Digesting Anomalies: a q-factor Approach for the Thai Market

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We study the extent to which a q-factor approach explains other cross-sectional factor returns in the Thai market from 2000 to 2019. Univariate summaries of test portfolio factors show that the Thai portfolios have almost double the statistical and economic significance of those from the US. Similar results apply when benchmarking the q-factors with the CAPM or the Fama-French six-factor model. In addition, we find that the q-factor model lowers the estimated alphas more than the Fama-French six-factor model for 13 out of 15 test anomalies. Our findings suggest that the q-factor is a better empirical asset pricing model in Thailand, showing external validity of the model even in an emerging market.

Keywords: Factor investing, q-factor, empirical asset pricing

JEL Classification: G12, G14

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1. Introduction

The innovation of Hou et al. (2015) was the introduction of a theoretically-driven factor model which at least matched or outperformed the Fama-French three-factor or four-factor model. But while the Fama-French three to five-factor framework has been tested in emerging markets (e.g., Foye, 2018), the investment capital asset pricing model-based factors per Hou et al. (2015) have not been tested. Comparing the Fama-French performance to the q-factor performance is important as the latter is theoretically motivated with a neoclassical model. In addition, Hou et al. (2018) show that the q-factor model in the US subsumes both the Fama-French five-factor model and the Stambaugh and Yuan (2017) model.

In this paper, we test whether the q-factor asset pricing model that includes profitability and investment factors can better explain equity returns than the equivalent Fama-French model in Thailand. We find that although the Fama-French model explains a large portion of returns, like for the US market, the q-factor performs even better. The q-factor attenuates remaining alphas on 13 of the 15 sets of test portfolios, except for the book-to-market anomaly, which is part of the Fama-French model but not the q-factor model. Our findings corroborate the conclusion by the q-factor model from Hou et al. (2018).

Although the Thai stock market is still relatively small compared to the likes of Japan or China, as of 2019, the total market capitalization of the Stock Exchange of Thailand (SET) is around USD 570 billion, making it the 13th largest in the world and the second biggest in Southeast Asia after Singapore. In addition, it is the most liquid market in terms of trading volume in absolute dollar terms and relative to market capitalization. But despite its growing prominence, academic research on asset pricing factors and anomalies in Thailand remains limited. Extant research is based on the Fama and French (1993) three-factor model, augmented by the Amihud (2002) illiquidity factor (e.g., Puksamatanan, 2011; Pojanavatee, 2020) or the low beta factor (Saengchote, 2017). To the best of our knowledge, there is no published study on alternative asset pricing models, particularly with profitability and investment factors.

Beyond extending the q-factor tests, our study advances the strand of finance literature focusing on Asian-Pacific markets by rigorously testing and restricting the possible set of asset pricing models relevant to the region. The by-product of this replication study and the factors is a comprehensive list of asset pricing anomalies that have not been studied in detail. Empirical tests in Thailand are informative of broader asset pricing theories; as such, developing markets have typically been viewed as inefficient or more subject to behavioral biases (Chang et al., 2000; Morck et al., 2000).

2. Data & Methodology

2.1 Data Sources and Sample Construction

For the Thai sample, we use monthly equity data and quarterly/annual accounting data for firms in Thailand that are publicly listed in the Stock Exchange of Thailand (main market) and the Market for Alternative Investment (for smaller firms) obtained from Refinitiv Datastream and WorldScope, and the Stock Exchange of Thailand. The sample period is between July 2000 and June 2019, covering 19 years and exactly 228 months, due to data limitations to generate some anomaly portfolios. The sample includes both active and those that have delisted, with the number of firms rising from approximately 300 to 700 over this period.

Following Schmidt et al. (2017) and Saengchote (2021), we drop observations with extreme returns. We also screen out "penny stocks" with low prices relative to the tick size. Although the tick size in Thailand is less than one percent of the stock price per tick on average, stocks with prices less than THB 1 move in THB 0.01 increments, magnifying their returns per tick movement. Consequently, we exclude stocks trading below THB 0.90 at the time of ranking. These penny stocks account for less than one percent of total trading volume on average.

For the US sample, we use the data libraries of Kenneth French and Hou et al. (2015), set to the same time span as our Thai sample.[1] This facilitates the comparability of results across the two countries while providing an out-of-sample extension for Hou et al. (2015).

To form portfolios, we use a combination of market-based data (such as market capitalization, returns, and trading volume) and accounting data (such as book value of equity, asset growth, and profitability). For the accounting data, Thailand follows the International Financial Reporting Standards (IFRS) but implemented with a one-year lag whenever the IFRS are updated. Therefore, these values would also be comparable with those for other countries following similar standards.

[1] The data can be retrieved from *https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html* and *http://global-q.org/testingportfolios.html*.

2.2 Methodology

We test the performance of the q-factor model in comparison to the Fama-French six-factor model on a set of asset pricing anomalies using (i) factor spanning regressions of the long-short portfolios constructed from univariate sorts on asset pricing factors and (ii) pricing regressions of 6 (2×3 size-characteristics independent bivariate sorts) portfolios using the Gibbons, Ross and Shanken (1989) test.[2] For each portfolio i, we consider standard factor-spanning tests of the form:

$$r_{i,t} = \alpha_i + \sum_j \beta_j^i f_{j,t} + \varepsilon_t,$$

where $r_{i,t}$ is the test portfolio (e.g. candidate factor or long-short anomaly portfolio), $f_{j,t}$ is the factor premium and β_j^i is the factor loading of factor j of an asset pricing model on portfolio i.

Our portfolio spanning tests use the Barillas and Shanken (2017) tests as well as marginal contribution to maximum squared Sharpe ratio in (Fama and French 2018). We evaluate asset pricing models based on (i) factor premia and statistical significance, and (ii) factor spanning regressions with respect to the Fama and French (2018) six-factor model, the resulting adjusted R^2, and each factor's marginal contribution to a model's maximum squared Sharpe ratio, measured by the ratio of the squared intercept to the squared residual standard error (α^2/s^2).

We follow the factor construction methodologies of Fama and French (2018) and Hou et al. (2015) as closely as the data allow. Details of the variable definitions are shown in the appendix. The MKT factor is constructed as the value-weighted return of all stocks in both markets minus the one-month Treasury bill rate obtained from the Bank of Thailand. Fama-French factors are constructed by double-sorting (2×3 portfolios) annually to control for size, with a threshold determined by the 90 percent of total market capitalization as recommended for non-US markets by Fama and French (2012). 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; the CMA factor on size and total asset growth; the SMB factor in this version controls for value, operating profitability and investment by first creating three 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

[2] For the US sample, we use 15 (3×5) portfolios for each asset pricing anomaly.

factor; the UMD factor is constructed monthly using the market capitalization at the end of the ranking month and the cumulative 2-12 months' (skipping the most recent month's) prior returns. The Hou et al. (2015) q-factors are constructed using the 2×3×3 sort on size, total asset growth, and return on equity.

For the test portfolios, we use 15 sets of test portfolios which is a subset of the 35 statistically significant anomalies considered in Hou et al. (2015), which we classify using the same scheme (momentum, value/growth, investments profitability, and trading friction). Selection into this subset follows a two-step procedure: first, we estimate the slope of Fama-Macbeth regressions of stock characteristics on future returns. Second, we calculate the long-short spreads constructed from 2×3 sorts on size and characteristics.[3] From the initial list of 50, we report the 15 remaining anomalies with statistically significant spreads that will be the basis for further analyses.[4]

3. Empirical Results

Table 1 shows the summary statistics of the factors for both the US and Thailand. The average returns to the US q-factors in Panel A are smaller than those from Table 1 Panel A of Hou et al. (2015) with sample between January 1972 and December 2012. The I/A and ROE factors in Thailand have average returns more than double those in the US over the same period with a slightly higher standard deviation, resulting in higher Sharpe ratios. In Panel B, we report the average returns of the long-short spreads constructed from 2×3 sorts. Of the 15 statistically significant anomalies in Thailand, only 6 are statistically significant in the US, comprising earnings momentum (Abr-1, Abr-6), value (B/M), and profitability (ROA, ROE, NEI). More importantly, 6 anomalies that are significant in Hou et al. (2015) are no longer significant in this sample. Taken together with the insignificant q-factor premia in Panel A, this could result from crowding out following publication and wider adoption of such strategies, as documented by McLean and Pontiff (2016) and Calluzza et al. (2019). On the other hand, the more statistically and economically significant Thai premia compared to those in the US during the same period is consistent with the circumstances in Thailand where factor investing has not yet gained wide adoption.

[3] While Hou et al. (2015) use long-short spreads constructed from univariate deciles, we use bivariate sorts to construct long-short spread to control for the potential influence of size on the anomaly. Consequently, for the US sample, the anomalies are constructed from 3×5 portfolios.

[4] Similar to Hou et al. (2020), we use 1.96 as the critical value throughout the paper.

Panel A of Table 2 shows the empirical results of the relationship between the q-factors and the Fama-French factors in the US. It is important to note that in Hou et al. (2015), the factor-spanning regressions were conducted with respect to the four-factor version, which has been subsequently expanded to include both profitability and investment in Fama and French (2018). Similar to Hou et al. (2015), ME is spanned by SMB. In this six-factor version, I/A and ROE are also spanned by CMA and RMW (and UMD) respectively, as reflected in its statistically insignificant intercept, high adjusted R^2 and low a^2/s^2. This makes the q-factor model more comparable to the Fama-French model than the version tested in Hou et al. (2015). In Panel B, we find that the Fama-French model performs similarly to the q-factor model.[5] The GRS test results also show similar evidence, with 10 statistically insignificant test statistics compared to 6.

Table 3 shows the main empirical results for Thailand. Like in the US, ME is also strongly related to SMB, I/A to CMA and ROE to RMW and UMD. However, unlike the US result, the ROE factor is not fully spanned by the Fama-French factors with an alpha of 0.93% per month and a t-statistic of 5.10, suggesting that the q-factor model has potential to outperform the Fama-French model in Thailand. When evaluated against the 15 anomalies (which all have significant alphas with respect to single-factor CAPM), the q-factor model attenuates the alphas for 13 out of 15 anomalies compared to the Fama-French factors. In particular, the q-factor performs better than the Fama-French factors for momentum-related factors (S-Rev in Thailand has the opposite sign compared to theoretical prediction, making it more a short-term momentum than reversal), investment (NDF, OA) and profitability (ROA, ROE, NEI). Similar to the US result, the q-factor model is unable to price the book-to-market anomaly. The GRS test results also point to superior performance of the q-factor model, with 6 statistically insignificant test statistics compared to 3 for the Fama-French model. With this evidence, we conclude that the q-factor model performs better in Thailand.

4. Conclusion

Using an appropriate asset pricing model is important for both industry-related benchmarking results as well as academic research. This paper compares the relative performance of the Fama-French six-factor model with the q-factor model in Thailand. Our replication of the US data yields somewhat different results from Hou et al. (2015) due to

[5] Hou et al. (2015) find that the alpha of the HML and UMD factors are only 0.06% and 0.13% in the q-factor model, suggesting that they are captured by the q-factor model already. Out-of-sample test with data between July 2000 and June 2019 suggests otherwise.

differences in the timeframe. While the q-factor model outperforms the four-factor Fama-French model in Hou et al. (2015), the performance is comparable to the six-factor version. For Thailand, on the other hand, the q-factor model is superior on many dimensions despite having four factors. Overall, our results highlight the academic need to re-examine the empirical results in non-US markets as well as in the US with different timeframes, as the choice of an appropriate asset pricing model may change over time given the evolving behavior of market participants, as evidenced by McLean and Pontiff (2016) and Calluzza et al. (2019).

Table 1. Summary Statistics of US Replicated Anomalies and Thai Anomalies.

This table reports the summary statistics from January 2000 to June 2019 with 228 months of data. The US Fama-French factors are obtained from Kenneth French's website, while the q-factors and anomalies are obtained from Hou-Xue-Zhang's global-q.org website. For construction of Fama-French factors, at the end of June in each year, stocks are divided into big cap and small cap stocks using a threshold where large cap stocks represent 90 percent of market capitalization as recommended by Fama and French (2012). For other characteristics (book-to-market ratio, operating profitability, and asset growth), stocks are divided into 3 groups based on the 30th and 70th percentiles. Monthly value-weighted returns on the 6 size-characteristics sorted portfolios are calculated and from the bases for the high-minus-low (book-to-market, HML; operating profitability, RMW) or low-minus-high (asset growth, CMA) factors. For construction of q-factors, the definition of profitability used is return on equity (ROE), which is computed using quarterly net income before extra/preferred dividend and book equity. Stocks are independently sorted by size (ME), ROE and asset growth (I/A) in to 18 portfolios which are rebalanced monthly. The size factor (ME) is the low-minus-high difference between the 9 small portfolios and 9 big portfolios. The investment factor (I/A) is the low-minus-high difference between the 6 low I/A portfolios and 6 high I/A portfolios. The ROE factor is the high-minus-low difference between the 6 high ROE portfolios and 6 low ROE portfolios. The anomalies are constructed from independent sorting on size and characteristics (6 portfolios) using 30th and 70th percentiles as cut-offs and reported as long-short spreads. Average returns, standard deviations, and Sharpe ratios are all presented as monthly returns.

Panel A: Fama-French and q-factors									
		United States				Thailand			
	Factors	Mean	SD	*t*	SR	Mean	SD	*t*	SR
Fama-French	MKT	0.47	4.37	1.63	0.11	1.04	6.08	2.59	0.17
	SMB	0.27	2.58	1.60	0.11	0.13	3.78	0.51	0.03
	HML	0.23	2.94	1.19	0.08	0.70	2.89	3.63	0.24
	RMW	0.47	2.49	2.83	0.19	0.19	3.26	0.90	0.06
	CMA	0.27	2.03	2.02	0.13	0.39	2.89	2.04	0.14
	UMD	0.14	5.06	0.43	0.03	0.81	5.52	2.22	0.15
q-factors	ME	0.31	2.61	1.82	0.12	0.25	3.64	1.04	0.07
	I/A	0.22	1.96	1.71	0.11	0.45	2.85	2.40	0.16
	ROE	0.34	2.88	1.78	0.12	1.10	3.34	4.97	0.33

Panel B: Test Anomalies									
		United States				Thailand			
	Anomaly	Mean	SD	*t*	SR	Mean	SD	*t*	SR
Momentum	Abr-1	0.43	1.82	3.58	0.24	1.30	2.68	7.35	0.49
	Abr-6	0.25	1.33	2.89	0.19	0.74	1.90	5.93	0.39
	R6-1	0.23	4.46	0.79	0.05	0.77	4.68	2.50	0.17
	R11-1	0.17	5.95	0.44	0.03	0.86	5.54	2.34	0.15
Value/Growth	B/M	0.58	3.48	2.50	0.17	0.70	2.89	3.65	0.24
	E/P	0.32	2.54	1.90	0.13	0.64	3.70	2.60	0.17
	CF/P	0.35	3.10	1.69	0.11	0.64	3.66	2.63	0.17
	D/P	0.12	2.74	0.68	0.04	0.66	4.74	2.10	0.14
Investments	I/A	0.17	1.74	1.52	0.10	0.40	2.89	2.07	0.14
	NDF	0.14	1.28	1.63	0.11	0.44	2.26	2.96	0.20
	OA	0.01	1.76	0.08	0.01	0.56	2.50	3.39	0.22
Profitability	ROA	0.66	3.85	2.57	0.17	0.87	2.71	4.86	0.32
	ROE	0.76	3.84	2.98	0.20	1.07	2.89	5.57	0.37
	NEI	0.50	2.37	3.18	0.21	0.72	3.83	2.83	0.19
Trading Friction	S-Rev	0.40	4.18	1.45	0.10	-0.94	4.58	3.09	-0.20

Table 2. Pricing errors and tests of overall performance: Replication of the United States.

This table replicates Table 1 (Panel A) and Table 4 (Panel B) of Hou et al. (2015) using data from July 2000 to June 2019 for ease of compatibility. Panel A shows the results of factor spanning regressions of q-factor on CAPM and Fama-French six-factor models. Maximal contribution to Sharpe ratio proposed by Barillas and Shanken (2017) is calculated as the ratio between the square of the intercept and the square of the residual standard errors. Panel B shows the average return (m) of each asset pricing anomaly and the spanning regression alpha (α) with respect to different asset pricing models (CAPM, Fama-French six-factor and q-factor) and the associated t-statistics (t_m, t, t_{FF}, t_q) of the average returns, CAPM alpha, Fama-French six-factor alpha and q-factor alpha respectively. p, p_{FF}, p_q are the p-values of the GRS test on the null hypothesis that the alphas of the portfolios formed on each of the variable are jointly zero. Returns are represented in percentage points and absolute values of *t*-statistics are reported in parentheses under the point estimates in Panel A.

Panel A: q-factor Loadings for Fama-French Factors

	Mean	α	β_{MKT}	β_{SMB}	β_{HML}	β_{RMW}	β_{CMA}	β_{UMD}	Adj. R^2	α^2/s^2
ME	0.31	0.23	0.19						0.09	0.83
	(1.82)	(1.37)	(4.90)							
		0.02	0.03	0.95	0.14	-0.00	-0.06	0.04	0.95	0.10
		(0.43)	(2.79)	(53.6)	(6.90)	(0.113)	(2.00)	(4.73)		
I/A	0.22	0.27	-0.10						0.04	1.96
	(1.71)	(2.10)	(3.33)							
		-0.02	-0.01	0.01	0.04	0.01	0.86	-0.01	0.88	0.13
		(0.50)	(0.45)	(0.54)	(1.91)	(0.38)	(27.6)	(0.60)		
ROE	0.34	0.52	-0.39						0.34	5.00
	(1.78)	(3.35)	(10.9)							
		0.14	-0.06	-0.17	0.03	0.53	-0.06	0.26	0.76	0.96
		(1.37)	(2.30)	(4.10)	(0.644)	(10.4)	(1.01)	(12.2)		

Panel B: Test Portfolios Results for Fama-French and q-factors

	Abr-1	Abr-6	R6-1	R11-1	B/M	E/P	CF/P	D/P	I/A	NDF	OA	ROA	ROE	NEI	S-Rev
m	0.43	0.25	0.36	0.17	0.58	0.32	0.35	0.12	0.17	0.14	0.01	0.66	0.76	0.50	0.40
α	0.49	0.28	0.63	0.44	0.58	0.37	0.39	0.23	0.19	0.15	-0.07	0.90	0.99	0.60	0.24
α_{FF}	0.43	0.21	0.13	0.00	0.18	-0.03	-0.14	0.06	0.15	0.05	0.07	0.31	0.36	0.32	0.45
α_q	0.39	0.15	-0.17	-0.39	0.40	0.13	0.10	0.17	0.05	0.02	0.11	0.22	0.27	0.20	0.41
t_m	3.58	2.89	0.91	0.44	2.50	1.90	1.69	0.68	1.52	1.63	0.08	2.57	2.98	3.18	1.45
t	4.27	3.26	1.79	1.21	2.50	2.23	1.88	1.33	1.62	1.77	0.64	4.31	4.60	4.17	0.92
t_{FF}	3.94	2.88	0.67	0.05	1.48	0.32	1.10	0.40	1.53	0.60	0.69	2.24	2.61	2.61	1.70
t_q	3.40	1.89	0.58	1.35	2.28	0.86	0.55	1.11	0.50	0.23	1.05	2.35	2.98	2.11	1.55
p	0.00	0.00	0.01	0.01	0.01	0.03	0.12	0.01	0.07	0.71	0.02	0.00	0.00	0.00	0.00
p_{FF}	0.00	0.00	0.26	0.26	0.08	0.63	0.66	0.22	0.24	0.74	0.79	0.00	0.00	0.00	0.05
p_q	0.00	0.00	0.02	0.01	0.01	0.34	0.40	0.29	0.07	0.71	0.24	0.00	0.00	0.00	0.01

Table 3. Pricing errors and tests of overall performance: Thailand

This table reports the factor spanning regressions of q-factors and anomaly portfolios using Thai data from July 2000 to June 2019. Panel A shows the results of factor spanning regressions of q-factor on CAPM and Fama-French six-factor models. Maximal contribution to Sharpe ratio proposed by Barillas and Shanken (2017) is calculated as the ratio between the square of the intercept and the square of the residual standard errors. Panel B shows the average return (m) of each asset pricing anomaly and the spanning regression alpha (α) with respect to different asset pricing models (CAPM, Fama-French six-factor and q-factor) and the associated t-statistics (t_m, t, t_{FF}, t_q) of the average returns, CAPM alpha, Fama-French six-factor alpha and q-factor alpha respectively. p, p_{FF}, p_q are the p-values of the GRS test on the null hypothesis that the alphas of the portfolios formed on each of the variable are jointly zero. Returns are represented in percentage points and absolute values of t-statistics are reported in parentheses under the point estimates in Panel A.

Panel A: q-factor Loadings for Fama-French Factors										
	Mean	α	β_{MKT}	β_{SMB}	β_{HML}	β_{RMW}	β_{CMA}	β_{UMD}	Adj. R^2	α^2/s^2
ME	0.25	0.54	-0.28						0.21	0.03
	(1.04)	(2.46)	(7.75)							
		0.20	-0.03	0.90	-0.03	-0.02	-0.02	0.01	0.91	0.04
		(2.60)	(2.15)	(40.8)	(1.29)	(0.80)	(0.68)	(0.35)		
I/A	0.45	0.49	-0.03						0.00	0.03
	(2.40)	(2.55)	(-1.05)							
		0.01	0.009	0.03	0.09	0.07	0.83	0.04	0.73	0.00
		(0.06)	(0.48)	(0.92)	(2.54)	(1.86)	(20.8)	(2.15)		
ROE	1.10	1.26	-0.16						0.08	0.16
	(4.97)	(5.86)	(4.47)							
		0.93	-0.07	-0.07	-0.09	0.35	0.05	0.28	0.40	0.14
		(5.10)	(2.17)	(1.30)	(1.45)	(5.67)	(0.69)	(8.37)		

Panel B: Test Portfolios Results for Fama-French and q-factors															
	Abr-1	Abr-6	R6-1	R11-1	B/M	E/P	CF/P	D/P	I/A	NDF	OA	ROA	ROE	NEI	S-Rev
m	1.30	0.74	0.77	0.86	0.70	0.64	0.64	0.66	0.40	0.44	0.56	0.87	1.07	0.72	-0.94
α	1.36	0.82	1.01	1.10	0.65	0.82	0.82	1.09	0.43	0.46	0.58	1.01	1.15	0.97	-1.06
α_{FF}	1.24	0.72	0.35	0.04	0.00	0.42	0.44	0.99	0.01	0.29	0.54	0.96	1.13	0.59	-0.62
α_q	1.15	0.69	0.22	-0.12	0.57	0.43	0.44	0.72	0.20	0.29	0.55	0.49	0.33	0.46	-0.50
t_m	7.35	5.93	2.50	2.34	3.65	2.60	2.63	2.10	2.07	2.96	3.39	4.86	5.57	2.83	3.09
t	7.64	6.62	3.35	3.05	3.37	3.43	3.46	4.04	2.19	3.02	3.48	5.47	5.68	4.10	3.46
t_{FF}	6.92	5.82	1.77	1.62	2.21	2.31	2.40	4.15	1.37	2.14	3.19	5.43	6.18	2.68	2.02
t_q	5.97	5.18	0.71	0.34	2.86	1.88	1.96	2.93	1.84	1.86	3.09	2.99	2.72	1.92	1.55
p	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.08	0.02	0.00	0.00	0.00	0.00	0.00
p_{FF}	0.00	0.00	0.01	0.22	0.00	0.03	0.02	0.00	0.05	0.06	0.00	0.00	0.00	0.17	0.01
p_q	0.00	0.00	0.02	0.18	0.03	0.09	0.08	0.10	0.02	0.09	0.00	0.00	0.00	0.27	0.01

Appendix A. PBFJ Replication Study Master Pitch Template

Pitcher Team Names	Ben Charoenwong National University of Singapore Sampan Nettayanan Naresuan University Kanis Saengchote Chulalongkorn University	JEL Code	G12, G14	Date Completed	March 5, 2021
(A) Working Title	Digesting anomalies: a q-factor approach for the Thai Market				
(B) Basic Research Question	Can the investment CAPM q-factor model better explain equity returns than the Fama-French model in Thailand?				
(C) Key paper(s)	*Target replication paper*: Hou, K., Xue, C., & Zhang, L. (2015). Digesting anomalies: An investment approach. The Review of Financial Studies, 28(3), 650-705. *Key papers*: Barillas, F., & Shanken, J. (2017). Which alpha?. The Review of Financial Studies, 30(4), 1316-1338. Fama, E. F., & French, K. R. (2018). Choosing factors. Journal of Financial Economics, 128(2), 234-252.				
(D) Motivation/Puzzle	The key innovation of Hou et al. (2015) was the introduction of a theoretically-driven factor model which at least matched or out-performed the Fama-French three-factor or four-factor model. However, while the Fama and French three to five factor framework has been tested in emerging markets, the investment capital asset pricing model-based factors per Hou et al. (2015) have not been tested. We seek to study whether similar conclusions apply out of sample, paying particular attention to the institutional detail in Thailand in terms of accounting regimes and reporting frequencies.				
THREE	Three core aspects of any empirical research				
(E) Idea?	The core idea behind this study is that the q-factor asset pricing model that includes profitability and investment factors can better explain equity returns than the Fama-French model. We extend the evidence in Table 4 of Hou et al. (2015) to the Thai stock market.				
(F) Data?	We use monthly equity data and quarterly/annual accounting data for firms in Thailand that list in the Stock Exchange of Thailand (main market) and the Market for Alternative Investment (for smaller firms) between July 2000 and June 2019 (19 years) with data retrieved from Refinitiv Datastream, WorldScope, and Eikon. The number of firms rise from approximately 300 to 700 over this period. To form portfolios, we use a combination of market-based data (such as market capitalization, returns and trading volume) and accounting data (such as book value of equity, asset growth, and profitability). We use information for stocks listed, allowing those which later failed (so the sample is survivorship-free) in all equity markets in Thailand. Therefore, we do not anticipate selection bias. However, the asset pricing anomalies chosen for this study may differ from the U.S. setting due to (i) data availability to construct sorting variables and (ii) different setting. Given the lack of academic research on anomalies in Thailand, we first establish a list of statistically significant anomalies and then base our analysis of asset pricing models on them.				
(G) Tools?	We apply an algorithm to clean data for potential errors, handle outliers, and exclude "penny stocks" and other illiquid non-tradable stocks when forming portfolios. We will construct the q-factors following the methodology of Hou et al. (2015), namely using portfolio sorts and then use the Barillas and Shanken (2016) tests as well as marginal contribution to maximum				

	squared Sharpe ratio in Fama-French (2018), to examine (i) factor premia and statistical significance, and (ii) factor spanning regressions with respect to the Fama and French (2018) six-factor model (with momentum). We also will also test the performance of the q-factor model in comparison to the six-factor model on a set of asset pricing anomalies using (i) factor spanning regressions of the long-short portfolios constructed from univariate sorts on asset pricing factors and (ii) pricing regressions of 6 (2x3 size-characteristics independent bivariate sorts) portfolios. Stata will be used to perform the analyses.
TWO	Two key questions
(H) What's New?	We apply similar factor construction methodologies as the original papers, extending it to a new country with different institutional settings, and evaluates it performance relative to the extended version of the Fama-French model using more updated empirical tests.
(I) So What?	The extension of the Hou et al. (2015) analysis will provide additional out-of-sample tests which extend the theoretically-driven q-factor. As part of a paradigm shift, we believe such rigorous out-of-sample testing is important to advance the consensus asset pricing model. For practice, the asset management industry can learn more about new portfolio constructions which may result in more robust portfolios with more stable returns.
ONE	One bottom line
(J) Contribution?	Beyond just extending the q-factor tests, our study advances the strand of finance literature focusing on Asia-Pacific markets by rigorously testing and restricting the possible set of asset pricing models that are relevant for the region. The byproduct of this replication study in addition to the factors is a list of asset pricing anomalies which has so far been little studied.
(K) Other Considerations	Data availability is the key consideration for this project. Some anomalies cannot be studied because underlying data is not available, but all the data required for the asset pricing factors are available. The overall completion risk of this project is low.

Appendix B. Supplementary Data

Here, we discuss the procedure to construct asset pricing factors and test portfolios. For annually sorted portfolios, financial statements data as of end of December are used for sorting in June of the following year to ensure data is available to investors on the sorting date. Similarly, quarterly financial statement items are lagged by one quarter. All returns in the factor and test portfolio construction are total returns inclusive of dividend payments. We discuss the variable definitions used for factor construction below, with WorldScope data codes in parentheses where applicable.

Fama-French factors

Book equity is for the HML factor 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). To calculate the book-to-market ratio, we use the end-of-year value of the book equity divided by market cap in December of the same year. Operating profitability for the RMW factor is computed as sale (WC01001) minus cost of goods sold (WC01051), selling, general, and administrative expenses (WC01101), and interest (WC01251), divided by lagged book equity. Asset growth for the CMA factor is computed from annual changes total assets (WC02999).

q-factors

The q-factors require computation from quarterly data which have the same data item code as earlier with suffix A. For example, the I/A factor uses asset growth like the CMA factor but uses WC02999A instead of WC02999. For the ROE factor, the definition of profitability is slightly different from the RMW factor, as the numerator used is net income before extra/preferred dividend (WC01551A) and denominator is one-quarter lagged book equity.

Test portfolios

Abr-1, Abr-6. Abnormal returns around quarterly earnings announcement date. For each announcement date, we compute the abnormal returns over the value-weighted market portfolio over a 4-day window (from one day before announcement to two days after). Abr_i is sorted monthly, and stocks whose most recent announcement dates are more than 6 months old are removed from the sample.

$$Abr_i = \sum_{d=-2}^{+1} r_{i,d} - r_{m,d}$$

Abr-1 portfolios are formed with 1-month holding period, while Abr-6 portfolios are formed with 6-month holding period. That is, in each month, there are 6 sub-portfolios which are formed at different points in time. The returns of the 6 sub-portfolios are then equally-weighted to form the test portfolio.

R6-1, R11-1. Momentum; specifically, Rj-1 are momentum portfolios formed on past j-month cumulative returns and 1-month holding periods. Portfolios are formed monthly.
B/M. Book-to-market ratio, defined earlier.
E/P. Earnings-to-price ratio, computed as net income (WC01751) divided by market capitalization at December t-1. E/P is sorted annually.
CF/P. Cashflow-to-price ratio, computed as net income (WC01751) plus depreciation and amortization (WC01151) divided by market capitalization at December t-1. CF/P is sorted annually.
D/P. Dividend-to-price ratio, sorted on dividend yield (DY) at the end of June. D/P is sorted annually.
I/A. Investment-to-asset ratio, computed from annual changes total assets (WC02999). I/A is sorted annually.
NDF. Net debt financing, computed as change in total debt (WC03255), scaled by average total assets (WC02999). NDF is sorted annually.
OA. Operating accruals, computed as annual change in operating assets, which is defined as current assets (WC02201) less cash and short-term investments (WC02001), minus change in operating liabilities, which is defined as current liabilities (WC03101) less short-term debt and current portion of long-term debt (WC03051), minus depreciation and amortization (WC01151), scaled by lagged total assets (WC02999). OA is sorted annually.
ROA. Return on assets, computed as net income before extra/preferred dividend (WC01551A) divided by lagged total assets (WC02999A). ROA is sorted quarterly.
ROE. Return on equity, computed as net income before extra/preferred dividend (WC01551A) divided by lagged book equity (defined earlier). ROE is sorted quarterly.
NEI. Number of consecutive quarters with an increase in earnings, counted from quarterly net income before extra/preferred dividend (WC01551A), up to 8 quarters. NEI is sorted quarterly.
S-Rev. Short-term reversal, ranked based on one-month return with one-month holding period. Portfolios are formed monthly.

Code to replicate our empirical results and the data files are available online. Additional details on factor construction are available from Saengchote (2021).

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