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Fama-French Model: New Perspectives from the UK Stock Market

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I investigated the performance of the Fama-French three-factor asset pricing model using UK stock returns. Using monthly data of the FTSE 100 index constituents from January 2007 to December 2011, the Fama-French model is compared with a modified version by changing the Book-to-Market (B/M) factor to Price-to-Earnings (P/E) factor. Results show that the original Fama-French model can explain the variability of excess returns on the UK stock market slightly better than the modified version with reasonably high adjusted R^2 values. Both models can explain better the excess returns when compared to the one-factor Capital Asset Pricing Model (CAPM).

Keywords: Fama and French Model, Factor Models, Asset Pricing, Price-to-Earnings Ratio
JEL Classification Codes: G11, G12, G15

I. Introduction

Asset pricing models are used to determine the theoretical price of a security or portfolio and they should undergo constant evaluation to test the robustness and effectiveness of the model in a particular market. The existing Fama-French three-factor model is an empirically motivated and tested model with inbuilt size and value proxies to explain stock returns. The size and value premiums are usually indicated using market capitalisation and B/M ratios. However, the two indicators have been chosen from the results of prior empirical research (Fama and French, 1992). As time passes, the results from prior empirical research might not stand the test of time. To the best of my knowledge there are no studies so far on the effectiveness of the Fama-French model on the UK stock market for the most recent period of 2007 to 2011. For that reason, I will be testing the effectiveness of the existing Fama-French three-factor model for the period and comparing the existing model with a modified version.

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The main objective of this paper is to investigate the performance of the Fama-French three-factor asset pricing model using UK stock returns. Using monthly data of the FTSE 100 index constituents from January 2007 to December 2011, the Fama-French model is compared with a modified version. The modified model is constructed by swapping the B/M factor for a different price ratio, the Price-to-Earnings (P/E) ratio, as the alternate indicator of the value premium found by Fama and French (1992) and Basu (1977). I contribute to the existing literature by providing evidence of the validity of the P/E ratio as a replacement for the widely used B/M ratio in the Fama-French model on the UK stock market.

I find that the original Fama-French model can explain the variability of excess returns on the UK stock market slightly better than the modified model as evidenced by the higher adjusted R^2 values. The main difference in the model lies in the value factor, which is HML and LMH, in the original and modified respectively. Both HML and LMH appear to have the statistical ability to explain the time-series return variation. Therefore, the B/M ratio remains a very strong proxy for the value premium found on the UK stock market. The statistically significant results from the modified model reveal that the P/E ratio provides relatively high explanatory power for the variability in the excess returns found on the UK stock market. Additionally, both models were found to explain excess returns better than the one-factor CAPM.

However, there are limitations to this study which might have affected the reliability of the results. First, the period studied is within a volatile period where the UK experienced economic downturns, notably in 2008 and 2010. The volatility in the period could affect the correlation and relationship between the dependent and independent variables within the asset pricing models. Second, the data set has been limited to the FTSE 100 constituents. Although the FTSE 100 represents 84% of the UK stock market, only the largest 100 companies in the UK are listed within the index which introduces a bias towards large companies. Additionally, the FTSE 100 and FTSE All-Share indices have been value weighted, allowing bigger firms to have a larger impact on the composition of each index. This is in contrast with the study as the portfolios have been equally weighted instead. Moreover, this study uses an annual re-weighting methodology, whereas the FTSE 100 is re-weighted every quarter. Third, the composition of SMB, HML and LMH factors are calculated using the FTSE 100 instead of the FTSE All-Share, while MP is calculated from the latter. The difference in calculation methodology might have an impact on the ratios considering the FTSE 100 only accounts for the largest companies in the UK. Accordingly, readers should take note of the limitations and their impact on the results of this study.

II. Theoretical Background

2.1. CAPM

The capital asset pricing model (CAPM) was developed to price and determine the required rate of return for all risky assets. Sharpe (1964) found that the return on an asset should be equal to its cost of capital. Following that, the expected return of a security or portfolio should be equal to the risk-free rate plus a premium for the expected risk. The design of the CAPM is generally attributed to the Nobel Laureate, William Sharpe. However, Lintner and Mossin also derived similar theories independently. Consequently, the model is also known as the Sharp-Lintner-Mossin CAPM.

The CAPM is the product of capital market theory, which was built on the Markowitz portfolio theory. Some assumptions of the capital market theory include: all investors are rational and Markowitz-efficient, and investors can borrow or lend any amount of money at the risk-free rate. Some of these assumptions might be unrealistic, but it achieves its primary objective of explaining and predicting behaviour in the real world. If the model is able to explain the variability of returns on a wide range of risky assets, it would be considered useful even if some of its assumptions are unrealistic (Reilly and Brown, 2003).

The CAPM formula is as follows:

$$R_p = R_f + \beta(R_m - R_f) \tag{1}$$

Where:
R_p= Expected rate of return for asset or portfolio p
R_f= Risk-free rate
β = Market Beta
$(R_m - R_f)$ = Equity market premium

The beta of the security in the CAPM formula is a standardised measure of systematic risk, which cannot be diversified away in a portfolio of securities. According to the CAPM the market beta is predicted to be positive and it should be sufficiently significant to explain the cross section of expected asset returns (Fama, 2010). With this in mind riskier securities would have higher beta coefficients due to the higher market risk premiums (Jones, 2004).

Roll (1977) criticised the CAPM and found a major issue in the capital market theory on which the CAPM was based. The capital market theory was formulated on an ex-ante basis, yet it can only be tested on an ex-post basis. This meant that the CAPM has not been proven empirically and remains untestable, as the market portfolio is unobservable. This prompted Roll (1977) to come up with an alternative.

2.2. APT (Arbitrage Pricing Theory)

Following the criticisms of the CAPM, Roll (1977) came up with an alternate asset pricing model, which is now widely known as the APT. It is based on the notion of each security having only one price; hence two identical securities cannot sell at different prices. Market prices would adjust accordingly to eliminate any arbitrage opportunities to arrive at market equilibrium (Jones, 2004). According to the APT the expected security returns are linearly related to a set of indices. These indices represent multiple common risk factors which influence the expected security returns (Reilly and Brown, 2003). Essentially, the total risk premium on a diversified portfolio would be equal to the risk premiums on each source of systematic risk as a form of compensation (Bodie et al., 2011). The APT model is as follows:

$$R_p = E(R_p) + \beta_1 f_1 + \beta_2 f_2 + \cdots + \beta_n f_n + \varepsilon_p \tag{2}$$

Where:
R_p = Actual rate of return on security p in any given period t
$E(R_p)$ = Expected return on security p
f = Deviation of a systematic factor from its expected value
β = Sensitivity of security p to a factor
ε_p = Random error term, unique to security p

Unlike the CAPM the APT does not necessarily instil the need or the inclusion of a market portfolio in its pricing theory. However, the APT does not suggest what the set of indices or risk factors are. The number of risk factors existent is also unclear from the APT (Reilly and Brown, 2003). Berry et al. (1988) concluded that the risk factors must possess three characteristics to be applicable under the APT. First, each suggested risk factor must influence expected returns and be robust enough to be determined empirically through statistical analysis. Second, the risk factors must also have a consistent impact on the stock market returns. Therefore, firm-specific events would fail to meet the second criterion. And third, the factors must be unpredictable and unexpected by the market.

The results from empirical tests of the APT have so far been mixed. The risk factors tested for the APT are found inconsistent in each time-series (Reilly and Brown, 2003). Roll and Ross (1980) argued that the APT is an approach for strategic portfolio planning and only few systematic factors would consistently affect long-term average returns. Consequently, they suggested picking a few factors which affect a wide range of assets to increase its consistency in explaining the portfolio returns, instead of a shotgun approach. Modifications of multifactor models of risk and return have been attempted to identify the essence of systematic risk exposure through testing sets of different variables.

One successful approach is the adoption of macroeconomic variables into the multifactor model – such as inflation, changes in consumer confidence, changes in real GDP and more – as representative of the essence of the systematic risks.

2.3. Fama-French Model

Another approach in identifying systematic risk exposure is the adoption of microeconomic characteristics of individual securities. One such example is the Fama-French (1993) three-factor model. Small firms and high B/M stocks were observed to have increased risk exposure and tended to do better than the market as a whole consistently (Fama and French, 1992). These conclusions were then put together to form the Fama-French three-factor model, which is an expansion of the pre-existing CAPM.

The traditional CAPM uses only one independent variable, known as the market beta, to describe the returns of a portfolio with the returns of the market as a whole. This failed to explain the small firm and value stock anomalies. The emergence of the Fama-French model accounted for these anomalies found in the CAPM, by employing two additional variables to represent the risk exposure due to the small firm effect and value premium.

Fama and French (1992) found that the CAPM is able to account for and explain over 60% of the market returns. However, over 90% of stock market returns can be accounted for, with the inclusion of the two additional factors. The Fama-French three-factor model is as follows:

$$R_p = R_f + \beta_p(R_m - R_f) + s_p(HML) + h_p(SMB) \quad (3)$$

Where:
R_p = Expected rate of return for asset or portfolio p
R_f = Risk-free rate
β = Beta of the security due to factor
$(R_m - R_f)$ = Equity market premium
(SMB) = Equity premium difference between small and big stocks
(HML) = Equity premium difference between high and low B/M stocks

The market premium does play a role in the Fama-French three-factor model, which is designed to capture systematic risk originating from macroeconomic factors. The two microeconomic variables mentioned above have been chosen after long and consistent observations. The expected risk premiums calculated from an individual firm's market capitalisation and B/M ratio can be matched to the deviations of the results from the CAPM with actual stock returns. Fama and French note that SMB and HML might not be obvious candidates for relevant risk factors. Nevertheless, they may proxy for fundamental variables that have yet to be theorised and proven. They justify their model and selected factors based on empirical grounds through statistical research (Bodie et al., 2011).

Empirical approaches such as the Fama-French model face significant issues, as the selected proxies of sources of risk or factors in the proposed models still carry significant sources of uncertainty (Bodie et al., 2011). When researchers repeatedly scan the database of security returns in search of explanatory factors, they may eventually uncover coincidental past patterns, which is also known as data-snooping. Black (1993) argued that return premiums to factors such as firm size have not been consistent since its discovery. However, Fama and French (1993, 1996) found that size and B/M ratios can explain excess returns in extended length of time periods and different geographically-located markets, thus reducing the potential effects of data-snooping and increasing the reliability of the Fama-French model.

2.4. Modified Models

These multifactor models based on the APT are advantageous due to their flexibility for modification. There have been many attempts to modify or augment the original Fama-French (1993) model - to either change the risk proxies themselves or increase the number of microeconomic risk factors in the model to obtain higher predictive capabilities for excess market returns. The Fama-French model was extended to include another price momentum factor by Carhart (1997), while the BARRA model has around 70 different microeconomic risk factors.

In this study, I look at how the value premium indicator, HML, can be modified to improve the existing Fama-French model. There is more than one way of calculating and valuing a stock's price. The different price ratios, such as Price-to-Book (P/B), Price-to-Cash flows (P/CF) or P/E ratios are fundamentally different in their extraction of the risk premium associated with value stocks. Each price ratio is suitable in representing the value premium of the Fama-French (1993) model. The choice of picking the B/M ratio was arbitrary according to Fama and French (2011) and it has worked out coincidentally well with empirical proof. The book value in the numerator of the B/M ratio is more stable over time than earnings or cash flow. The usage of the B/M ratio would allow the investor to keep turnover down in a value portfolio and minimise transactions. Even so, all financial ratios have their issues, including the B/M ratio (Fama and French, 2011). Since the different ratios are highly similar in statistical terms, there is a need to continually test the robustness and validity of the Fama-French model in different time periods and markets through modifications and test whether other financial ratios would be a better fit than the suggested B/M ratio.

The P/E ratio is one of the most relevant tools for stock valuation and can be calculated by dividing the market value per share by its earnings per share. It tells us how much investors are willing to pay for each unit of earnings. Alternatively, it can be seen as a form of market summary evaluation of a company's prospects. Research by Basu (1977) and Truong (2009) has noted that low P/E stocks consistently outperform high P/E stocks in the US and New Zealand respectively.

P/E ratios vary among companies due to differing expectations about future earnings growth rates. If the company is expected to achieve higher earnings growth rates in the future, it will be priced higher than companies with low projected earnings growth rates (Jones, 2004). P/E ratios are also commonly used as proxies for expected growth rates in dividends or earnings.

By modifying the fundamental indicator used from B/M ratios to P/E ratios, an alternate fundamental statistic would be tested empirically to extract the risk premium associated with value stocks on the UK stock market. The original Fama-French (1993) model consists of the three following factors: (1) broad market index, (2) firm size, and (3) B/M ratio. The first two factors will remain the same while the third factor will be modified to assess the effectiveness of the P/E ratio in explaining the value premium, in place of the previous B/M ratio. The modified Fama-French three-factor model is as follows:

$$R_p = R_f + \beta_p(R_m - R_f) + s_p(SMB) + l_p(LMH) \quad (4)$$

Where:
R_p = Expected rate of return for asset or portfolio i
R_f = Risk-free rate
β, s, l = Beta of the security due to factor
$(R_m - R_f)$ = Equity market premium
(SMB) = Equity premium difference between small and big stocks
(LMH) = Equity premium difference between low and high P/E stocks

III. Literature Review

There are extensive amounts of literature on asset pricing models. For the purpose of this study I will concentrate on literature relating to the Fama-French three-factor model.

3.1. Fama-French Model

Fama and French (1996) re-examined their proposed three-factor model (Fama and French, 1993) from 1963 to 1993 and found that the model can explain the returns on portfolios formed on size and B/M ratios. They also found that the model gives similarly strong results when portfolios were formed on other value factors such as P/E, P/Cash flow and Sales/Growth instead of B/M, which were recommended by Lakonishok et al. (1994). They concluded that forming the portfolios on the other value factors provided no additional dimensions of risk or expected return when compared with the portfolio formed from size and B/M ratios. However, they found that the model was unable to explain the momentum anomaly in short-term returns found by Jegadeesh and Titman (1993).

Homsud et al. (2009) tested the CAPM and Fama-French three-factor model on the Thailand stock exchange from 2002 to 2007. The three-factor model was found to have better explanatory power in stock returns over the CAPM for only four out of six groups: S/L, S/H, B/M and B/H. Homsud et al. (2009) suggested that there could be other variables that would explain better the premiums found on the Thailand stock exchange.

Taneja (2010) tested the CAPM and Fama-French model on the Indian stock market from 2004 to 2009 and found that the Fama-French model captures more common return variations than the CAPM. However, their data sets are statistically insignificant due to almost perfect positive correlation between the SMB and HML factors, and suggested a two-factor model in place of the original three-factor model to price assets in India.

Bahl (2006) tested the CAPM and Fama-French model using data from the Indian BSE 100 index. The market premium was found to have the highest explanatory power in both the CAPM and the Fama-French model. The Fama-French model appeared to be better than the CAPM in explaining the variability of excess stock returns on the Indian stock market from 2001 to 2005.

Ajili (2003) tested the Fama-French model using data from 274 stocks on the French stock market from 1976 to 2001. It was found that the market premium has very strong explanatory powers, while the size effect and value premium have a small impact on the excess returns of the French stock market.

3.2. Modified Fama-French Models

Bundoo (2006) found that the Fama-French model holds true. Although the Mauritius stock exchange has only been in operation for 15 years with 40 companies listed as of 2004, size and value premiums were found from 1997 to 2003. Additionally, the augmented version shows that the time variation in beta is priced, with the size and value factors still statistically significant.

Azam and Ilyas (2011) tested the effectiveness of three models: CAPM, original Fama-French three-factor and an augmented five-factor model. They found that all three models are able to explain the variability of excess returns on the Karachi stock exchange from 2003 to 2007. However, the Fama-French five-factor model has slightly more explanatory power than the other two models.

Mouselli (2010) tested the Fama-French model in the UK from 1991 to 2006, albeit with some changes. The value factor, HML, is split up into HMLS and HMLB to test which component of value premium provides better explanatory power for the variability of excess returns on the UK stock market. Results reveal that the value premium in average returns is mainly due to small market capitalisation stocks, and suggested altering the Fama-French model by replacing HML with HMLS.

Carhart (1997) proposed a revision to the Fama-French model by adding a fourth factor – momentum to account for the short-term returns anomaly found by Jegadeesh and Titman (1993). The inclusion of the fourth factor into the pricing model reduces the pricing anomaly of portfolios.

Lam et al. (2010) investigated the performance of the four-factor asset pricing model using Hong Kong stock returns by adding an additional momentum factor to the original Fama-French model to explain the short-term anomalies found by Jegadeesh and Titman (1993).

3.3. Value Premium

Basu initiated much of the research on value investing in 1977 and investigated the relationship between the performance of share prices and its constituent P/E ratios. Empirical studies on 753 NYSE-listed firms from 1957 to 1971 disclosed evidence that value stocks outperform growth stocks. Low P/E portfolios consistently earn higher returns than high P/E portfolios. The results from the 14-year study contradict the efficient market hypothesis and indicate that value investing can consistently beat the market over long periods of time. He further concluded that although publicly available information is instantly reflected in share prices, there are still some discrepancies and lags in the adjustment process.

Empirical studies by Truong (2009) determined that low P/E stocks outperformed high P/E stocks in New Zealand from 1997 to 2007. He noted that the value premium could be explained by investors' inaccurate estimates from past performance and that the market corrects itself when presented with new information. He warned that a low PE portfolio could be highly undiversified as different industries might have different P/E averages. Therefore he suggested similar research could be done by having cut-off level P/E ratios for each individual industry.

Johnson et al. (1989) re-examined the relationship between the performances of NYSE-listed stocks and their P/E ratios using a similar approach to the one employed by Basu in the 1977 study. Johnson et al. (1989) claimed that their study introduced doubt over

Basu's conclusions, especially when back-testing was re-applied from 1979 to 1985. Findings concluded that, despite having the same approach, low P/E stocks were not the reason for the moderate excess returns achieved. Black (1993) and Mackinlay (1995) argued that the value premium observed from past US returns is sample-specific and unlikely to recur.

IV. Data

All the data used in this study is collected from the Bloomberg Professional® database compiled by Bloomberg L.P. The data set contains the historical constituents of the FTSE 100 from 2007 to 2011. The FTSE 100 is re-weighted quarterly by the FTSE Group and accounts for approximately 84% of the UK's market capitalisation (FTSE Group plc, 2011).

To be included in the test a firm must have data from Bloomberg for the following: Market Capitalisation, P/B ratio and monthly stock price for the period tested. Firms that have any missing figures or negative B/M values are removed from the data set. Firms with more than one type of share quoted on the stock market are also taken out of the samples. For example, Royal Dutch Shell shares are double-listed as type A and type B equities on the index. In such a case, one of the duplicates will be removed.

Firm size is measured by market capitalisation. Bloomberg defines it as being the product of the closing price as of the fiscal period end date and shares outstanding at that period end date. Period end date is the most recent annual for which full fundamental data has been collected. B/M ratios are obtained by taking the reciprocal of P/B ratios calculated from Bloomberg. P/B ratio is defined as the market price divided by the book value, and its reciprocal gives the B/M ratio. P/E ratios are obtained from Bloomberg and defined as the market value per share divided by earnings per share.

V. Methodology

This paper will follow the research methodology employed by Lam et al. (2010) and L'Her et al. (2004). Fama and French's choice to sort firms into three groups on B/M and two on ME follows the evidence in Fama and French (1992) that B/M has a stronger role in average stock returns than size. The selected splits have been arbitrary and there has been no evidence to prove that the tests are insensitive to such choices (Fama and French, 1993). Consequently, this paper will sort the firms in a similar method into three by two – forming six categories.

5.1. Fama-French Model

The firms are sorted first by the firm size into two categories: small and large. The firms will then undergo a second round of sorting, according to their B/M ratios, into low, medium and high. The double sorting method will divide the FTSE 100 into six approximately value-weighted portfolios, namely: S/H, S/M, S/L, B/H, B/M and B/L. Portfolios are formed by the number of stocks to maintain a reasonably balanced number of stocks in each portfolio as per the Lam et al. (2010) paper.

Average monthly returns of the six portfolios are calculated and re-balanced each year. Repeating this procedure for a period of five years produces 60 equally-weighted monthly returns from January 2007 to December 2011 for each of the six portfolios. The monthly returns are then used to obtain the SMB and HML values through the following formulas:

$$SMB = \frac{(S/L - B/L) + (S/M - B/M) + (S/H - B/H)}{3} \quad (5)$$

SMB (Small minus big) is the simple average of the returns on the small-stock portfolios minus the returns on the big-stock portfolios (Lam et al., 2010).

$$HML = \frac{(S/H - S/L) + (B/H - B/L)}{2} \tag{6}$$

HML (high minus low) is the simple average of the returns on the high B/M portfolios minus the returns on the low B/M portfolios.

5.2. Modified Model

The modified Fama-French model is a reconstruction of the original Fama-French three-factor model by changing the HML risk proxy into an alternate LMH (low minus high), which is the simple average of the returns on the low P/E portfolios minus the average returns on the high P/E portfolios.

To construct the P/E factor, I follow Lam et al.'s (2010) method. Similar to the above methodology, every December of year t-1 the 100 companies are ranked first by size, followed by their P/E ratios instead of the B/M ratios. The 100 stocks are then divided at the intersection of size and PE ratio into six portfolios with approximately equal number of stocks: S/H, S/M, S/L, B/H, B/M and B/L. The LMH factor is calculated as per the formula below:

$$LMH = \frac{(S/L - S/H) + (B/L - B/H)}{2} \tag{7}$$

LMH (low minus high) is the simple average of the returns on the low P/E portfolios minus the returns on the high P/E portfolios.

5.3 Regression Analysis

The calculated SMB, HML and LMH values will be put under ordinary least squares (OLS) regression analysis to obtain the relevant beta coefficients of the two models below. Assuming Gauss-Markov assumptions hold, OLS will produce the best linear unbiased estimators (BLUE).

$$(R_{p,t} - R_{f,t}) = \alpha + \beta_p(R_m - R_f) + s_p(SMB) + h_p(HML) \tag{8}$$

$$(R_{p,t} - R_{f,t}) = \alpha + \beta_p(R_m - R_f) + s_p(SMB) + l_p(LMH) \tag{9}$$

If the two models above are valid, the beta coefficients of the factors in each model are expected to be significantly different from zero. In addition, the intercept, α, will be expected to be insignificantly different from zero in order to meet Merton's (1973) definition of a well-specified asset pricing model.

VI. Empirical results

Table I presents the descriptive statistics of the six portfolios for the original Fama-French three-factor model and the modified version on the UK stock market. Statistics from both models portray similar trends.

Both Panel A and Panel D, while controlling for market capitalisation, show positive relationships between size and B/M. Average market capitalisation increases from low to high B/M stocks except for the B/H portfolio of the modified model. I find that the market capitalisation is more stable across the different B/M ratio levels for small stocks as compared to large stocks. This did not come as a surprise because the FTSE 100 is dominated by a small group of large stocks, where the ten largest FTSE 100 companies make up to 46% of the index market capitalisation (FTSE Group plc, 2011).

Panel B shows that smaller firms consistently have larger B/M ratios across all three B/M levels as compared to larger firms, while Panel E shows a similar trend – that smaller firms tend to have smaller P/E ratios than larger firms, except for a small inverted difference in the middle P/E group (S/M and B/M).

Panel C and Panel F show very healthy statistics. The 12 portfolios have an average of 13.55 stocks each with a standard deviation of 0.566. Panel C and Panel F also reveal that an average of 84.2 out of the FTSE 100 is used annually in the data collection for the original Fama-French model. The same statistic drops to 78.4 for the modified model. Since the FTSE 100 represents approximately 84.35% of the UK stock market, using circa 80 stocks could hypothetically represent 68% of the UK stock market if the portfolios have been value weighted. I presume approximately 80 stocks would be sufficient as a proxy for the UK stock market for the purpose of this study.

Table I
Descriptive statistics for 6 size-B/M and 6 size-P/E portfolios from Jan 2007 to 2011.

	Original Model					Modified Model			
	Panel A: Average of annual Mkt Cap					Panel D: Average of annual Mkt Cap			
	L	M	H	All		H	M	L	All
S	3700	4103	3906	3903	S	4027	4010	4051	4029
B	34578	38884	57416	43626	B	27768	55066	47009	43281
All	19139	21493	30661	23765	All	15898	29538	25530	23655
	Panel B: Average of annual BM					Panel E: Average of annual PE			
S	0.170	0.458	3.296	1.308	S	43.73	16.05	5.56	21.78
B	0.162	0.395	1.424	0.660	B	48.23	14.71	7.31	23.42
All	0.166	0.426	2.360	0.984	All	45.98	15.38	6.44	22.60
	Panel C: Average annual # of firms					Panel F: Average annual # of firms			
S	13.8	13.8	14.4	42.0	S	13.0	13.0	13.0	39.0
B	14.6	13.8	13.8	42.2	B	13.2	13.0	13.2	39.4
All	28.4	27.6	28.2	84.2	All	26.2	26.0	26.2	78.4

6.1 Portfolio Returns

The average returns for both the size groups (small and big) decrease from low B/M ratios to medium to high B/M ratios, while the standard deviation increases for the same portfolios of size and value as depicted in Table II. There is a highly similar trend found for the modified model. The results shows a positive relationship between size and average monthly returns, which contradicts the inverse relationship hypothesis between size and returns as concluded by Fama and French (1992, 1996), Conner and Sehgal (2001), Ajili (2003), Bundoo (2006) and Bahl (2006).

Most of the portfolio returns show negative skewness values, suggesting that most of the data is skewed towards the right side. Additionally, most kurtosis values are positive suggesting that the data sets tend to have a distinct peak near the mean rather than a flatter distribution. The two statistical results combine to tell us that the data sets have a narrow range of values and skewed away from the mean.

A higher B/M ratio would suggest that the stock is riskier and therefore demand a higher value premium. From the findings in Table II, the average returns of the portfolios (both small and large groups) decrease with higher B/M ratios, showing an inverse relationship between the B/M ratio and returns of the portfolio. Similarly, the trends found in the original model prevail in the modified model.

Table II

Summary statistics on portfolio returns from Jan 2007 to Dec 2011.

	Panel A: Original Model					Panel B: Modified Model			
	Mean	SD	SK	Kurtosis		Mean	SD	SK	Kurtosis
S/L	0.59%	0.0508	-0.345	0.156	S/H	0.69%	0.0522	-0.458	0.163
S/M	0.10%	0.0513	-0.149	-0.126	S/M	-0.21%	0.0526	-0.215	-0.072
S/H	-1.79%	0.0707	-0.429	2.206	S/L	-1.62%	0.0659	-0.683	2.182
B/L	1.07%	0.0402	-0.33	-0.434	B/H	0.97%	0.0463	-0.335	-0.275
B/M	0.11%	0.0564	-0.792	1.096	B/M	0.39%	0.0545	-0.755	0.745
B/H	-0.15%	0.0815	0.639	2.599	B/L	-0.02%	0.0794	1.096	3.789
SMB	-0.71%	0.0223	-0.339	0.293	SMB	-0.83%	0.0245	-0.385	0.368
HML	-1.80%	0.0437	0.955	4.898	LMH	-1.65%	0.0387	0.705	4.087
R_f	2.62%	0.0246	0.469	-1.756	R_f	2.62%	0.0246	0.469	-1.756
R_m	-0.08%	0.0496	-0.376	0.054	R_m	-0.08%	0.0496	-0.376	0.054
MP	-2.70%	0.0609	-0.359	0.230	MP	-2.70%	0.0609	-0.359	0.230

SD = Standard deviation and SK = Skewness in Panel A and Panel B.

6.2. Pearson Correlation

For the original model there is poor correlation between MP and SMB, and between HML and SMB, thus no significant inter-correlation problems in the two pairs. This supports the findings of Bahl (2006) and Conner and Sehgal (2001). However, there is almost perfect positive correlation between MP and HML. This implies that using only either MP or HML can explain better the excess variability in stock returns. This contradicting information supports the findings of Ajili (2003).

For the modified model, the two pairs MP-SMB and HML-SMB remain poorly correlated, signifying no inter-correlation problems. Similarly, the Pearson Correlation figure of 0.452 between MP and LMH is lower than that of MP and HML, 0.609 – suggesting less risk of inter-correlation.

Table III

Pearson Correlation between the variables from Jan 2007 to Dec 2010.

	Panel A: Original Model				Panel B: Modified Model		
	MP	SMB	HML		MP	SMB	HML
MP	1			MP	1		
SMB	-0.019	1		SMB	-0.088	1	
HML	0.609	-0.037	1	LMH	0.452	-0.121	1

6.3. OLS Regression

Table IV below present the results of the monthly time-series regressions on the six portfolios' excess returns and their respective significance at 95% or 99% confidence level from both the original and modified versions of the Fama-French model.

For the purpose of this study I have concentrated on unstandardised beta coefficients rather than standardised coefficients. Not all the predictors used have been measured with the same degree of reliability, and there are potential outliers or overly influential data points. In addition, standardised estimates are more subjective to sampling variability.

I will discuss the regression results in the following order: MP, SMB, HML, LMH, Intercept, Adjusted R^2, Durbin Watson d-statistics, methods used to mitigate autocorrelation errors, measures of heteroskedasticity and collinearity.

Table IV

Coefficients of Intercept, MP, SMB, HML, LMH.

Panel A: Original model				Panel B: Modified Model			
R_p-R_f = $\alpha + \beta_p$MP + s_pSMB + h_pHML				R_p-R_f = $\alpha + \beta_p$MP + s_pSMB + l_pLMH			
Size medians	B/M tertiles			Size medians	B/M tertiles		
	L	M	H		H	M	L
	α				α		
S	-0.030	-0.060	-0.012	S	-0.020	-0.010	-0.010
B	-0.010	-0.009	-0.001	B	-0.010	-0.010	-0.002
	β_p				β_p		
S	0.587**	0.424**	0.511**	S	0.623**	0.573**	0.589**
B	0.461**	0.613**	0.493**	B	0.567**	0.617**	0.601**
	s_p				s_p		
S	0.201	-0.067	0.549*	S	0.118	0.093	0.541**
B	-0.648**	-0.672**	-0.997**	B	-0.606**	-0.614*	-1.029**
	h_p				l_p		
S	0.028	0.429**	0.815**	S	-0.022	0.131	0.722**
B	-0.078	0.215	1.135**	B	-0.237	0.049	1.019**

* Significance at the 5% level

** Significance at the 1% level

6.3.1. MP (Market Premium)

From Table IV, all 12 market betas are highly significant at the 0.01 significance level. The six market betas from the original model range from 0.424 to 0.613, averaging at 0.515. On the other hand, the market betas from the modified model range from 0.567 to 0.623, averaging at 0.595.

6.3.2. SMB

From Table IV, four of the six portfolios have beta coefficients of SMB with significance at the 0.05 significance level for the original model. The beta coefficients of SMB, b_2 ranges from -0.997 to 0.549.

For the modified model, four of the portfolios also have SMB betas significant at the 0.05 significance level – ranging from -1.029 to 0.541. Interestingly, the coefficients of SMB are all negative for large firms while remaining positive for all small firms. The results suggest that the SMB factor of the largest UK firms has a negative impact on their expected returns. Damodaran (2009) suggested that negative betas could occur in firms where strange things happened during the regression period, such as an acquisition battle or lawsuits that affected the correlation with the market.

6.3.3. HML/LMH

In the original model, three of the six coefficients for HML are statistically significant at 0.01 significance level. The coefficients range from -0.078 to 1.135 with a mean of 0.424. The results indicate that the HML factor captures the common variation in average returns that are missed by the market factor. For the modified model, two of the six coefficients for LMH are statistically significant at 0.01 significance level. The coefficients range from -0.237 to 1.019 with an average of 0.277.

As some of the beta values are highly significant, both HML and LMH appear to have the statistical ability to explain the time-series return variation. However, the average beta of LMH is almost half of HML, suggesting that the LMH factor captures less common variation in the excess returns than HML.

6.3.4. Intercept

According to Table IV, all 12 intercepts for both models are insignificantly different from zero. The intercepts range from -0.060 to -0.001, consequently there are almost no intercepts left in each of the three-factor models. This is in line with results from Fama and French (1993) and Lam et al. (2009), where only the independent variables are used as explanatory variables. This supports the significance of the two models to explain the variability of the excess returns on the UK stock market.

Table V
Adjusted R^2 Squared and Durbin Watson Statistics.

	Panel A: Original Model				Panel B: Modified Model		
	L	M	H		H	M	L
	Adjusted R^2				Adjusted R^2		
S	0.423	0.462	0.686	S	0.402	0.387	0.632
B	0.293	0.543	0.764	B	0.420	0.477	0.716
	Durbin-Watson				Durbin-Watson		
S	1.012	0.942	1.135	S	0.908	0.954	1.010
B	1.102	0.899	1.051	B	0.933	0.868	0.918

6.3.5. Adjusted R^2

R^2 is an indicator of the predictive capability of the independent variables on the dependent variables, and reveals how much of the variability observed in the data is accounted for by the models used. The values above have been adjusted to take into account the number of predictors included.

For the original model the adjusted R^2 range from 0.293 to 0.764 with a mean of 0.529. After controlling for B/M, the adjusted R^2 values are reasonably stable across the two size groups. The figures increase accordingly with their respective B/M ratios, suggesting higher B/M groups have a larger explanatory power than lower B/M groups. Therefore, the variability of excess returns is explained better by the three factors (MP, SMB and HML) in higher B/M firms.

For the modified version the adjusted R^2 range from 0.387 to 0.716 with a mean of 0.506. This is slightly lower than the original model of 0.529, suggesting that the modified model is only minimally poorer in explaining the variation in stock excess returns than the original model. Additionally, the adjusted R^2 model seems to provide a more stable predictive capability as all portfolios have a minimum of 38.7% predictive capability compared to 29.3% for the original model.

6.3.6. Durbin-Watson d-statistics

The Durbin-Watson d-statistics is a test for auto-correlation and the results range from 0.899 to 1.135 for the original model and 0.868 to 1.010 for the modified model. Since the d-statistics calculated are below values of d_L at 5% significance level, the null hypothesis of no autocorrelation is rejected. The presence of autocorrelation among the variables introduces inefficiencies in the beta coefficients calculated using OLS in Tables IV and V.

The occurrence of autocorrelation could be due to the inertia or sluggishness in the time-series data used in the regression. Since the independent variables – MP, SMB and HML – are information derived from the stock market, they follow recurring and self-sustaining fluctuations in economic activity. The period tested in this paper is from 2007 to 2011 and Figure 1 shows the large fluctuation in the FTSE All-Share Index within the period due to the economic downturn (Gujarati and Porter, 2010).

As the regressions used in the model involve time-series data successive observations, the independent variables (MP, SMB, HML and LMH) used in the models could be autocorrelated. From the bottom of the economic cycle in 2009, economic recovery starts and most of the time-series data starts moving upwards. In the upswing process the value of a series at one point in time is greater than its previous value. The autocorrelation could be attributed to the momentum, built up in the time-series, as the upswing continues into 2011 before slowing down (Gujarati and Porter, 2010).

Figure I
FTSE All-Share Index 2007-2010

Source: Google Finance 2012

6.3.7. GLS (Generalised Least Squares) Regression

GLS is one of the ways to overcome autocorrelation by transforming the data sets through the Prais-Winsten procedure. GLS produces an asymptotically more efficient estimator than OLS assuming that the time-series are weakly dependent and autocorrelation is present (Woolridge, 2009). GLS is used by Brennan and Subrahmanyam (1996) in estimating the factor coefficients of the Fama-French model, and is supported by Roll and Ross (1994) to be more superior to OLS especially during empirical finance research. Kandell and Stambaugh (1995) also support the use of GLS over OLS because GLS can reduce the impact of extreme sensitivities of cross-sectional results.

The GLS results from Table VI reveal similar results to the OLS results in Table IV in terms of statistical significance of the beta coefficients calculated. Most of the beta coefficients of MP, SMB, HML and LMH remain statistically significant at 5% significance level, while the intercepts remain insignificant. Two notable differences are the higher levels of market beta which are much closer to the theoretical value of one and the higher adjusted R^2 values. Under GLS the three factors in the original model can explain between 78.0 and 93.0% of the market returns and between 80.0 and 89.5% of the modified model.

The different estimates calculated through GLS and OLS suggest that serial correlation was a problem, making the estimates calculated from OLS in Table IV statistically inefficient and producing misleading conclusions. This supports the views of Roll and Ross (1994) and Kandell and Stambaugh (1995) that GLS is a statistically more powerful regression tool for empirical finance and appears to be better than OLS in predicting the BLUEs.[2]

Table VI

[2] I attempted another method to resolve the autocorrelation issue, which can be found in the appendix.

Regression results through GLS.

Panel A: Original model R_p-$R_f = \alpha + \beta_p MP + s_p SMB + h_p HML$				Panel B: Modified Model R_p-$R_f = \alpha + \beta_p MP + s_p SMB + l_p LMH$			
Size medians	B/M tertiles			Size medians	B/M tertiles		
	L	M	H		H	M	L
	α				α		
S	0.005	0.003	-0.001	S	0.011	0.001	0.004
B	0.001	0.000	0.007	B	0.004	0.000	0.011
	β_p				β_p		
S	1.144**	0.949**	1.010**	S	1.073**	0.961**	1.003**
B	0.932**	1.115**	1.060**	B	0.969**	1.046**	1.031**
	s_p				s_p		
S	0.780**	0.551**	0.948**	S	0.607**	0.653**	0.945**
B	-0.237	-0.071	-0.410**	B	-0.106	-0.235*	-0.447**
	h_p				l_p		
S	-0.394**	0.044	0.560**	S	-0.244*	0.033	0.657**
B	-0.350**	-0.141	0.700**	B	-0.283**	0.152	0.814**
	Adjusted R^2				Adjusted R^2		
S	0.889	0.875	0.893	S	0.873	0.8003	0.888
B	0.780	0.895	0.930	B	0.867	0.864	0.895

* Significance at the 5% level
** Significance at the 1% level

6.3.7. Heteroskedasticity

The Breusch-Pagan test and White tests are used to test whether heteroskedasticity is present in the data (Woolridge, 2009). If heteroskedasticity is present, the OLS estimator will no longer be the best linear unbiased estimator. The Breusch-Pagan χ^2 results are lower than the critical values at 5% significance level. Similarly in the White test, most of the χ^2 results remain lower than the critical values at 5% significance level except for S/H, B/L and B/H of the original model and B/L of the modified model. Consequently, there are no serious heteroskedasticity problems.

Table VII
Heteroskedasticity χ^2 Results.

	Panel A: Original Model				Panel B: Modified Model		
	L	M	H		H	M	L
	Breusch-Pagan				Breusch-Pagan		
S	0.04	0.08	0.17	S	0.08	0.05	0.05
B	2.39	0.29	0.71	B	0.79	1.05	0.12
	White				White		
S	12.66	15.77	27.89**	S	13.56	9.72	13.38
B	28.70**	12.00	14.64	B	14.69	16.65	18.60*

* Significance at the 5% level
** Significance at the 1% level

6.3.8. Tolerance & Variable inflation

Tolerance is the reciprocal of variable inflation and measures collinearity among the independent variables in each model. Since tolerance levels are more than 0.25 and VIF levels are below four (O'Brien, 2007), there are no serious multi-collinearity problems. The independent variables (MP, SMB, HML and LMH) are unique predictors of their respective models and non-collinear on other variables.

Table VII
Tolerance & Variable inflation.

	Panel A: Original Model			Panel B: Modified Model	
	Tolerance	VIF		Tolerance	VIF
MP	0.629	1.589	MP	0.794	1.259
SMB	0.999	1.001	SMB	0.984	1.016
HML	0.629	1.590	LMH	0.789	1.268

6.4. Comparing with CAPM

The same data inputs of the above Fama-French models are put through OLS and GLS regression to obtain the statistical values of predictive capability of the CAPM on the same range of stocks and time period. To account for autocorrelation I will only analyse the results from GLS regression.

All of the market betas in the CAPM are significant at 1% significance level, and range from 0.786 to 1.341. This comes to an average of 1.026, which is similar to the results from the Fama-French models in Table VI. All of the intercepts are insignificantly different from zero, adhering to Merton's (1973) definition of a well-specified asset pricing model. The adjusted R^2 values of the CAPM average at 0.761, as opposed to 0.877 for the original Fama-French model and 0.865 for the modified version. This suggests that the Fama-French models can explain better the variability of the excess returns for the same data inputs from the UK stock market when compared to the CAPM. This supports the findings of Azam and Ilyas (2011), Taneja (2010) and Bahl (2006).

Table IX
Regression results of the CAPM using OLS and GLS.

R_p-$R_f = \alpha + \beta_p$MP

	Panel A: CAPM using OLS				Panel B: CAPM using GLS		
	L	M	H		H	M	L
	α				α		
S	-0.004	-0.009	-0.021**	S	0.003	-0.002	-0.015
B	-0.005	-0.006	-0.001	B	0.006	0.002	0.007
	β_p				β_p		
S	0.598**	0.612**	0.863**	S	0.934**	0.941**	1.095**
B	0.387**	0.712**	0.997**	B	0.786**	1.060**	1.341**
	Adjusted R^2				Adjusted R^2		
S	0.436	0.411	0.517	S	0.737	0.800	0.633
B	0.224	0.482	0.485	B	0.679	0.888	0.830
	Durbin-Watson				Durbin-Watson (transformed data)		
S	1.095	0.719	1.325	S	2.506	2.637	2.254
B	1.078	0.575	0.536	B	2.545	2.700	2.127

** Significance at the 1% level

VII. Summary and Conclusions

The validity of the original and modified Fama-French three-factor models on the UK stock market is examined over the period from January 2007 to December 2011. The original Fama-French model includes the three following factors: MP, SMB and HML. On the other hand, the modified version in this study includes MP, SMB and LMH. To our knowledge this is the first study that compares the original model with a modified version by substituting the B/M factor with P/E on the UK market for the above tested period.

Table X shows that both versions of the Fama-French model are better than the CAPM in explaining excess returns. However, the original model is slightly better than the modified version as evidenced by the slight increment in adjusted R^2 values for both regression methods. However, the limitations with the data collection could have caused a divergence in the regression results. Research should be repeated to test the above models again on a wider spectrum of UK stocks with increased timely rebalancing of portfolios to imitate the indices more accurately, and increase the division of portfolios from two by three intersection into five by five intersection, which have been used by academia such as Fama and French (1993) and Lam et al. (2009), so that the asset pricing models can be investigated in greater depth.

Table X
Summary of Models.

	$CAPM_{OLS}$	$FF3F_{Original, OLS}$	$FF3F_{Modified, OLS}$	$CAPM_{GLS}$	$FF3F_{Original, GLS}$	$FF3F_{Modified, GLS}$
α	-0.008	-0.020	-0.010	0.000	0.0025	0.005
β_p	0.695	0.515	0.595	1.026	1.035	1.014
s_p	-	-0.272	-0.250	-	0.260	0.236
h_p	-	0.424	0.277	-	0.070	0.163
Adj. R^2	0.426	0.529	0.506	0.761	0.877	0.865

The table reports simple average beta coefficients which allow positive and negative values to cancel each other out. For specific beta coefficients, refer to the individual tables above.
FF3F = Fama-French three-factor model

Appendix
A. Alternate Method for Correcting Autocorrelation

To account for the autocorrelation I attempted to test the original model with an additional lagged regressor variable of $(R_p\text{-}R_f)_{t-1}$. The model tested is as follows:

$$(R_p - R_f)_t = \alpha + \beta_p MP + s_p SMB + h_p HML + r_p(R_p\text{-}R_f)_{t-1} \quad (10)$$

Where:
R_p = Expected rate of return for asset or portfolio p
R_f = Risk-free rate
β, s, h, r = Beta of the security due to factor
$(R_m - R_f)$ = Equity market premium
(SMB) = Equity premium difference between small and big stocks
(HML) = Equity premium difference between high and low B/M stocks
$(R_p - R_f)_{t-1}$ = Lagged dependent variable

From Table XI, the beta coefficients of the above model present similar results to the original model in Table IV and Table V. Additionally, the beta coefficient of the lagged variable, r_p, are insignificant and therefore the above model is dropped from further analysis.

Table XI

Regression results of the original model with lagged dependent variable.
$(R_p\text{-}R_f)_t = \alpha + \beta_p MP + s_p SMB + h_p HML + r_p(R_p\text{-}R_f)_{t-1}$

Size medians	B/M tertiles			Size medians	B/M tertiles		
	L	M	H		H	M	L
	α				Adjusted R^2		
S	0.000	-0.003	-0.013	S	0.424	0.486	0.683
B	-0.008	-0.006	0.001	B	0.329	0.569	0.772
	β_p				Durbin-Watson		
S	0.601**	0.446**	0.516**	S	1.186	1.253	1.108
B	0.463**	0.630**	0.495	B	1.495	1.237	1.253
	s_p						
S	0.206	-0.004	0.558*				
B	-0.652**	-0.641**	-0.923**				
	h_p						
S	0.002	0.367*	0.816**				
B	-0.138	0.146	1.074**				
	r_p						
S	0.104	0.170	-0.012				
B	0.211	0.176	0.111				

* Significance at the 5% level
** Significance at the 1% level

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