0.496**	0.018									0.257
BHRC	FF2015	0.446**	0.012	0.028	0.872	-0.327	0.633	0.987**	0.019	1.701***	0.002	0.559
	FF1993	0.530**	0.006	0.274**	0.047	0.970	0.110					0.327
	CAPM	0.510**	0.014									0.289
BHWa	FF2015	0.429**	0.022	0.011	0.965	-0.277	0.655	-0.061	0.881	0.099	0.841	0.266
	FF1993	0.447**	0.010	0.043	0.827	-0.229	0.609					0.301
	CAPM	0.425**	0.014									0.322
BHWc	FF2015	0.462**	0.020	-0.096	0.717	-0.768	0.122	0.012	0.980	0.650*	0.096	0.397
	FF1993	0.534***	0.005	0.053	0.830	-0.358	0.315					0.381
	CAPM	0.504***	0.003									0.388
BLRA	FF2015	0.835***	0.000	-0.086	0.697	0.106	0.871	0.393	0.199	-0.174	0.558	0.695
	FF1993	0.772***	0.000	0.006	0.979	-0.104	0.792					0.690
	CAPM	0.7652***	0.0000									0.704
BLRC	FF2015	0.264*	0.081	-0.018	0.934	-1.771***	0.003	0.714	0.115	0.945**	0.047	0.326
	FF1993	0.293*	0.072	0.094	0.550	-1.012***	0.005					0.216
	CAPM	0.221	0.190									0.070
BLWA	FF2015	0.897***	0.000	0.301	0.197	0.377	0.646	-0.493	0.183	-0.630	0.260	0.577
	FF1993	0.880***	0.000	0.305	0.239	-0.209	0.605					0.567
	CAPM	0.795***	0.000									0.549
BLWC	FF2015	0.652***	0.008	0.154	0.645	-1.313	0.065	-0.483	0.489	0.810	0.167	0.449
	FF1993	0.797***	0.001	0.415	0.225	-0.917*	0.074					0.417
	CAPM	0.651**	0.011									0.307
SHRA	FF2015	0.654***	0.000	1.028***	0.000	-0.387	0.488	1.030**	0.035	-0.114	0.806	0.556
	FF1993	0.528***	0.0002	0.845***	0.000	-0.219	0.590					0.458
	CAPM	0.311*	0.095									0.117
SHRC	FF2015	0.769***	0.001	1.107***	0.003	-1.095	0.127	0.571	0.192	1.084*	0.076	0.626
	FF1993	0.829***	0.0001	1.272***	0.000	-0.282	0.546					0.583
	CAPM	0.504*	0.060									0.166
SHWA	FF2015	0.703***	0.000	0.964***	0.000	-1.031*	0.057	0.118	0.804	0.584	0.232	0.655
	FF1993	0.756***	0.000	1.0815**	0.000	-0.637*	0.076					0.652
	CAPM	0.461**	0.033									0.179
SHWC	FF2015	0.602***	0.002	0.965***	0.0008	-0.779	0.224	0.010	0.984	1.475**	0.011	0.614
	FF1993	0.768***	0.0003	1.307***	0.000	0.148	0.783					0.520
	CAPM	0.4564*	0.0808									0.136
SLRA	FF2015	0.778***	0.0002	0.985***	0.0001	-1.070*	0.083	0.765*	0.096	0.105	0.836	0.599
	FF1993	0.705***	0.0009	0.894***	0.000	-0.825*	0.020					0.577
	CAPM	0.447*	0.079									0.176
SLRC	FF2015	0.505***	0.0004	0.791***	0.0001	-1.313**	0.027	-0.284	0.633	0.598	0.282	0.535
	FF1993	0.604***	0.000	0.973***	0.000	-1.004**	0.020					0.525
	CAPM	0.317	0.125									0.068
SLWA	FF2015	0.625***	0.003	1.171***	0.0001	-1.934***	0.005	0.116	0.829	0.876	0.127	0.680
	FF1993	0.711***	0.001	1.357***	0.000	-1.358**	0.017					0.665
	CAPM	0.314	0.292									0.039
SLWC	FF2015	0.703***	0.0002	1.158***	0.000	-1.288**	0.074	-0.123	0.813	1.599***	0.006	0.733
	FF1993	0.898***	0.000	1.549***	0.000	-0.314	0.639					0.636
	CAPM	0.504**	0.046									0.131

Note: * significance at 10%, ** at 5%, *** at 1%.

APPENDIX G

Table G1. Intercepts: 2x2x2x2 factors sort on Size, B/M, OP, Inv

Model	a	t(a)	P-value	Model	a	t(a)	P-value
Dependent variable: BHRA				Dependent variable: SHRA			
FF2015	0.0001	0.0109	0.9914	FF2015	0.0010	0.0868	0.9313
FF1993	−0.0090	−1.0219	0.3130	FF1993	0.0023	0.2870	0.7756
CAPM	−0.0112	−1.2705	0.2109	CAPM	−0.0024	−0.2631	0.7937
Dependent variable: BHRC				Dependent variable: SHRC			
FF2015	0.0055	0.5143	0.6100	FF2015	0.0099	0.5857	0.5615
FF1993	−0.0057	−0.6384	0.5269	FF1993	0.0030	0.2462	0.8068
CAPM	−0.0072	−0.9416	0.3518	CAPM	−0.0031	−0.2686	0.7896
Dependent variable: BHWA				Dependent variable: SHWA			
FF2015	0.0030	0.2647	0.7926	FF2015	0.0006	0.0579	0.9541
FF1993	0.0039	0.4447	0.6590	FF1993	0.0005	0.0714	0.9434
CAPM	0.0050	0.6676	0.5080	CAPM	−0.0038	−0.4999	0.6198
Dependent variable: BHWC				Dependent variable: SHWC			
FF2015	−0.0101	−1.1442	0.2597	FF2015	0.0065	0.6550	0.5164
FF1993	−0.0087	−1.4829	0.1459	FF1993	−0.0004	−0.0413	0.9672
CAPM	−0.0068	−1.1202	0.2690	CAPM	−0.0051	−0.5257	0.6019
Dependent variable: BLRA				Dependent variable: SLRA			
FF2015	−0.0072	−1.0035	0.3220	FF2015	−0.00543	−0.5196	0.6063
FF1993	−0.0098	−1.5827	0.1214	FF1993	−0.0057	−0.7236	0.4735
CAPM	−0.0085	−1.5139	0.1375	CAPM	−0.0092	−1.0085	0.3190
Dependent variable: BLRC				Dependent variable: SLRC			
FF2015	−0.0027	−0.201399	0.8415	FF2015	0.007276	0.875823	0.3866
FF1993	−0.0120	−1.387116	0.1731	FF1993	−0.006730	−1.058666	0.2961
CAPM	−0.0111	−1.426373	0.1612	CAPM	−0.008872	−1.200644	0.2366
Dependent variable: BLWA				Dependent variable: SLWA			
FF2015	−0.0208**	−2.1549	0.0376	FF2015	−0.013245	−1.134389	0.2637
FF1993	−0.0019	−0.2450	0.8077	FF1993	−0.005965	−0.724223	0.4731
CAPM	−0.0012	−0.1741	0.8626	CAPM	−0.010300	−1.007529	0.3195
Dependent variable: BLWC				Dependent variable: SLWC			
FF2015	−0.0096	−0.7934	0.4325	FF2015	0.0097	0.6621	0.5119
FF1993	−0.0145*	−1.8203	0.0762	FF1993	−0.0010	−0.0997	0.9211
CAPM	−0.0131	−1.3234	0.1929	CAPM	−0.0064	−0.6227	0.5368

Note: * significance at 10%, ** at 5%, *** at 1%.

APPENDIX H

Table H1. Coefficients: 2x2x2x2 factors sort on Size, B/M, OP, Inv

D.V.	Model	b	P-value	s	P-value	H	P-value	r	P-value	c	P-value	Adj. R ²
BHRA	FF2015	0.582***	0.005	0.467***	0.006	-0.700	0.247	0.743	0.281	0.450	0.179	0,324
	FF1993	0.530***	0.007	0.469***	0.004	-0.190	0.711					0,327
	CAPM	0.496**	0.018									0,257
BHRC	FF2015	0.492***	0.004	-0.0001	0.9996	0.295	0.794	0.282	0.760	1.131**	0.038	0,327
	FF1993	0.498***	0.009	0.073	0.553	0.616	0.414					0,284
	CAPM	0.510**	0.014									0,289
BHWa	FF2015	0.426**	0.015	-0.048	0.789	-0.412	0.532	-0.108	0.851	-0.019	0.959	0,283
	FF1993	0.435**	0.016	-0.045	0.801	-0.481	0.355					0,318
	CAPM	0.425**	0.014									0,322
BHWc	FF2015	0.462***	0.008	-0.166	0.327	-0.416	0.427	-0.509	0.314	0.303	0.380	0,419
	FF1993	0.514***	0.008	-0.122	0.526	-0.685	0.184					0,408
	CAPM	0.504***	0.003									0,388
BLRA	FF2015	0.798***	0.000	-0.122	0.511	-0.520	0.277	0.385	0.363	-0.034	0.934	0,695
	FF1993	0.764***	0.000	-0.141	0.415	-0.291	0.356					0,700
	CAPM	0.765***	0.000									0,704
BLRC	FF2015	0.311**	0.044	0.134	0.433	-1.392**	0.047	0.817	0.261	0.402	0.415	0,177
	FF1993	0.251	0.108	0.130	0.361	-0.844*	0.092					0,159
	CAPM	0.221	0.190									0,070
BLWA	FF2015	0.735***	0.0003	0.116	0.293	0.333	0.534	-1.300**	0.011	-1.166***	0.001	0,636
	FF1993	0.816***	0.000	0.083	0.595	-0.610	0.136					0,559
	CAPM	0.795***	0.000									0,549
BLWC	FF2015	0.630***	0.005	0.147	0.563	-1.361**	0.042	-0.528	0.476	1.110**	0.044	0,520
	FF1993	0.707***	0.003	0.253	0.387	-1.534**	0.012					0,460
	CAPM	0.651**	0.011									0,307
SHRA	FF2015	0.418***	0.002	0.901***	0.000	-0.166	0.823	0.465	0.511	-0.596	0.273	0,460
	FF1993	0.362**	0.011	0.836***	0.000	0.037	0.927					0,427
	CAPM	0.311*	0.095									0,113
SHRC	FF2015	0.570*	0.005	1.120***	0.0001	-0.360	0.664	0.103	0.896	0.762	0.165	0,522
	FF1993	0.582***	0.004	1.173***	0.000	-0.196	0.786					0,523
	CAPM	0.504*	0.060									0,166
SHWA	FF2015	0.519***	0.0004	1.010***	0.000	-0.684	0.251	-0.228	0.726	0.232	0.574	0,636
	FF1993	0.546***	0.0002	1.037***	0.000	-0.791*	0.087					0,647
	CAPM	0.461**	0.033									0,179
SHWC	FF2015	0.479***	0.010	0.929***	0.0003	-0.478	0.584	-0.268	0.738	1.105**	0.047	0,486
	FF1993	0.533**	0.011	1.024***	0.0001	-0.494	0.431					0,446
	CAPM	0.456*	0.081									0,136
SLRA	FF2015	0.564***	0.009	0.895***	0.0001	-0.884	0.157	0.427	0.500	-0.337	0.416	0,496
	FF1993	0.518**	0.015	0.852***	0.0001	-0.670	0.131					0,499
	CAPM	0.447*	0.079									0,176
SLRC	FF2015	0.458***	0.002	0.868***	0.000	-2.171***	0.0002	0.823	0.123	0.988***	0.009	0,631
	FF1993	0.414***	0.002	0.907***	0.000	-1.542***	0.001					0,596
	CAPM	0.317	0.125									0,068
SLWA	FF2015	0.393*	0.053	1.309***	0.000	-1.141	0.213	-0.602	0.445	-0.353	0.471	0,640
	FF1993	0.436**	0.047	1.308***	0.000	-1.552**	0.032					0,647
	CAPM	0.314	0.292									0,039
SLWC	FF2015	0.547***	0.002	1.181***	0.000	-1.037	0.260	-0.240	0.761	1.567***	0.009	0,679
	FF1993	0.611***	0.001	1.309***	0.000	-0.975	0.219					0,599
	CAPM	0.504**	0.046									0,131

Note: * significance at 10%, ** at 5%, *** at 1%.