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by

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ABSTRACT

There are several ways to motivate why profitability and investment should affect stock returns. In this paper, I investigate the valuation approach of Fama and French (2015) and the q-theory approach of Hou, Xue and Zhang (2015). While the underlying theories are different, their empirical predictions are the same. Slight differences in factor construction methods afford an opportunity to combine the features of the two models. I find that reinterpreting the q factors (with more frequent rebalancing and more layers of sorting) as Fama-French valuation factors can lead to improvement in model performance. In this modified version, the market risk, size, value, profitability and investment effects are all priced in Thailand.

Key words: asset pricing model, factor-mimicking portfolios

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1. Introduction

How do we know whether an asset is fairly priced? This elusive yet pervasive question of which asset pricing model we should used continues to be one of the most important question for academics and practitioners alike. The theoretical motivations behind asset pricing models are wide-ranging. For example, the Sharpe (1964)-Lintner (1965) Capital Asset Pricing Model is motivated by investor's risk aversion, wealth allocation decision and the ability portfolio-based view of risk diversification, while the Breeden (1979)- Lucas (1978)-Merton (1973) Consumption-Based CAPM is motivated by consumption and saving problem of the representative agent. At the very least, we know that risk-averse investors demand compensation for taking on risk, but what are the sources of risks and how should they be priced? Do different markets price risks differently?[1]

Empirically, factors in asset pricing models are characteristics of stocks that deliver persistent returns that are statistically different from zero over the long run. However, they can either be interpreted as "systematic" sources of risks that cannot be diversified away in an efficient market and hence are priced in the model, or "anomalies" that are driven by behavioral biases or market frictions in inefficient markets. While these two interpretations are often empirically indistinguishable in the data, the fact that they can systematically explain returns lead to their incorporation into asset pricing models as benchmarks. Given that an asset pricing model essentially encompasses a view that some components of returns are predictable, factors that are rooted in fundamental theories about how economic agents operate tend to gain more acceptance.

In the past, many researchers have documented the effect of profitability and investment on stock returns,[2] and two notable asset pricing models have explicitly included them as factors. First, the Fama-French (2015, 2018) model, which is commonly adopted in academic literature as the benchmark for systematic risk adjustment, build on the Modigliani and Miller (1961) dividend discount model to motivate the factors. Second, the Hou, Xue and Zhang (2015) and Hou et al. (2018) q-factor model, which has recently gained popularity due to its success in explaining many

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[1] The workhorse of the academic literature in the past has undoubtedly been the Fama-French (1993) 3-factor model, which extends the the Jensen (1968) single factor model by incorporating the risks associated with small and value (rather than growth) firms and the Carhart (1997) 4-factor model that incorporates commonly-observed price momentums documented by Jegadeesh and Titman (1993).

[2] For example, Haugen and Baker (1996); Piotroski (2000); Fama and French (2006); Novy-Marx (20103); Titman, Wei and Xie (2004); and Polk and Sapienza (2008).

market anomalies, is motivated by a macroeconomic model where the representative firm has capital stock adjustment cost, often used in the investment literature. Despite different motivations (which, in this paper, I refer to as the valuation approach and the q-theory approach), their predictions are similar: firms with higher profitability and lower investment should have higher returns.

In this paper, I investigate the relevance of profitability and investment on stock returns in Thailand from with both approaches. My main objective and contribution is to reconcile the similarities and differences across the two models and combine their successes in a way that is still theoretically founded. In doing so, I select the Thai stock market in hope that this comprehensive review of priced risks could be a starting point for future academic studies or practitioners in investment management.[3]

In the rest of the paper, I will outline the two alternative theories that lead to the predictions on profitability and investment factors, then Section 3 describes the data, factor construction methodology and tests that will be used to assess the performance of the two models. Section 4 reports and discusses the results, then I will and conclude with section 5.

2. Motivating the Profit and Investment Factors

The latest version of the Fama-French model (2018) is valuation-based and motivated by the dividend discount model of Modigliani and Miller (1961), and augmented with the momentum factor reluctantly – as the authors admit – by popularly demand.[4] To illustrate the point, I reproduce the argument made in Fama and French (2015) in proposition of their 5-factor model. Let Y denote the equity earnings of a firm, B denote its book value of equity, and D denote dividend. With clean

[3] More and more researchers are testing the asset pricing models outside the developed markets. For example, Chiah et al (2016) and Hyunh (2018) test the Fama-French five-factor model in Australia, Hu et al. (2018) in China, Hapsari and Wasistha (2017) in Indonesia, and Nguyen (2018) in Vietnam. To my best knowledge, there is no consensus on which factors are priced in in the Thai stock market. An unpublished working paper by Puksamatanan (2011) suggests that the value factor is priced, while the size factor is not.

[4] The momentum factor lacks the theoretical motivation, but its pervasiveness in many markets (even in asset classes other than equity) leads to its eventual adoption in many asset pricing models. Fama and French (2018) lament that "we worry, however, that opening the game to factors that seem empirically robust but lack theoretical motivation has a destructive downside: the end of discipline that produces parsimonious models and the beginning of a dark age of data dredging that produces a long list of factors with little hope of sifting through them in a statistically reliable way."

surplus accounting (that is, $D_t = Y_t - dB_t$, where $dB_t \equiv B_t - B_{t-1}$), we can write the dividend discount model as:

$$M_t = \sum_{\tau=1}^{T} \frac{E[D_{t+\tau}]}{(1+r)^\tau} = \sum_{\tau=1}^{T} \frac{E[Y_{t+\tau} - dB_{t+\tau}]}{(1+r)^\tau} \tag{1}$$

By scaling the left-hand side and the right-hand side with B_t, we get:

$$\frac{M_t}{B_t} = \sum_{\tau=1}^{T} \frac{E[Y_{t+\tau}/B_t - dB_{t+\tau}/B_t]}{(1+r)^\tau} \tag{2}$$

Equation (2) has 3 implications: holding all other components constant, (1) lower B_t/M_t, (2) higher profitability ($Y_{t+\tau}/B_t$), and (3) lower book equity growth ($dB_{t+\tau}/B_t$), imply higher expected stock returns. These theoretical insights are direct implications of the dividend discount model and suggest that profitability (RMW) and investment (CMA) should perhaps be part of the asset pricing model in addition to size (SMB) and value (HML) factors. In the implementation, Fama and French (2015), constructs the investment factor based on total asset growth rather than book equity growth. It is also worth noting that the definition of "investment" in previous literature varies across papers; for example, Titman, Wei and Xie (2004) use average capital expenditure to sales, while Xing (2008) use Thomas and Zhang (2002) use change in inventory to total assets.

Hou, Xue and Zhang (2015), on the other hand, uses a 2-period model based on Cochrane (1991) and the representative in the economy faces quadratic adjustment cost. The first order condition of this model with respect to the firm's investment decision (where marginal benefit of investment, Tobin's q – in the fashion of Hayashi (1982), is equal to the marginal cost of investment) taken in conjunction with household's consumption-based stochastic discount factor gives rise to an equation that implies a firm's return should positively depend on profitability and negatively on investment-to-asset ratio. Since this implication is derived from a firm's investment decision, its essence is capital budgeting.

The empirical predictions are essentially the same as Fama and French (2015), but the motivating theories are different. The Hou, Xue and Zhang (2015) q-factor model, which contains market risk (MKT), size (ME), profitability (ROE) and investment (I/A) can explain more than half of 80 documented anomalies and outperforms the Fama-French (1993) 3-factor model and the Carhart (1997) 4-factor model. In its construction, the investment factor is computed from changes in total assets like Fama and French (2015). The authors explain their choice of proxy by stating that “asset growth is the most comprehensive measure of investment-to-assets”.

One potential drawback of the 2015 q-factor model is that is based on a simple 2-period model, while the Fama-French (2015) 5-factor model is based on an infinite-horizon valuation model. Hou et al. (2018) extends their investment model to infinite period, which results in expected growth of marginal q be part of the first order condition, where higher expected growth (EG) is associated with higher expected return. Expected growth of marginal q is empirically not observable, but the authors argue that expected I/A growth can be use as proxy. I spell out the definitions here again since the nomenclatures are easy to confuse: “investment” (I/A) in this model is historical *level* of asset growth, while “expected growth” in this model is expected *change* in asset growth, which proxies for growth in marginal q. Both factors rely on asset growth as proxies, but the investment aspect is based on change, while the expected growth aspect is based on the rate of change.

3. Data and Empirical Methodology

To construct asset pricing factors, I use Refinitiv Datastream to retrieve prices, returns and financial statements of all stocks that ever listed in Thailand, active and inactive. I do not make a distinction between stocks listed in the main board, the Stock Exchange of Thailand (SET) and the alternative board, the Market for Alternative Investment (MAI) and consider them jointly as the “market”. Exchange-traded funds are excluded from the sample,[5] but I include property funds and REITs because their holdings are not listed stocks, making them a distinct asset class rather than a pass-through vehicle, in defining the market. I retrieve both market and accounting data from December 1999 to June 2019 to construct factors starting July 2000 to June 2019, covering exactly 19 years. Following Schmidt et al. (2017), I drop observations with extreme returns and, in addition, screen out “penny stocks” with low prices. Definitions of penny stocks vary paper-by-paper, but the idea is to screen out stocks with mechanically extreme price movements. To pick the cutoff, I refer to the tick size. The tick size in Thailand is usually less than 1% per tick, but

[5] I include securities whose Datastream field TYPE is EQ, and TRAC not CEF, DRC, ETF, ETFC, ETFE, OPF, RTS and UNT.

stocks with prices less than THB 1 move in THB 0.01 increments, magnifying their returns per tick movement. Consequently, I screen out stocks trading below THB 0.90 at the time of ranking. These penny stocks account for less than 1% of total trading volume on average. To ensure liquidity, I also require that rankable stocks trade consecutively for at least 3 months before ranking date.

I follow the factor construction methodologies of Fama and French (2018) and Hou et al. (2018) as closely as data allows. Specifically, the MKT factor is constructed as the value-weighted return on the market portfolio of all sample stocks minus the one-month Treasury bill rate obtained from the Bank of Thailand. The SMB, HML, RMW, and CMA factors are constructed based on rankings which are conducted at the end of June using financial statements data from the previous year (December). All factors are constructed by double-sorting (2x3 portfolios) to control for size, with cutoff determined by the median market cap of all stocks (SET and MAI) at the end of June. The HML factor sorts on size and the book-to-market ratio computed from the value of the book equity divided by market cap at December of the previous year, the RMW factor on size and operating profitability and the CMA factor on size and total asset growth.[6] The SMB factor in this version controls for value, operating profitability and investment by first creating 3 sub-SMB factors that are double-sorted on size and the three variables, then the three sub-SMB factors are averaged as the overall SMB factor. The UMD factor, on the other hand, is constructed monthly using market cap at the end of the ranking month and the cumulative 2-12 months (11 months, skipping the most recent month) prior returns.

While the Fama-French (2018) 6-factor model combines annual with monthly sorting with double-sorting, the original Hou, Xu and Zhang (2015) q-factor model sorts *monthly* on three dimensions: size, ROE and total asset growth (2x3x3 portfolios). The 18 value-weighted portfolios are then recombined by equal weighting to construct the ME, I/A and ROE factors. The EG factor added in Hou et al. (2018), on the other hand, is constructed as a double-sort (2x3) on size and expected change in I/A. I follow the author's methodology and calculated predicted change in I/A as a function of log of Tobin's q, cash flows to asset ratio, and change in ROE, winsorized at 1%

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[6] The operating profitability used for RMW factor in Fama and French (2015) and Fama and French (2018) are different. In this paper, I follow the Fama and French (2015) definition.

and 99%, but reduce the estimation window from 120 months to 36 months and impose minimum data requirement of 12 months due to data limitation.

The q-factor model does not include the UMD factor since it is spanned by the other 4 factors. The 6-factor model is illustrated by Equation 3, while the q-5 model is illustrated by Equation 4. r_{it}^{e} denotes portfolio returns in excess of the risk-free rate. All returns are measured at the monthly frequency.

$$r_{it}^{e} = \alpha_i + b_i MKT_t + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + u_i UMD_t + \varepsilon_{it} \tag{3}$$

$$r_{it}^{e} = \alpha_i + \beta_{MKT}^{i} MKT_t + \beta_{ME}^{i} ME_t + \beta_{I/A}^{i} I/A_t + \beta_{ROE}^{i} ROE_t + \beta_{EG}^{i} EG_t + \varepsilon_{it} \tag{4}$$

Book equity is computed as the sum of common shareholders' equity (WC03501) and preferred stock (WC03451) when available, otherwise it is total assets (WC02999) minus total liabilities (WC03351). The RMW factor is constructed at the end of June using operating profitability from previous year's financial statements computed as sale (WC01001) minus cost of goods sold (WC01051), selling, general, and administrative expenses (WC01101), and interest (WC01251), divided by lagged book equity. The q-factor quarterly ROE computation is slightly different from 6-factor definition both in terms of frequency and definition of profit. The numerator used is net income before extra/preferred dividend (WC01551A) and denominator is one-quarter lagged book equity, computed with quarterly data (same data item code as earlier with suffix A). Quarterly financial statement items are lagged by one quarter to ensure data is available to investors on ranking date. To compute expected change in I/A, additional financial statements items are required: net receivables (WC02051), total inventories (WC02101), prepaid expenses (WC02140), accounts payable (WC03040), deferred income (WC03262) and total debt (WC03255). All returns in the factor and test assets construction are total returns. The breakpoints of firm-based characteristics at end of June are reported in Table 1.

Table 1: Breakpoints for portfolio formations

Market value of equity (ME) is reported in THB million. Operating profitability (OP), asset growth rate (AG; I/A), return on equity (ROE) and expected growth rate of I/A (EG) are reported as decimals. ROE and EG are ranked at the end of every month but the reported values are as of June. The breakpoint for ME is the median, while the breakpoints for BM, OP, AG, ROE and EG (and unreported MOM) are the 30th and 70th percentiles. Stocks are required to trade for at least 3 consecutive months. Penny stocks priced below 0.90 Baht are excluded from the sample. The number of eligible stocks at the end of each June is reported in the last column.

Year	ME	BM2	BM3	OP2	OP3	AG2	AG3	ROE2	ROE3	EG2	EG3	N
2000	750	0.70	1.84	0.06	0.36	-0.08	0.05	-0.16	0.11	-0.22	0.09	285
2001	1,100	1.09	2.60	0.10	0.36	-0.04	0.07	-0.03	0.13	-0.15	0.11	312
2002	1,440	0.92	1.74	0.09	0.30	-0.05	0.06	0.01	0.05	-0.12	0.11	329
2003	1,748	0.69	1.43	0.11	0.36	-0.01	0.11	0.02	0.05	-0.05	0.13	363
2004	2,045	0.38	0.84	0.12	0.35	0.02	0.17	0.02	0.05	-0.05	0.13	398
2005	1,837	0.55	1.07	0.12	0.35	0.01	0.18	0.02	0.05	-0.07	0.11	429
2006	1,625	0.64	1.21	0.12	0.34	0.02	0.17	0.02	0.05	-0.11	0.10	454
2007	1,692	0.63	1.24	0.10	0.31	0.00	0.13	0.01	0.04	-0.09	0.14	440
2008	1,673	0.56	1.23	0.09	0.30	-0.01	0.12	0.02	0.05	-0.12	0.09	416
2009	1,338	0.99	1.97	0.10	0.31	-0.04	0.09	0.00	0.04	-0.10	0.10	449
2010	1,768	0.70	1.40	0.10	0.29	-0.03	0.09	0.02	0.05	-0.08	0.12	467
2011	1,977	0.51	1.08	0.12	0.31	0.01	0.14	0.02	0.05	-0.08	0.10	474
2012	2,220	0.55	1.12	0.11	0.30	0.02	0.15	0.02	0.05	-0.10	0.07	526
2013	2,880	0.39	0.84	0.09	0.31	0.03	0.17	0.01	0.06	-0.07	0.11	554
2014	3,222	0.45	0.93	0.08	0.29	0.00	0.17	0.01	0.04	-0.05	0.12	580
2015	3,590	0.36	0.82	0.06	0.26	0.00	0.13	0.01	0.04	-0.08	0.09	586
2016	3,620	0.42	0.92	0.07	0.26	-0.01	0.10	0.01	0.04	-0.11	0.06	608
2017	4,100	0.38	0.82	0.08	0.25	0.00	0.11	0.01	0.04	-0.09	0.10	604
2018	3,236	0.38	0.77	0.08	0.24	0.01	0.11	0.01	0.04	-0.08	0.07	605

Once stocks are ranked, value-weighted portfolios are formed (2x3 or 2x3x3) and the relevant portfolios are combined to generate the long-short, factor-mimicking portfolios. For brevity, I refer the reader to Fama and French (2018) and Hou et al. (2018) for detailed instructions of how the portfolios are constructed.

In order to test the relevance and performance of the asset pricing models, I use factor spanning regressions of individual components on the remaining factors, and intercept tests on test assets, which are double-sorted portfolios. The idea behind the factor spanning test is that relevant factors in an asset pricing model should not be spannable (that is, the factor is a linear combination of the remaining factors). In other words, the alpha of individual factors on the remaining factors should be statistically different from zero.

For the intercept tests, the most commonly used method is the Gibbons, Ross and Shanken's (1989) GRS statistic, which is a joint test of whether the intercepts (alphas) of the regressions of test assets on the selected factor model are statistically different from zero. A good asset pricing model should have low GRS statistic, which implies that the null hypothesis that the alphas are jointly zero cannot be rejected. In other words, the pricing model can explain the variation in returns of the test assets.

Other statistics based on the test assets' alphas can also be insightful. For example, the average of the absolute value of alphas (the mean absolute deviation, denoted $A|\alpha_i|$, where $A|.|$ is the average operator) should be close to zero. Let $\bar{r}_i$ be the difference between the average return of the test assets and the market return. Dividing the average of the absolute values (or the squared values) of the alphas by the absolute values (or the squared values) of the corresponding test asset can also reveal how much unexplained dispersion there is relative to total dispersion. Let us denote the absolute statistic with $A|\alpha_i|/A|\bar{r}_i|$ and the squared statistic with $A\alpha_i^2/A\bar{r}_i^2$.

Earlier statistics are based on the estimated value of the intercepts and ignored the precision with which they are estimated, so we can make use of the standard errors of the intercept as well. The ratio of the intercept and the standard error can be thought of as the Sharpe ratio of the intercept. A good asset pricing model should have low intercept Sharpe ratio (either small intercept or low precision). Another way to make use of the standard error is to average their squared values and divide it by the average of the squared values of intercepts, which can be written as $As^2(\alpha_i)/A\alpha_i^2$. With this statistic, a higher value is associated with better asset pricing model.

4. Results

4.1 Univariate Analysis

The average monthly returns, average monthly standard deviation and the corresponding t-statistics for the 10 long-short factors over the 19 years sample period are reported in Table 2 and their correlations are reported in Table 3. The only common factor in the two models, MKT, is large statistically significant at 99% level, but has the highest standard deviation. Of the original 5-factor model, only HML is statistically significant (with both highest average monthly returns and lowest standard deviation) at 99% level. The Fama-French size factor does not appear to be present in Thailand, which is consistent with the view summarized by Van Dijk (2011) that the size factor is not consistent.

The factors under the q-5 model, on the other hand, are all statistically significant at 95% level, with the ROE factor having the highest return and t-statistic. Using the higher hurdle t-statistic of 3 as proposed by Harvey, Liu and Zhu (2016) to address the concern on data mining, it is the only factor of the 10 that pass this more stringent criteria, and by a wide margin. The EG factor, while statistically significant, is negative, contrary to the proposition and the empirical result of the original q-5 model.[7] The result in Table 3 shows that the EG factor is negatively correlated to CMA and I/A, which suggests that the factor may capture the second order effect of investment rather than proxy for expected growth of marginal q, which is known to be difficult to estimate empirically.

Table 2: Average factor returns from July 2000 – June 2019

	MKT	SMB	HML	RMW	CMA	UMD	ME	I/A	ROE	EG
Mean	1.0%	0.4%	0.6%	0.3%	0.3%	0.8%	0.6%	0.5%	1.3%	-0.5%
SD	6.1%	4.4%	3.0%	3.3%	3.1%	4.8%	4.0%	3.0%	3.4%	3.2%
t-stat	2.59	1.23	2.93	1.32	1.60	2.47	2.23	2.34	5.79	2.24

Table 3: Factor correlation matrix

This table reports Pearson's correlation coefficients between each pair of factors. * corresponds to 5% statistical significance level.

	MKT	SMB	HML	RMW	CMA	UMD	ME	I/A	ROE
SMB	-0.4473*								
HML	-0.008	0.060							
RMW	-0.1685*	-0.2152*	-0.1781*						
CMA	-0.002	0.039	0.3327*	-0.4123*					
UMD	-0.101	0.2220*	0.016	-0.069	0.062				
ME	-0.4785*	0.9292*	0.098	-0.1900*	0.062	0.1552*			
I/A	-0.071	0.1359*	0.2383*	-0.3185*	0.7601*	0.1708*	0.1468*		
ROE	-0.2647*	0.002	-0.1767*	0.4395*	-0.1532*	0.3352*	0.076	0.096	
EG	-0.069	0.2084*	0.015	-0.109	-0.2546*	0.059	0.1534*	-0.1629*	0.011

In response the elusiveness of the size factor, Asness et al. (2018) argue that firm size is confounded with firm quality, and when controlling for quality (which, in their paper, is a combination of profitability, growth, safety and payout), the size effect exists and is on par with other factors such as value and momentum. While the construction of both the SMB and ME factors already control for profitability, the triple-sort methodology of the q-factor likely controls for more aspects of quality and thus achieve results more like Asness et al. (2018).

From the univariate results, it seems that the q-5 model could perform better in Thailand. To investigate this further, I turn to the factor spanning regressions and intercept tests.

[7] In the original q-5 model, I/A, ROE and EG all have t-statistics greater than 3, with EG coming in the highest at 9.81.

4.2 Factor Spanning Regressions

Table 4 reports the results of the factor spanning regressions of the Fama-French and q-factor models. Let us begin from Panel A with the results of the Fama-French models. Recognizing the existence of the momentum effect in the market, I skip the 5-factor model (2015) and report the Carhart (1997) 4-factor for comparison.[8] None of the Fama-French factors are spanned by other factors, with HML seemingly most independent of the factors, as evident in low factor loadings and adjusted R-squared. The UMD factor is partially explained by size and profitability, a finding echoed in Hou, Xue and Zhang (2015).[9] While SMB and RMW are not priced in the univariate analysis, their alphas are large and statistically significant when controlling for other factors, beckoning an alternative view that there is a duality between (1) whether a factor is priced and (2) how should its proxy be constructed.

Panel B reports the results for the q-factor models, starting with the original Hou, Xue and Zhang (2105) q-factor, the Hou et al. (2018) q-5 factor and the augmented q-5 factor with the addition of UMD, which I include given the prevalence of momentum in the market. Similar to Hou, Xu, Zhang (2015), UMD is essentially non-existent and explainable mainly by size and profitability, similar to earlier result of the Fama-French models (but the Fama-French model still has room the UMD factor). I/A seems to be spannable, particularly if EG is included. Its loading is negative, consistent with the negative correlation reported in Table 3. As suspected earlier, EG likely captures the same effect as I/A and may not be a good proxy for expected growth in marginal q. The most notable result here is the ROE factor, which has t-statistic in excess of 6, due to higher value of alpha.

Factor spanning test can also be used to examine components of a given factor model against other asset pricing models. The results in Table 5 indicates that the two models are similar, which is not surprising given the commonality in the factor construction process. However, the q-factor size and profitability factors cannot be explained by the Fama-French models, while the q-factor models can explain most of the Fama-French factors, except value. This result is different from Hou et al. (2018), where the q-5 factors can span most Fama-French factors, except operating

[8] For the 4-factor model, the SMB factor is constructed using the original method in Fama and French (1993), as operating profitability and investment are not part of the model.
[9] Fama and French never really utilize the factor spanning regressions but tend to opt for intercept tests instead.

profitability defined using cash measure. In sum, the factor spanning results suggest a fair degree of overlap and the agreement that size and profitability (and perhaps investment) matter for returns.

Table 4: Factor spanning tests of individual components of Fama-French 6-factor model and q-5 model

t-statistics in square brackets.

Panel A: Fama-French 6-factor model

Factor	Alpha		MKT		SMB		HML		RMW		CMA		UMD		Adj R2
SMB	0.51	[1.896]	-0.329	[-7.817]			-0.125	[-1.469]					0.140	[2.845]	0.239
SMB	0.76	[2.954]	-0.357	[-8.757]			0.049	[0.572]	-0.452	[-5.405]	-0.157	[-1.753]	0.146	[3.105]	0.311
HML	0.62	[2.995]	-0.029	[-0.780]	-0.076	[-1.469]							0.012	[0.315]	-0.004
HML	0.48	[2.368]	0.003	[0.0740]	0.030	[0.572]			-0.035	[-0.503]	0.304	[4.507]	-0.004	[-0.110]	0.094
RMW	0.70	[3.607]	-0.174	[-5.133]	-0.258	[-5.405]	-0.033	[-0.503]			-0.407	[-6.515]	0.017	[0.470]	0.279
CMA	0.38	[1.936]	-0.063	[-1.816]	-0.087	[-1.753]	0.276	[4.507]	-0.394	[-6.515]			0.005	[0.130]	0.237
UMD	0.73	[2.051]	0.029	[0.451]	0.249	[2.845]	0.036	[0.315]							0.026
UMD	0.67	[1.824]	0.043	[0.644]	0.286	[3.105]	-0.013	[-0.110]	0.059	[0.470]	0.017	[0.130]			0.026

Panel B: q-5 model

Factor	Alpha		MKT		ME		I/A		ROE		EG		UMD		Adj R2
ME	0.97	[3.728]	-0.321	[-8.087]			0.163	[2.031]	-0.0764	[-1.069]					0.236
ME	1.01	[3.945]	-0.314	[-7.962]			0.196	[2.443]	-0.0775	[-1.096]	0.211	[2.478]			0.253
ME	1.00	[3.917]	-0.314	[-8.003]			0.173	[2.134]	-0.120	[-1.616]	0.198	[2.329]	0.094	[1.815]	0.260
I/A	0.27	[1.226]	0.012	[0.341]	0.111	[2.031]			0.079	[1.333]					0.0163
I/A	0.19	[0.869]	0.013	[0.361]	0.133	[2.443]			0.079	[1.358]	-0.202	[-2.898]			0.0477
I/A	0.19	[0.871]	0.009	[0.237]	0.116	[2.134]			0.036	[0.592]	-0.207	[-2.997]	0.089	[2.103]	0.0621
ROE	1.46	[6.400]	-0.165	[-4.061]	-0.066	[-1.069]	0.100	[1.333]							0.0684
ROE	1.47	[6.376]	-0.165	[-4.054]	-0.069	[-1.096]	0.104	[1.358]			0.0221	[0.272]			0.0646
ROE	1.32	[5.999]	-0.159	[-4.111]	-0.097	[-1.616]	0.0436	[0.592]			-0.004	[-0.052]	0.226	[5.087]	0.158
EG	-0.35	[-1.700]	0.005	[0.142]	0.127	[2.478]	-0.180	[-2.898]	0.015	[0.272]					0.0421
EG	-0.35	[-1.687]	0.003	[0.0872]	0.120	[2.329]	-0.187	[-2.997]	-0.003	[-0.052]			0.0388	[0.955]	0.0417
UMD	-0.07	[-0.197]	0.049	[0.862]	0.169	[1.999]	0.200	[1.957]	0.463	[5.106]					0.132
UMD	-0.03	[-0.088]	0.049	[0.852]	0.155	[1.815]	0.219	[2.103]	0.461	[5.087]	0.105	[0.955]			0.131

Table 5: Factor spanning tests of Fama-French 6 factor model on augmented q-5 model

t-statistics in square brackets.

Panel A: Fama-French 6-factor on q-5

Factor	Alpha		MKT		SMB		HML		RMW		CMA		UMD		Adj R2
ME	0.38	[3.550]	-0.0425	[-2.248]	0.819	[30.76]	0.228	[6.707]					-0.0419	[-1.914]	0.854
ME	0.33	[3.172]	-0.0523	[-2.774]	0.810	[30.92]	0.0513	[1.494]	0.00198	[0.0558]	0.0201	[0.558]			0.867
ME	0.36	[3.474]	-0.0524	[-2.805]	0.821	[31.07]	0.0500	[1.470]	0.00187	[0.0534]	0.0242	[0.678]	-0.0464	[-2.235]	0.870
I/A	0.22	[1.142]	0.0041	[0.119]	0.0904	[1.862]	0.241	[3.874]					0.0848	[2.122]	0.085
I/A	0.21	[1.558]	-0.0109	[-0.446]	0.0662	[1.950]	-0.0208	[-0.469]	0.0109	[0.238]	0.720	[15.45]			0.581
I/A	0.17	[1.233]	-0.0107	[-0.444]	0.0509	[1.490]	-0.0191	[-0.433]	0.0110	[0.243]	0.715	[15.47]	0.0647	[2.412]	0.590
ROE	1.48	[7.141]	-0.195	[-5.342]	-0.199	[-3.863]	-0.233	[-3.536]					0.256	[6.045]	0.237
ROE	1.35	[6.334]	-0.107	[-2.790]	0.00696	[0.131]	-0.141	[-2.010]	0.426	[5.909]	0.0616	[0.840]			0.228
ROE	1.17	[5.953]	-0.106	[-3.021]	-0.0534	[-1.072]	-0.134	[-2.082]	0.427	[6.450]	0.0387	[0.574]	0.256	[6.538]	0.350
EG	-0.39	[-2.030]	0.00942	[0.280]	0.118	[2.490]	0.0275	[0.454]					0.0110	[0.282]	0.017
EG	-0.23	[-1.249]	-0.0176	[-0.535]	0.0946	[2.068]	0.0853	[1.424]	-0.189	[-3.061]	-0.339	[-5.387]			0.139
EG	-0.24	[-1.298]	-0.0176	[-0.532]	0.0906	[1.944]	0.0858	[1.429]	-0.189	[-3.055]	-0.340	[-5.394]	0.0169	[0.461]	0.136

Panel A: q-5 on Fama-French 6-factor

Factor	Alpha		MKT		ME		I/A		ROE		EG		UMD		Adj R2
SMB	-0.11	[-0.893]	-0.0189	[-0.908]	1.014	[32.98]	0.00910	[0.245]	-0.0988	[-2.993]					0.866
SMB	-0.07	[-0.574]	-0.0194	[-0.950]	0.999	[32.59]	0.0297	[0.795]	-0.100	[-3.094]	0.114	[2.893]			0.871
SMB	-0.07	[-0.572]	-0.0246	[-1.252]	0.983	[33.22]	0.00654	[0.181]	-0.149	[-4.538]	0.103	[2.721]	0.106	[4.585]	0.881
HML	0.68	[3.115]	-0.00561	[-0.152]	0.0537	[0.983]	0.254	[3.836]	-0.185	[-3.156]					0.0867
HML	0.70	[3.176]	-0.00587	[-0.159]	0.0470	[0.847]	0.263	[3.903]	-0.186	[-3.166]	0.0529	[0.740]			0.0849
HML	0.70	[3.173]	-0.00691	[-0.186]	0.0437	[0.781]	0.258	[3.789]	-0.196	[-3.148]	0.0507	[0.706]	0.0212	[0.487]	0.0817
RMW	0.16	[0.803]	-0.111	[-3.342]	-0.222	[-4.519]	-0.374	[-6.288]	0.421	[7.993]					0.375
RMW	0.10	[0.493]	-0.110	[-3.366]	-0.199	[-4.067]	-0.405	[-6.801]	0.424	[8.164]	-0.177	[-2.804]			0.393
RMW	0.09	[0.484]	-0.105	[-3.253]	-0.183	[-3.765]	-0.383	[-6.449]	0.472	[8.724]	-0.166	[-2.664]	-0.104	[-2.739]	0.411
CMA	0.27	[1.863]	-0.0166	[-0.676]	-0.0397	[-1.091]	0.840	[19.08]	-0.215	[-5.501]					0.625
CMA	0.22	[1.540]	-0.0159	[-0.659]	-0.0216	[-0.597]	0.814	[18.50]	-0.213	[-5.546]	-0.142	[-3.049]			0.638
CMA	0.22	[1.540]	-0.0166	[-0.684]	-0.0237	[-0.650]	0.812	[18.22]	-0.219	[-5.393]	-0.144	[-3.068]	0.0136	[0.478]	0.637
UMD	-0.07	[-0.197]	0.0492	[0.862]	0.169	[1.999]	0.200	[1.957]	0.463	[5.106]					0.132
UMD	-0.03	[-0.088]	0.0487	[0.852]	0.155	[1.815]	0.219	[2.103]	0.461	[5.087]	0.105	[0.955]			0.131

4.3 Intercept Tests

Basic Test Assets

An asset pricing model is evaluated by how well it explains returns of test assets, typically double- or triple-sorted value-weighted portfolios. A well-performing asset pricing model should have low GRS, $A|\alpha_i|$, $A|\alpha_i|/A|\bar{r}_i|$, $A\alpha_i^2/A\bar{r}_i^2$, Sharpe ratio and high $As^2(\alpha_i)/A\alpha_i^2$. I begin with the 2x3 size-characteristics sorted portfolios that are the building blocks of the factors and the results reported in Table 6. The Fama-French models perform better on the size-BM/OP/AG portfolios, while the q-factor models perform better on the size-ROE. For the size-MOM portfolios, the q-factor models perform better, consistent with the results of the spanning regressions in Table 4.

Other Anomalies

One criticism of intercepts tests is that they tend be performed on tests assets that are the building blocks of the factors. It comes as no surprise then that the Fama-French factors work better on the Fama-French portfolios, while the q factors work better on the ROE portfolios. Researchers often address this shortfall by testing pricing models against other test assets, such as 5x5 portfolios rather than 2x3 portfolios, or portfolios sorted on other characteristics such as anomalies. In this paper, I do not construct detailed test assets as the number of Thai stocks is much lower than other established market. For this reason, I pick three sets of alternative test assets that are based on market anomalies: beta (Frazzini and Pedersen, 2014; Saengchote, 2017), earnings yield (Basu, 1983; essentially the inverse of PE ratio) and dividend yield (Litzenberger and Ramaswamy, 1979). The test assets are constructed as 2x3 independently sorted size-anomaly portfolios.[10] The results are reported in Table 7.

Both the Fama-French 6-factor and the q-factor perform well for the beta and price yield portfolios.[11] Across all test assets, the inclusion of EG and UMD factors in the q-factor model has

[10] Betas are estimated using 60-month rolling regression of stock returns on the value-weighted market returns, with minimum data requirement of 24 months. I apply the Vasicek (1973) adjustment to the estimated beta by shrinking it toward 1 with weight of 0.4 like Frazzini and Pedersen (2004). The adjusted coefficients in each month are then winsorized at 1% and 99% level. The beta portfolios are ranked monthly, while the earnings yield and dividend yield portfolios are ranked annually in June using December data from the previous year.

[11] The price yield (or earnings-to-price) anomaly is often classified as a value-versus-growth premium, but in this sample, it is unrelated to the book-to-market ratio, as the correlation between the two variables are only 0.0156 and statistically insignificant.

ambiguous effect, as its inclusion can either improve or worsen model fit, suggesting that the q-factor model perhaps only needs the original 4 factors of Hou, Xue and Zhang (2015). The dividend yield anomaly remains unexplained by both models, although the q-factor models seems to perform slightly better than the Fama-French counterpart. The results in this part give us some reassurance about the performance of the models: we can conclude that, while risk aversion and thus market risk premium matters, the single factor CAPM model can be improved significantly by additional factors, and investment and profitability play an important role in the Thai stock market. However, it is unclear which is the better model, which brings us to the next part: I argue that both models are good, and the combination of the two can afford us further improvements in attribution of returns.

Table 6: Summary statistics for regression intercepts

The test assets are 2x3 independent sorts on ME and BE/ME, OP, AG, MOM and ROE. The portfolios for BM, OP and AG are formed annually at June, while the ME, I/A, ROE, EG and MOM portfolios are formed monthly per the factor construction methodology.

	GRS	$p(GRS)$	$A\lvert\alpha_i\rvert$	$\frac{A\lvert\alpha_i\rvert}{A\lvert\bar{r}_i\rvert}$	$\frac{As^2(\alpha_i)}{A\alpha_i^2}$	$\frac{A\alpha_i^2}{A\bar{r}_i^2}$	$Adj.R^2$	SR
6 Size-BM portfolios								
MKT	3.78	0.001	0.402	1.43	0.20	2.21	0.67	0.32
MKT SMB3 HML	1.37	0.226	0.145	0.52	0.59	0.20	0.92	0.20
MKT SMB5 HML RMW CMA	1.36	0.232	0.116	0.41	0.81	0.15	0.92	0.21
MKT SMB5 HML RMW CMA UMD	1.40	0.215	0.117	0.42	0.79	0.16	0.92	0.21
MKT ME IA ROE	1.85	0.090	0.241	0.86	0.30	0.90	0.85	0.26
MKT ME IA ROE EG	1.85	0.091	0.254	0.90	0.32	0.84	0.85	0.26
MKT ME IA ROE EG UMD	1.85	0.091	0.244	0.91	0.31	0.84	0.85	0.26
6 Size-OP portfolios								
MKT	3.79	0.001	0.497	1.63	0.16	2.53	0.66	0.33
MKT SMB3 HML	3.13	0.006	0.299	0.98	0.21	0.81	0.87	0.31
MKT SMB5 HML RMW CMA	1.54	0.166	0.153	0.50	0.60	0.18	0.92	0.22
MKT SMB5 HML RMW CMA UMD	1.42	0.207	0.131	0.43	0.81	0.14	0.92	0.22
MKT ME IA ROE	1.71	0.120	0.189	0.62	0.64	0.35	0.85	0.25
MKT ME IA ROE EG	1.59	0.150	0.214	0.70	0.62	0.36	0.86	0.24
MKT ME IA ROE EG UMD	1.73	0.115	0.193	0.71	0.60	0.36	0.86	0.25
6 Size-AG portfolios								
MKT	2.34	0.033	0.471	1.56	0.18	2.54	0.67	0.26
MKT SMB3 HML	0.65	0.690	0.106	0.35	1.77	0.10	0.88	0.14
MKT SMB5 HML RMW CMA	0.58	0.744	0.077	0.25	2.28	0.05	0.92	0.14
MKT SMB5 HML RMW CMA UMD	0.45	0.848	0.058	0.19	3.20	0.04	0.93	0.12
MKT ME IA ROE	1.44	0.200	0.168	0.56	0.77	0.30	0.87	0.23
MKT ME IA ROE EG	1.30	0.259	0.159	0.53	0.82	0.28	0.87	0.22
MKT ME IA ROE EG UMD	1.47	0.189	0.166	0.53	0.78	0.29	0.88	0.23
6 Size-MOM portfolios								
MKT	4.90	0.000	0.581	1.40	0.14	1.96	0.64	0.37
MKT SMB3 HML	4.29	0.000	0.320	0.77	0.29	0.54	0.82	0.36
MKT SMB5 HML RMW CMA	5.35	0.000	0.287	0.69	0.35	0.46	0.83	0.41
MKT SMB5 HML RMW CMA UMD	4.58	0.000	0.184	0.44	0.36	0.20	0.91	0.39
MKT ME IA ROE	1.94	0.075	0.168	0.55	0.64	0.26	0.81	0.27

MKT ME IA ROE EG	2.11	0.053	0.169	0.52	0.75	0.23	0.81	0.28
MKT ME IA ROE EG UMD	1.94	0.076	0.157	0.37	0.65	0.14	0.88	0.27
6 Size-ROE portfolios								
MKT	8.38	0.000	0.581	1.20	0.11	1.62	0.64	0.49
MKT SMB3 HML	9.32	0.000	0.613	1.27	0.07	1.30	0.83	0.54
MKT SMB5 HML RMW CMA	8.05	0.000	0.543	1.12	0.09	1.04	0.83	0.52
MKT SMB5 HML RMW CMA UMD	7.10	0.000	0.466	0.96	0.11	0.83	0.84	0.49
MKT ME IA ROE	1.57	0.158	0.182	0.38	1.09	0.10	0.82	0.24
MKT ME IA ROE EG	1.62	0.143	0.207	0.43	0.83	0.13	0.83	0.25
MKT ME IA ROE EG UMD	1.55	0.162	0.176	0.41	0.85	0.12	0.84	0.24

Table 7: Summary statistics for regression intercepts

The test assets are 2x3 independent sorts on Beta and E/P, and D/P. The portfolios for E/P and D/P are formed annually at June, while the Beta portfolios are formed monthly.

	GRS	$p(GRS)$	$A\|\alpha_i\|$	$\frac{A\|\alpha_i\|}{A\|\bar{r}_i\|}$	$\frac{As^2(\alpha_i)}{A\alpha_i^2}$	$\frac{A\alpha_i^2}{A\bar{r}_i^2}$	$Adj.R^2$	SR
6 Size-Beta portfolios								
MKT	4.63	0.000	0.514	1.97	0.19	3.65	0.62	0.36
MKT SMB3 HML	2.61	0.018	0.334	1.28	0.17	1.69	0.82	0.28
MKT SMB5 HML RMW CMA	1.76	0.109	0.247	0.95	0.35	0.81	0.83	0.24
MKT SMB5 HML RMW CMA UMD	1.27	0.272	0.188	0.73	0.56	0.49	0.83	0.20
MKT ME IA ROE	1.41	0.211	0.178	0.66	0.78	0.42	0.79	0.23
MKT ME IA ROE EG	1.54	0.165	0.189	0.79	0.50	0.68	0.80	0.24
MKT ME IA ROE EG UMD	1.47	0.189	0.180	0.84	0.44	0.76	0.80	0.23
6 Size-EP (price yield) portfolios								
MKT	2.89	0.010	0.424	1.47	0.18	2.43	0.69	0.28
MKT SMB3 HML	1.64	0.137	0.148	0.51	0.64	0.21	0.91	0.22
MKT SMB5 HML RMW CMA	0.48	0.820	0.081	0.28	2.11	0.06	0.91	0.12
MKT SMB5 HML RMW CMA UMD	0.74	0.617	0.081	0.28	2.08	0.07	0.91	0.16
MKT ME IA ROE	1.56	0.160	0.171	0.59	0.77	0.29	0.88	0.24
MKT ME IA ROE EG	1.56	0.159	0.158	0.55	0.76	0.29	0.88	0.24
MKT ME IA ROE EG UMD	1.58	0.155	0.169	0.54	0.75	0.29	0.88	0.24
6 Size-DP (dividend yield) portfolios								
MKT	7.84	0.000	0.626	1.76	0.17	3.22	0.59	0.47
MKT SMB3 HML	6.03	0.000	0.439	1.23	0.20	1.57	0.78	0.43
MKT SMB5 HML RMW CMA	4.56	0.000	0.357	1.00	0.30	0.97	0.81	0.38
MKT SMB5 HML RMW CMA UMD	4.38	0.000	0.333	0.94	0.33	0.90	0.81	0.38
MKT ME IA ROE	3.91	0.001	0.327	0.92	0.48	0.89	0.76	0.38
MKT ME IA ROE EG	3.51	0.002	0.280	0.79	0.58	0.72	0.76	0.36
MKT ME IA ROE EG UMD	3.88	0.001	0.328	0.79	0.57	0.72	0.76	0.38

Modified Fama-French Model

Despite different motivations, the Fama-French and the q-factor model both demonstrate the role of profitability and investment in asset pricing. Before proceeding, I would like to reiterate the similarities and differences between the two models: both models define profitability as ROE and investment as total asset growth, but the definition of ROE and the frequency of calculation differ slightly, and Fama-French portfolios are ranked annually as 2x3 sorts, while q-factor's are ranked monthly as 2x3x3 sorts. The double-sorting methodology used since Fama and French (1993) was from when there were only two new factors, the SMB and HML, and the sorting was done to partial out one effect on another. If factors are not orthogonal, then further sorting to control other aspects may be important to disentangle the effect of the factor that could otherwise be embedded in other elsewhere (for example, Asness et al, 2018).

One disadvantage of the capital budgeting-based q-factor model is that it inherently relies on quadratic adjustment cost and the ability to measure the marginal q, a variable that is known to be notoriously difficult to estimate in corporate finance. In addition, it has no room for the value factor that is shown to be very persistent in the case of the Thai stock market.[12] The Fama-French model, on the other hand, is motivated by valuation and has room for value, profitability and investment effects which are observed in data. To combine their strengths, I propose a simple modification to the Fama-French (2015) 5-factor model, where MKT and HML are retained, but SMB is replaced with ME, RMW replaced with ROE and CMA with I/A.[13] This way, we can retain the factors that are priced empirically, while retain the theoretical connection to the valuation principle.

Using the modified Fama-French 5-factor model, I run the intercept tests on the 8 sets of 2x3 portfolios used earlier. The results are reported in Table 8. For most test assets, model performance is better, with the most visible improvement in the size-BM portfolios. At statistical significance level of 5%, all test assets are explained; the previously anomalous dividend yield portfolios are now also priced. By combining the Fama-French and q-factor models, we can better explain returns in the Thai stock market.

[12] In Hou, Xue and Zhang (2015), the HML factor is spanned by the q-factors in the US market. However, this may not be in the case in other markets, and value effect is also known to be common in many markets (see, for example. Asness, Moskowitz and Pedersen, 2013). The dividend discount model still allows for the value effect without having to resort to behavior-based explanations.

[13] The original q-factor model already spans UMD, and EG in the q-5 model is problematic, so I do not include the two in the model.

Table 8: Summary statistics for regression intercepts with the reconciled model

	GRS	$p(GRS)$	$A\|\alpha_i\|$	$\frac{A\|\alpha_i\|}{A\|\bar{r}_i\|}$	$\frac{As^2(\alpha_i)}{A\alpha_i^2}$	$\frac{A\alpha_i^2}{A\bar{r}_i^2}$	$Adj.R^2$	SR
Size-BM	1.64	0.950	0.094	0.33	2.12	0.09	0.89	0.00
Size-OP	0.26	0.955	0.094	0.48	0.74	0.31	0.89	0.10
Size-AG	1.21	0.303	0.126	0.42	1.17	0.20	0.88	0.22
Size-MOM	1.50	0.179	0.145	0.37	0.88	0.13	0.86	0.24
Size-ROE	1.54	0.166	0.154	0.32	1.06	0.10	0.89	0.24
Size-BETA	1.83	0.094	0.157	0.54	1.60	0.26	0.84	0.27
Size-EP	0.95	0.457	0.141	0.50	1.16	0.20	0.80	0.19
Size-DY	1.00	0.428	0.144	0.87	0.40	1.03	0.88	0.20

5. Conclusion

In this article, I set out to test the performance of the valuation-based Fama-French and the capital-budgeting based q-factor models in Thailand and find that both models perform well, but on different aspects. The result gives us an opportunity to combine the strengths of the two into a better-fitting model that incorporates market risk, size, value, profitability and investment effects, which are direct implications of a risk-averse investor using dividend discount model to value equity investment.

Arguably, asset pricing factors require leap of faith and philosophical stance, with both classical theories and behavioral biases/market frictions capable of delivering the same empirical finding. Both beliefs are not necessarily contradictory, and I take no stand in the interpretation; here in Thailand, we find evidence that some stock characteristics do persistently deliver abnormal returns, and they are consistent with international evidence, but only after redefining how the factor-mimicking portfolios are constructed. Portfolio sorts are convenient and insightful, but special care should be taken ensure that the confounding effects that could contaminate the portfolios are purged to the best extent possible before using them as reference points.

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