Mutual fund performance evaluation with active peer benchmarks of domestic equity funds in Thailand

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We use the active peer benchmarks (APB) methodology suggested by Hunter et al. (2014) to capture commonalities or common idiosyncratic noise in fund strategies. These commonalities cannot be captured by the Carhart 4-factor model and it also decreases the accuracy in fund performance evaluation. Firstly, we examine the efficiency of the APB methodology compared with the Carhart 4-factor model. Then we also use the APB methodology to evaluate the performance of actively managed Thai open-end domestic equity funds from January 2006 through December 2020. In the APB methodology, we focus on two dimensions: fund returns and the fund's investment objectives. Our study applies the Carhart 4-factor model with the added benchmark that indicates an equal investment in each fund included in the category as a whole. We call this additional benchmark an "active peer benchmark" (APB). We discover that the active peer benchmark (APB) methodology is able to decrease the average time series pair-wise residual correlations between individual funds in the same APB category when we add the APB factors to the Carhart 4-factor model, which increases the accuracy in fund performance assessment. This active peer benchmarks methodology is also able to determine which mutual funds within each peer group are performing the best.

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Pornthip Supasinthanaphat

TABLE OF CONTENTS

Page

1. Introduction

Investors expect portfolio managers to add value to their investment by creating an excess return over the benchmark return, which induces portfolio managers to choose easy-to-beat benchmarks that may not be the proper benchmark to compare with that mutual fund return in evaluating mutual fund performance. Portfolio managers tend to adopt easy-to-beat benchmarks because of principal-agent problems while selecting a prospectus benchmark. Sensoy (2009) discovered that among US equity mutual funds, self-identifying funds with wide market benchmarks, such as the S&P or Russell, have a 31.2 percent better fit benchmark, as calculated by the monthly regression R-squared of fund return on benchmark return. To measure the real skill of portfolio managers, we should use a better method than comparing mutual funds' NAV returns versus normal prospectus benchmark returns. In this study, we make use of the Hunter et al. (2014) suggested active peer benchmarks (APB), which focus on two dimensions: fund returns and the fund's investment objectives.

Investment in mutual funds provides benefits to investors in many aspects, such as professional management, economies of scale, diversification, liquidity, and convenience. Investors can choose mutual funds that suit their risk and return level (risk appetite). From 2010 to 2019, the ratio of Mutual Funds to Total Asset Under Management in this industry increased from 28.54 MB/percent to 45.84 MB/percent (AIMC, 2020), representing a 60.61 percent increase over a 10-year period. Fund Accounts to Bank Deposit Accounts has grown from 3.11 to 6.79 (AIMC, 2019), which is about 118.33 percent. This can imply that the potential of the Thai economy is highly influenced by the mutual fund industry.

To measure mutual fund performance, we have to focus on the real skill of portfolio managers, which we are not able to calculate purely on NAV returns. Many studies have researched and developed models to extract the skill of portfolio managers from other returns that investors should already receive to redeem for the risk that investors have to take or the returns that just come from luck. The origin of these studies are based on the Capital Asset Pricing Model or CAPM (Sharpe, 1964), which leads to the Sharpe Ratio in comparing mutual fund performances and then evolves to the Jensen model (Jensen, 1968) that uses only one single risk factor, which is a market factor and delivers alpha as an indicator of fund manager skills. After that, size and book to market risk factors were added in the Fama-French 3-Factor model (Fama and French, 1993). Later, momentum was added to the Carhart Model (Carhart, 1997) as the fourth risk factor, respectively. In this literature, the active peer benchmarks factor was added as another exogenous risk factor augmented with the Carhart 4-factor model to conduct a more accurate performance assessment of portfolio managers, relative to the original model.

One way to enhance mutual fund performance is by creating strategies that exploit commonalities in mutual fund returns. Similar strategies across mutual funds cause correlated residuals from general models, which decrease the ability of those models to identify fund manager’s performance and reduce the potential to classify skilled and unskilled managers.

This study aims to examine the ability in evaluating mutual fund performance of the APB factor, whether it is better than the standard 4 factors or not. By comparing how well these models assess manager's alpha via R-squares, t-stat and magnitude of alphas, t-stat and magnitude of standard 4 factors, and t-stat and magnitude of APB factors.

We also test whether the APB factor enables us to capture incremental commonality in fund residuals better than standard 4 factors. By calculating Pearson correlations of individual funds' residuals within peers using the APB augmented model, we compare individual funds' residuals from the standard Carhart four-factor model within the same peer group. If the APB factor is better at capturing commonality in fund residuals than all standard 4 factors, the residuals' correlation within the peer group from the APB augmented model should be less than the residuals' correlation, utilizing the traditional 4-factor approach within the same group.

Moreover, we also use the active peer benchmarks (APB) factor, which is an additional factor to the standard Carhart 4-factor model that consists of market return factor (rmrf), size factor (smb), value factor (hml), and momentum factor (umd), in measuring the performance of domestic equity funds in Thailand.

Our study expects to inspect outperform fund managers by focusing on alphas that managers are able to generate and to identify superior mutual funds in each APB group. Using data from actively managed Thai equity mutual funds from January 2006 until December 2020, the main data points on which we focus are monthly NAV returns and investment objectives, which are available on the Morningstar Direct database.

In this study, active peer benchmarks (APB) were created as additional benchmarks to capture common idiosyncratic noise among funds in the same category. We define suitable benchmarks in categorizing funds by using Morningstar's equity style box. The monthly NAV return on funds in the same peer group is equally weighted in the active peer benchmark. The peer group signals fund styles, including the subgroup of stocks to achieve these fund styles. Using an active peer benchmark is easier than trying to indicate various exogenous risk factors that illustrate several complicated strategies used by mutual funds in a peer group. Applying active peer benchmarks to particular mutual funds can imply the intention of defying the most effective active strategies among a group of similar strategies that target a similar set of stocks.

Many portfolio managers in a peer group can actively adjust their investment styles across time, causing their exposure to risk factors to change over time. An active peer group return augmented with a passive factor has the potential to capture these commonalities across funds (Pastor and Stambaugh, 2002), leading to a more accurate performance regression model in evaluating the alpha of mutual funds.

To study the APB's effect on actively managed Thai mutual funds, we use the Carhart 4-factor model to compare with the APB augmented with the Carhart model as a fund performance measurement. We start our study by regressing the APB itself with the Carhart model to get the APB's alpha, which is the average alpha of individual funds within a peer group. Then we calculate Pearson correlations of individual funds' residuals from the Carhart model within that peer group. The large correlation illustrates common idiosyncratic noise which is not accounted for by the Carhart model. By the way, adding the APB factor to the Carhart model enables capturing these unknown commonalities, causing individual fund pair correlations within a peer group to decrease (Hunter et al., 2014). Hunter, Kandel, and Wermers also found the significant and positive coefficient of the APB's coefficient even after the inclusion of the Carhart 4-factor model, and it is superior to the level of significant of all standard factors, except for the market return factor. These show the potential of the active peer benchmark in improving mutual fund performance evaluation models to distinguish between skilled and unskilled fund managers. They further found that within individual active peer groups, skilled portfolio managers are able to generate alphas from common strategies and also after controlling for common strategy alphas. One of the benefits of using active peer benchmarks is that there is no need to use a long horizon of passive asset returns.

To the best of my knowledge, this is the first study to make use of active peer benchmarking (APB) to evaluate Thai mutual fund performance, focusing on estimating the real skill of the portfolio manager. This is the first study applying the Active Peer Benchmarks methodology to assess the ability to generate alpha from portfolio managers after adjusting for the peer group return, which provides a reasonable comparison and helps in solving the problem that the fund manager's self-selected benchmarks (prospectus benchmarks) can be mismatched due to the fund manager's self-selected benchmarks (prospectus benchmarks) to generate excess return over the benchmark, which can mislead investors. The reasons behind inappropriate prospectus benchmarks come from portfolio managers' career concerns and their receiving commissions or bonuses (Chan Chen and Lakonishok, 2002). There is some evidence of mismatched benchmarks in active U.S. equity funds, against the correlation of fund returns, size of market capitalization, and value-growth dimensions (Sensoy, 2009; Kacperczyk, Sialm, and Zheng, 2008).

The Active peer benchmarks methodology also helps with the lack of style-specific benchmarks in Thailand. According to Thai stock exchange data (2021), Thai market indexes include the SET Index, SET50 & SET100, Industry Group Index and

Sector Index, sSET, SETCLMV, SETHD (SET High Dividend 30 Index), SETTHSI (Thailand Sustainability Investment Index), and SETWB (SET Well-Being Index). While from the Morningstar Database, there are some other styles of Thai equity mutual funds' investment strategies, such as growth stock funds, small-mid cap growth funds, minimum volatility funds, mid-small minimum variance funds, and momentum funds. But there are no any indexes that seem to fit with these styles, and it seems hard to have all indexes be able to cover various investment styles. Therefore, applying an APB technique can solve this problem, it would be helpful in identifying the top mutual funds within a peer group for both individual and institutional investors.

2. Literature review

Many scholars have researched and developed mutual fund performance measurement models to conduct more accurate performance assessments of portfolio managers. Starting from the Modern Portfolio Theory (MPT) proposed by Markowitz (1952), it states that rational investors make decisions based on their expected returns and risk exposures, which shifts the calculation of performance from raw returns to risk-adjusted returns. The original model of performance evaluation studies that is still popular and widely used due to its simplicity is the Capital Asset Pricing Model, or CAPM (Sharpe, 1964), which is based on Markowitz's mean-variance portfolio theory. The formula of CAPM is as follows:

$$R_t = \beta \cdot RMRF_t \tag{1}$$

R_t = Security or portfolio return minus risk free rate

RF_t = Risk-free return

$RMRF_t$ = Market return minus risk-free rate

β = A measure of correlation of the security or portfolio with the broad market

portfolio

After that, Michael Jensen implied CAPM (Sharpe, 1964) and presented the Jensen model (Jensen, 1968) that uses only one single risk factor, which is a market factor, and delivers alpha as an indicator of fund manager skills, also called Jensen's alpha. The positive alpha represents a skilled manager, and the negative alpha represents an unskilled manager. The Jensen model is shown in the following equation:

$$R_t = \alpha + \beta \cdot RMRF_t + e_t \tag{2}$$

α = an intercept of the regression model

e_t = the error term of the regression

Later, the source of returns is attributed further due to size and book-to-market risk factors in the Fama-French 3-Factor model (Fama and French, 1993), the size factor pointed out by Banz (1981), and the book-to-market factor pointed out by Basu (1983). There is empirical evidence that these two extended variables have the ability to explain a cross-sectional average return (Fama and French, 1992). The equation of the Fama French 3-Factor model is as follows:

$$R_t = \alpha + \beta \cdot RMRF_t + s \cdot SMB_t + h \cdot HML_t + e_t \qquad (3)$$

s = the exposure of a security, or portfolio, to the "small-capitalization risk-factor"

SMB_t = the small-capitalization factor

h = the exposure of a security, or portfolio, to the "value stock risk-factor"

HML_t = the value stock factor

Afterwards, the momentum variable was suggested by Jegadeesh and Titman (1993), who discovered that a stock's previous year's return is a key predictor of the next year's return. The momentum factor was added to the Fama-French 3-Factor model (Fama and French, 1993) as the fourth risk factor by Mark Carhart, and the model is called the Carhart 4-factor model (Carhart, 1997). The mathematical model of Carhart is as follows:

$$R_t = \alpha + \beta \cdot RMRF_t + s \cdot SMB_t + h \cdot HML_t + u \cdot UMD_t + \epsilon_t \qquad (4)$$

u = the exposure of a security, or portfolio, to the "momentum risk-factor"

UMD_t = the momentum factor

Lehmann, B. N., & Modest, D. M. (1987) studied the returns of 130 mutual funds during the period of January 1968 to December 1982 to investigate the sensitivity of conventional measures of mutual fund performance alphas to the chosen benchmark in evaluating normal performance by using CAPM benchmarks and various APT benchmarks. They found that the Jensen measures and Treynor-Black appraisal ratios of individual mutual funds are quite sensitive to the method used to construct the APT benchmark. And the fund rankings are less sensitive to the exact number of common sources of systematic risk. The yields from the ten-and fifteen-factor models were insignificantly different, while the yields from the five-factor benchmark exhibited only small differences. But the yields from CAPM benchmarks and the APT benchmarks were significantly different, which emphasizes that adopting the proper risk and expected return model is necessary.

Grinblatt, M., & Titman, S. (1994) implied quadratic regression on a sample of 279 mutual funds and 109 passive portfolios, using a variety of benchmark portfolios. To study the sensitivity of performance assessment to the chosen benchmark and compare two new measures that were developed to overcome the timing-related biases relative to the Jensen Measure, and analyze whether fund performance is related to fund attributes. They found that the chosen benchmark has a substantial impact on performance evaluation, implying that choosing the proper benchmark is important. They discovered that the benchmark is related to fund size, expenses, management fees, portfolio turnover, and load. And that performance is positively related to portfolio turnover but not related to the size of the mutual funds or to the expenses of those funds, implying that more spending on research and trade may not be covered by underpriced stocks.

Ferson, W. E., & Warther, V. A. (1996) modify classical performance measures to take account of well-known market indicators. The addition of lagged market-indicator variables to performance assessment (conditional performance assessment), considering that the use of publicly available data in a portfolio strategy does not indicate fund alpha, From January 1968 to December 1990, this study used monthly data from 63 mutual funds as well as lagged dividend yields and T-bill yields as market indicators. They found the change of fund market risk exposures in response to the market indicators. The conditional data is significant in both statistical and practical terms, and the conditional models improve the fund performance assessment compared to the unconditional models.

Hunter et al. (2014) presented an augmented model that relies on fund returns and investment objectives to capture commonalities among the same strategic funds. Each active peer benchmark is generated from an equally weighted portfolio of the same objective funds, as a benchmark for each fund in that peer, where the final set contains nine style groups: large cap (total, value, and growth); mid cap (total, value, and growth); and small cap (total, value, and growth). Implemented from 1980 to 2010 for the US mutual funds, the APB-augmented model decreases residuals within a group by one-third to one-half of their previous values, depending on the peer group. They discovered that for more than half of the funds in each peer group, the APB coefficients are positive and significant. Except for the market return, the level of significance is higher than any other traditional factor. There is also a portfolio manager's skill, as well as the potential of an APB-augmented model to identify superior funds.

Mateus, Mateus and Todorovic (2019) studied active peer benchmarks proposed by Hunter et al. (2014) in evaluating UK mutual fund performance and performance persistence from 817 active UK long-only equity mutual funds over the period 1992 to 2016, in which these funds are allocated to nine Morningstar style categories. They discovered that when compared to the standard Carhart model, the APB-adjusted model had a higher R-squared and statistically significant alpha. They also found that the funds with the highest APB-adjusted alphas within a particular peer group continue to outperform one year later, and that both winner and loser funds cause performance persistence.

3. Data

3.1 Data Sample

As the primary source of data, Morningstar Direct was used to collect all samples of actively managed Thai open-end domestic equity funds, on which we focused on monthly net asset value (NAV) returns and investment objectives from January 2005 till December 2020. monthly net asset value (NAV) returns. So, closed-end funds won't be included in the study, sector funds, and tax-saving funds (SSF, LTF, and RMF). For each mutual fund, we only include one shareclass. If another shareclass is available, it is used to replace the shareclass that no longer reports returns.

Other data used in this study include the monthly return on the Stock Exchange of Thailand (SET TRI), stock prices, market capitalization, and book-to-market ratio, as well as the monthly risk-free return obtained from Bloomberg Terminal.

For fund categorization, to construct active peer benchmarks (APB) for assessing actively managed Thai open-end domestic equity funds and examining the ability of the APB factor to capture commonality among funds in the same peer group. Firstly, we have to categorize peer groups of these equity funds, and each peer group has to be able to represent the same styles of investment objectives that exist commonalities in mutual fund returns. In other words, we can imply that each peer group will have the same styles of stocks or subgroups of stocks to accomplish these fund styles. So, we classify groups of equity mutual funds by Morningstar's equity style box, which divides equity mutual funds into 9 groups by considering the characteristics of individual funds or stocks that are held in individual funds on two dimensions, which include measurements for size and value-growth. The last nine active peer benchmarks (APB) groups we've developed are small-capitalization & value, small-capitalization & growth, small-capitalization & blend, mid-capitalization & value, mid-capitalization & growth, mid-capitalization & blend, large-capitalization & value, large-capitalization & growth, large-capitalization & blend, for a total of nine (3x3) categories as shown in Table 1. It must have at least five funds in the same category to qualify as a non-null group. The numbers in the table show the available funds in each peer, which we will test on the 4 peer groups that consist of Mid Cap & Value, Large Cap & Value, Small Cap & Blend, Mid Cap & Blend.

Table 1: Morningstar's equity style box

Equity Style Box	**Value**	**Growth**	**Blend**
Small Cap	Small Cap &Value (1)	Small Cap & Growth (2)	Small Cap & Blend (7)
Mid Cap	Mid Cap & Value (68)	Mid Cap & Growth (1)	Mid Cap & Blend (13)
Large Cap	Large Cap & Value (58)	Large Cap & Growth (-)	Large Cap & Blend (4)

3.2 Variable used

3.2.1 Active peer benchmarks' return calculation

In the Active Peer Benchmarks (APB) methodology, we've already categorized equity mutual funds into each peer group. Next, we have to calculate the active peer benchmark returns ($r_{APB_{i,t}}$) for each peer group. Firstly, we have to compute the excess return of each fund ($r_{i,t}$) in the same group by subtracting the risk-free return ($r_{f,t}$) from the monthly NAV return ($R_{i,t}$) of that fund as shown in the equation.

$$r_{i,t} = R_{i,t} - r_{f,t} \tag{5}$$

$R_{i,t}$ is the monthly NAV return of fund i during month t, while $r_{f,t}$ is the risk-free rate for the same period, and $r_{i,t}$ is the excess return of fund *i* during month *t*

After we get all of the excess returns of funds ($r_{i,t}$) in the same peer group, we use these funds' excess returns in the same peer to calculate in terms of an equally-weighted scheme. Finally, we will get the Active peer benchmarks returns ($r_{APB_{i,t}}$) for each peer group as shown in the equation below:

$$r_{APB_{i,t}} = \frac{1}{N_{APB_i}} \sum_{i=1}^{N_{APB_i}} r_{i,t} \tag{6}$$

$r_{APB_{i,t}}$ is the average excess return of the active peer group of funds to which fund i belongs, and N_{APB_i} is the number of funds in the APB to which fund i belongs.

3.2.2 The computation of factors in Carhart model

To study the Active peer benchmarks (APB) factor versus standard 4 factors, we have to construct all of the factors in the standard Carhart 4-factor model that consist of r_{rmrf}, r_{smb}, r_{hml}, and $r_{umd,t}$, respectively. Which r_{rmrf} is the monthly return on the Stock Exchange of Thailand (SET TRI) minus the risk-free return, which is the 1-month Treasury Bill rate of Thailand.

Next, Fama and French (1993)'s construction of r_{smb} and r_{hml} is used. Which the monthly return on the small minus big portfolios with about the same weighted average book-to-market ratio is represented by the expression $r_{smb,t}$, and $r_{hml,t}$ is the difference in the monthly returns on high and low book-to-market portfolios with about equal weighted average sizes.

The Stock Exchange of Thailand's (SET) stocks are first sorted and ranked according to their size and book-to-market ratio. However, equities with a negative book-to-market ratio or no book-to-market ratio are not included. Equities are divided into two portfolios by the median SET size (the 50-percentile breakpoint), which consists of Small (S) and Big (B) portfolios. Reclassify each portfolio into one of three categories according to the book-to-market ranked value's breakpoints for the bottom 30 percentile, middle 40 percentile, and top 30 percentile, respectively, which are Low (L), middle (M), and high (H). So, there are 6 portfolios comprised of S/L, S/M, S/H, B/L, B/M, and B/H. Then, value-weighted average monthly returns for six different portfolios are computed. Finally, r_{smb} and r_{hml} are computed as shown in the following equations, respectively.

$$r_{smb} = [(S/L - B/L) + (S/M – B/M) + (S/H - B/H)] / 3 \quad (7)$$

$$r_{hml} = [(S/H - S/L) + (B/H - B/L)] / 2 \quad (8)$$

Lastly, $r_{umd,t}$ is constructed according to Carhart (1997), which $r_{umd,t}$ is the return on the up minus the down portfolio. $r_{umd,t}$ is calculated as equally weighted average return of equities with the highest 30 percent eleven-month returns lagged one month (r_u) minus the lowest 30 percent eleven- month returns lagged one month (r_d). The equation is as follows:

$$r_{umd} = \frac{1}{N_u}\sum_{i=1}^{N_u} r_u - \frac{1}{N_d}\sum_{j=1}^{N_d} r_d \quad (9)$$

Which N_u is the number of stocks with the highest 30 percent eleven-month returns lagged one month and N_d is the number of stocks with the lowest 30 percent eleven-month returns lagged one month

3.3 Data descriptive

In this analysis, 146 actively managed Thai equities mutual funds from the years 2006 to 2020 were used., being able to get balanced information, with Morningstar Direct's database being as the major data source. The funds are categorized by fund strategies according to Morningstar's equity style box. The final sets of available fund information can be divided into four active peer groups, comprised of: Large Cap & Value, Mid Cap & Blend, Mid Cap & Value, and Small Cap & Blend. The available funds in these peer groups are 58, 13, 68, and 7 funds, respectively.

The necessary data for our models are shown in Table 2-5 with descriptive statistics. All of the data are conducted on a monthly basis.

From table 2, the average monthly NAV return of funds (R_i) retrieved from the Morningstar Direct database is 0.66% (7.90% p.a.), while the average monthly risk-free rate return (r_f) which is the 1-month T-bill rate from Bloomberg Terminal, is 0.18% (2.12% p.a.). So, the average monthly net excess return of funds (r_i), which comes from subtracting the average of the monthly risk-free return (r_f) from the monthly NAV return (R_i) of that fund, is 0.50% (5.97% p.a.). The average monthly market return (r_m), which is calculated by the SET total return index (SET TRI) from Bloomberg Terminal, is 0.88% (10.52% p.a.). We can see that the average monthly returns (R_i) of the actively managed Thai equity mutual funds are lower than the average monthly market returns (r_m) by 0.22% (2.62% p.a.). On average, we can imply that investing in all equities in the market or investing in the passive equity fund could generate a higher return than investing in the actively managed equity fund for 0.22% (2.62% p.a.), before subtracting for management fees.

Table 2: Data descriptive of fund returns, risk free returns, and market returns

This table reports the summary statistics of all variables from 2006 to 2020, including number of observations (N), average (Mean), standard deviation (S.D.), minimum value (Min), and maximum value (Max).

	Monthly return				
Variable	**N**	**Mean**	**S.D.**	**Min**	**Max**
R_i	16,168	0.66%	5.54%	-30.36%	24.84%
r_f	180	0.18%	0.09%	0.02%	0.41%
r_i	16,168	0.50%	5.54%	-30.64%	24.80%
r_m	180	0.88%	5.80%	-30.09%	17.98%

The descriptive statistics of the active peer benchmark returns for each peer group are shown in Table 3. The average monthly return for the Large Cap & Value style ($r_{Large\ Value\ APB}$) is 0.58% (6.95% p.a.), the average monthly return for the Mid Cap & Blend style ($r_{Mid\ Blend\ APB}$) is 0.68% (8.12% p.a.), the average monthly return for the Mid Cap & Value style ($r_{Mid\ Value\ APB}$) is 0.64% (7.62% p.a.), and the average monthly return for the Small Cap & Blend style ($r_{Small\ Blend\ APB}$) is 0.52% (6.25% p.a.). As we can see, the average monthly return for Mid Cap & Blend style ($r_{Mid\ Blend\ APB}$) is the highest, implying that this peer group outperforms other peer groups before adjusting for risk factors. Contrarily, the average monthly return for the Small Cap &

Blend style ($r_{Small\ Blend\ APB}$) is the lowest, implying that this peer group underperformed other peer groups in the period of 2006-2020 before adjusting for risk factors.

Table 3: Data descriptive of the APB returns

This table reports the summary statistics of all variables from 2006 to 2020, including number of observations (N), average (Mean), standard deviation (S.D.), minimum value (Min), and maximum value (Max).

		Monthly return			
Variable	**N**	**Mean**	**S.D.**	**Min**	**Max**
$r_{Large\ Value\ APB}$	180	0.58%	5.49%	-26.60%	17.12%
$r_{Mid\ Blend\ APB}$	180	0.68%	5.86%	-27.66%	16.88%
$r_{Mid\ Value\ APB}$	180	0.64%	5.39%	-24.84%	14.18%
$r_{Small\ Blend\ APB}$	72	0.52%	5.58%	-20.48%	21.28%

Table 4 reports the descriptive statistics of the constructed variables that would be used to form the 4-risk factors, which are portfolio returns. To construct the size risk factor and value risk factor, we have to calculate that the average monthly return for Small cap & Low book-to-market equities ($r_{Small\ Low}$) is 1.89% (22.65% p.a.), the average monthly return for Small cap & Medium book-to-market equities ($r_{Small\ Medium}$) is 0.95% (11.35% p.a.), the average monthly return for Small cap & High book-to-market equities ($r_{Small\ High}$) is 0.69% (8.27% p.a.), the average monthly return for Big cap & Low book-to-market equities ($r_{Big\ Low}$) is 2.03% (24.34%p.a.), the average monthly return for Big cap & Medium book-to-market equities ($r_{Big\ Medium}$) is 1.34% (16.07% p.a.), and the average monthly return for Big cap & High book-to-market equities ($r_{Big\ High}$) is 0.77% (9.21% p.a.). As we can see, the average monthly return for Big cap & Low book-to-market equities ($r_{Big\ Low}$) is the highest, implying that the portfolio of Big cap & Low book-to-market equities outperforms other portfolios from 2006 until 2020, before adjusting for risk factors. On the other hand, the average monthly return for Small cap & High book-to-market equities ($r_{Small\ High}$) is the lowest, implying that the portfolio of Small cap & High book-to-market equities underperforms other portfolios in the same period, before adjusting for risk factors. If we invested in the portfolio of Big cap & Low book-to-market equities, we would get a return of about 3 times of investing in the portfolio of Small cap & High book-to-market equities.

Next, to construct the momentum risk factor, we have to calculate the average monthly return for equally weighted average returns of equities with the highest 30 percent eleven-month returns lagged one month (r_u) is 5.26% (63.06% p.a.), and the average monthly return for equally weighted average returns of equities with the lowest 30 percent eleven- month returns lagged one month (r_d) is -1.67% (-20.00% p.a.). On the whole, we can see that equities seem to have more upturn than downturn.

Table 4: Data descriptive of portfolio returns

This table reports the summary statistics of all variables from 2006 to 2020, including number of observations (N), average (Mean), standard deviation (S.D.), minimum value (Min), and maximum value (Max).

Monthly return					
Variable	**N**	**Mean**	**S.D.**	**Min**	**Max**
$r_{Small\ Low}$	180	1.89%	5.81%	-23.44%	22.37%
$r_{Small\ Medium}$	180	0.95%	5.27%	-23.02%	23.81%
$r_{Small\ High}$	180	0.69%	5.76%	-25.42%	22.59%
$r_{Big\ Low}$	180	2.03%	5.58%	-22.92%	21.97%
$r_{Big\ Medium}$	180	1.34%	5.98%	-27.21%	20.37%
$r_{Big\ High}$	180	0.77%	6.25%	-31.98%	23.78%
r_u	180	5.26%	4.24%	-2.39%	19.58%
r_d	180	-1.67%	1.53%	-5.06%	2.93%

The descriptive statistics of the final set of data are shown in Table 5, which is the standard 4-risk factors. The first one is the average monthly return for market risk factor (r_{rmrf}), which equals 0.70% (8.39% p.a.), and this number comes from the average monthly return on the SET total return index (SET TRI) minus the monthly risk-free return. Secondly, the average monthly return of the size risk factor ($r_{smb,t}$) is -0.20% (-2.45% p.a.), which is the monthly return on the small minus big portfolios with about the same weighted-average book-to-market ratio. So, we can imply that big equities outperform small equities in this period. Next, the average monthly return for the value risk factor ($r_{hml,t}$) is -1.23% (-14.76% p.a.), which is the monthly return on the high minus low book-to-market portfolios with about the same weighted-average size. Then we can imply that low book-to-market equities (growth stocks) outperform high book-to-market equities (value stocks) in this period. Lastly, the average monthly return of the momentum risk factor ($r_{umd,t}$) is 6.92% (83.06% p.a.), which is the return on the up minus down portfolio.

Table 5: Data descriptive of the 4 standard risk factors returns

This table reports the summary statistics of all variables from 2006 to 2020, including number of observations (N), average (Mean), standard deviation (S.D.), minimum value (Min), and maximum value (Max).

	Monthly return				
Variable	**N**	**Mean**	**S.D.**	**Min**	**Max**
r_{rmrf}	180	0.70%	5.81%	-30.37%	17.94%
r_{smb}	180	-0.20%	2.26%	-6.47%	7.76%
r_{hml}	180	-1.23%	2.73%	-9.96%	9.90%
r_{umd}	180	6.92%	2.98%	1.64%	19.02%

4. Methodology

4.1 The performance of active peer group benchmarks

This section investigates whether, on average, after adjusting for the conventional 4 factors, fund groups can provide abnormal returns. So, from January 2006 to December 2020, we run the standard Carhart 4-factor regressions of the average excess return of the active peer group ($r_{APB_{i,t}}$) for each peer group, over 3-year periods, from January 2006 to December 2020. From this regression, we will get the 5 nonoverlapping 3-year periods of APB alphas from each peer group. We will also splice these APB alphas into time-series of each APB group. If the findings demonstrate a high proportion of statistically significant 3-year alphas, we can infer that there is a considerable degree of commonality in residuals among funds within each group, which we expect to be able to capture this commonality with the APB-augmented with Carhart 4-factor model of eq.13. The estimated 3-year alphas of each APB group could be both significant positive or negative across the periods due to the time-varying of individual fund performance. The Carhart model applied to APB $_i$ is as follows:

$$r_{APB_{i,t}} = \alpha_{APB_i} + \beta_{i,rmrf}\, r_{rmrf,t} + \beta_{i,smb}\, r_{smb,t} + \beta_{i,hml}\, r_{hml,t} + \beta_{i,umd}\, r_{umd,t} + \varepsilon_{APB_{i,t}} \tag{10}$$

α_{APB_i} is the abnormal return from the first-stage regression of the APB on the Carhart model, and it represents the average performance of each APB group after controlling for the 4 standard risk factors, which are market return factor ($r_{rmrf,t}$), size factor ($r_{smb,t}$), value factor ($r_{hml,t}$), and momentum factor ($r_{umd,t}$).

By the way, $\varepsilon_{APB_{i,t}}$ is the residual from the first-stage Carhart regression of the APB, which is the error term or commonality or common factors of each peer group return that 4 standard risk factors cannot capture.

For the factor loading which comprise of $\beta_{i,rmrf}$, $\beta_{i,smb}$, $\beta_{i,hml}$, and $\beta_{i,umd}$ are the sensitivity of APB i to market portfolio, size, book-to-market, momentum factors, respectively. Which all these betas are the slopes of the regression model. In other words, all of these betas are the magnitude of each factor.

Lastly, α_{APB_i} from eq.10 will be used in the APB-adjusted alpha version of the augmented model (eq. 14). And the regression of the APB augmented with Carhart 4-factor models (eq. 13) and the APB-adjusted alpha version of the augmented model (eq. 14) also needs to use $\varepsilon_{APB_{i,t}}$ from eq.10. Which we will describe more in detail in the later sections.

4.2 The regression of individual fund returns

Firstly, the APB regression of individual fund returns. We run the regression of the average excess return of the active peer group ($r_{APB_{i,t}}$) against the individual excess return of fund *i* ($r_{i,t}$) in that APB group to which fund *i* belongs. We run this regression over 3-year periods, for the period January 2006 to December 2020, to see whether the APB factor alone is able to capture commonality in mutual fund returns. Then we will compare the robustness of this model (eq.11) to the standard 4-factor model (eq.12), and also the augmented models (eq.13 and eq.14) in the later sections. So, if a simplified model based only on the APB is more robust than the standard Carhart 4-factor model, we should see lower residual ($\varepsilon_{i,t}$) and higher R-square compared with the standard Carhart 4-factor model. Moreover, the APB factors (λ_i^{APB}) should be more statistically significant and positive than the 4 standard risk factors ($\beta_{i,rmrf}$, $\beta_{i,smb}$, $\beta_{i,hml}$, $\beta_{i,umd}$) of the standard Carhart 4-factor model.

$$r_{i,t} = \alpha_i^{APB} + \lambda_i^{APB}\, r_{APB_{i,t}} + \varepsilon_{i,t} \tag{11}$$

α_i^{APB} is the abnormal return that a portfolio manager performs against the active peer benchmarks (APB). In other words, it represents the fund manager's skills. So, if a fund manager can outperform their active peer benchmarks, this alpha (α_i^{APB}) should be positive. But if the fund manager underperforms against active peer benchmarks (APB), this alpha (α_i^{APB}) should be negative. And if this alpha (α_i^{APB}) equals zero, it means that the fund manager's skill is neutral against the active peer benchmarks (APB). By the way, λ_i^{APB} is the sensitivity of fund *i* to ABP factor from a simplified regression model. while $\varepsilon_{i,t}$ is the residual, which is the error term or commonality or common factors of fund returns that APB factors are not able to capture from this regression model.

Secondly, the Carhart four-factor regression of individual fund returns The Carhart model is used as our baseline model to assess fund performance. We run the Carhart four-factor regression of individual fund returns, which we run over 3-year periods, from January 2005 to December 2020. The Carhart model applied to fund *i* is as follows:

$$r_{i,t} = \alpha_i + \beta_{i,rmrf}\, r_{rmrf,t} + \beta_{i,smb}\, r_{smb,t} + \beta_{i,hml}\, r_{hml,t} + \beta_{i,umd}\, r_{umd,t} + e_{i,t} \tag{12}$$

α_i is the abnormal return for fund *i* after controlling for the 4 standard risk factors. So, this alpha (α_i) implies portfolio manager skills that cannot be captured by the 4 standard risk factors. And $e_{i,t}$ is the error term, which is the commonality of fund returns that cannot be captured by this model.

We will compare the results of this Carhart model that applied to fund *i* (eq.12) to those of a model based solely on the APB (eq.11), the APB augmented to Carhart four-factor model (eq. 13), and the APB-adjusted alpha version of the augmented model (eq. 14) to determine which models are more robust than others in evaluating fund performance via R-squares, t-stat and magnitude of alpha, t-stat and magnitude of the 4 standard risk factors, t-stat and magnitude of APB factors. The most robust model should have the highest R-squares and also the highest statistically significant alphas (the alphas' magnitude should be the lowest because the incremental commonality can be captured by the risk factors in the model).

Thirdly, the APB augmented model regression of individual fund returns. From section 4.2, the residuals ($\varepsilon_{APB_{i,t}}$) from eq.10 are added to the standard Carhart 4-factor model as the APB factor, which will help in capturing commonality in mutual fund returns ($r_{i,t}$) further than the 4 standard risk factors. So, we expect that the APB augmented to the Carhart four-factor model (eq. 13) will generate a more accurate alpha in fund performance assessment. Then this APB augmented model (eq.13) should generate higher R-square and more statistically significant alphas compared to the standard 4-factor model (eq. 12). The APB augmented model (eq.13) is as follows:

$$r_{i,t} = \alpha_i + \beta_{i,rmrf}\, r_{rmrf,t} + \beta_{i,smb}\, r_{smb,t} + \beta_{i,hml}\, r_{hml,t} + \beta_{i,umd}\, r_{umd,t} + \lambda_i\, \varepsilon_{APB_{i,t}} + \varepsilon_{i,t} \tag{13}$$

The alpha (α_i) is the abnormal return for fund i after controlling for both the APB factor and the 4 standard risk factors. So, this alpha (α_i) represents fund manager skills that cannot be captured by both the APB factor and the 4 standard risk factors. So, we expect this alpha (α_i) from eq. 13 to be more accurate in mutual fund performance evaluation than the standard 4-factor model (eq.12) and also a model that is based solely on the APB (eq.11)

λ_i is the sensitivity of fund i to the ABP factor from the APB-augmented model, which we expect this APB loading factor to be more statistically significant and also have a higher magnitude than the 4 standard risk factors.

By the way, $\varepsilon_{i,t}$ is the residual or commonality on mutual fund returns which cannot be captured by both the 4 standard risk factors and the APB factor from this regression model (eq.13), which we expect this residual ($\varepsilon_{i,t}$) from eq.13 to be lower than the residual from the standard Carhart 4-factor model (eq. 12) and a model based solely on the APB (eq.11).

Lastly, the APB-adjusted alpha of the augmented model's regression of individual fund returns. From the section 4.2, the alphas (α_{APB_i}) and residuals ($\varepsilon_{APB_{i,t}}$) from eq.10 are added to the standard Carhart 4-factor model as the APB factor, which we call the APB- adjusted alpha version in eq. 14. We expect that this APB-adjusted alpha will help in capturing commonality in mutual fund returns ($r_{i,t}$) further than the standard 4 factors, and we also expect this APB-adjusted alpha to perform better than the normal APB factor in eq.13. So, we expect that the APB-adjusted alpha version of the augmented model (eq.14) will generate the most accurate alpha in fund performance evaluation. Then this APB-adjusted alpha of the augmented model (eq.14) should have the highest R-square compared to a model that is based solely on the APB (eq.11), the standard Carhart 4-factor model (eq.12), and the normal APB augmented model (eq.13). The APB-adjusted alpha of the augmented model is as follows:

$$r_{i,t} = \alpha_i + \beta_{i,rmrf}\, r_{rmrf,t} + \beta_{i,smb}\, r_{smb,t} + \beta_{i,hml}\, r_{hml,t} + \beta_{i,umd}\, r_{umd,t} + \lambda_i \left(\alpha_{APB_i} + \varepsilon_{APB_{i,t}}\right) + \varepsilon_{i,t} \tag{14}$$

We expect this APB-adjusted alpha of the augmented model (eq. 14) to identify the skilled subgroup of portfolio managers. The alpha (α_i) is the abnormal return for fund i after controlling for both the APB-adjusted alpha factor and the 4 standard risk factors. So, this alpha (α_i) represents portfolio manager skills that cannot be captured by both APB-adjusted alpha and the 4 standard risk factors. So, we expect this alpha (α_i) from eq.14 to be the most accurate in mutual fund performance assessment compared to a model that is based solely on the APB (eq.11), the standard Carhart 4-factor model (eq.12), and the normal APB augmented model (eq.13).

λ_i is the sensitivity of fund i to the APB-adjusted alpha factor from the APB-adjusted alpha of the augmented model (eq.14).

By the way, $\varepsilon_{i,t}$ is the residual or commonality on mutual fund returns which cannot be captured by both of the 4 standard risk factors and the APB-adjusted alpha factor from this regression model (eq.14), which we expect this residual ($\varepsilon_{i,t}$) from eq.14 to be the lowest compare to a model that is based solely on the APB (eq.11), the standard Carhart 4-factor model (eq.12), and the normal APB augmented model (eq.13).

4.3 Correlation between APB residuals

This test is for examining the efficiency of our APB method. If the APB method is efficient, the correlations between APB residuals (from eq.10) across peer groups should be low. Because each peer's APB residual should only represent their own risk factor. If there are high correlations, the accuracy of the APB method in fund performance evaluation will decrease.

To test whether there are correlations between equally weighted APB residuals ($\varepsilon_{APB_{i,t}}$ from eq.10) across APB groups, we calculate a Pearson correlation between each pair of APB residual time-series over a 15-year period from January 2006 to December 2020. Firstly, we get 5 nonoverlapping 3-year period residuals from eq.10 for each APB, and then we splice these residuals into a 15-year record for each APB. If there is overlap in the Morningstar's equity style box (either through the same or different stocks in a related industry) or funds that don't fit neatly into a single APB category, the results could show significant correlations.

4.4 Correlation between individual equity fund residuals

This test is to examine the influence of the APB-augmented model in capturing commonality among funds in the same peer group, compared with the standard 4-factor model. By comparing correlations of individual funds' residuals in the same peer group, from the four-factor model (eq.12) versus the APB-augmented model (eq.13). If the results exhibit low correlations from the APB-augmented model (eq.13), the ability of APB to capture commonality in fund returns in the same peer group will be high. Then the accuracy of the APB method in fund performance evaluation will increase.

To test whether there are correlations between individual equity fund residuals. If the Carhart 4-factor model captures systematic variation in returns properly, then the individual fund residuals exhibit commonalities with each other only due to their loading on similar idiosyncratic factors. Firstly, we compute pair-wise correlations between individual fund residuals from the four-factor model (eq.12). Then compute the percentage of significantly positive and significantly negative pair-wise correlations out of all possible pair-wise correlations in the peer group.

Next, compute correlation statistics, using each fund's residuals from the augmented model of eq.13, which we add the APB residual to the Carhart four-factor model. Then compute the percentage of significantly positive and significantly negative (at the 5% two- tailed confidence level) pair-wise correlations out of all possible pair-wise correlations in the peer group.

From the ability to capture commonality on fund return of the APB factor, we expect a smaller percentage of significant positive correlations of the residuals from eq.13 compared to eq.12.

4.5 Alpha estimation diagnostics

We consider whether the addition of the APB results in a more accurate separation of funds into positive and negative alphas (the more efficient in evaluating fund manager skills) relative to the standard Carhart 4-factor model. To test the influence of active peer benchmarks (APB) on mutual fund performance assessment via alpha evaluation. We expect that the APB-adjusted alpha of the augmented model (eq.14) should generate alphas close to zero, in the case that commonality in fund returns can be effectively captured by the APB factor. To perform this test, we compare these 4 models in many aspects, which all 4 models comprise of:

(1) the model based only on the APB factor [eq. 11]

(2) the standard four- factor model [eq.12]

(3) the APB-augmented model [eq.13]

(4) The APB-adjusted alpha of the augmented model [eq.14]

For each model within each peer group, we compute the percentage of funds with significantly positive and negative alphas, and also indicate the percentage of funds with insignificant alphas in each category (the percentage of funds within each group that have statistically significant APB alphas from eq.11, the percentage of funds within each group that have statistically significant 4-factor alphas from eq.12, and the percentage of funds within each group that have statistically significant alphas using the models of eq.13 and eq.14, respectively). Then, we also compute and compare adjusted R-squares from these 4 models.

Next, from these 4 models, we calculate the percentage of funds (within each peer group) having a statistically significant market factor (rmrf), size factor (smb), value factor (hml), and momentum factor (umd), and also the APB factor coefficient (λ). To compute these percentages, we count the number of significant p-values, which are those below 2.5% (to correspond to a two-tailed 95% confidence region), and divide them by the total number of funds within a particular APB category. If the APB factor is more efficient than the standard 4 risk factors, the results will exhibit a large number of significant positives for the APB factor coefficient in each peer group.

5. Empirical Results

This special project inclusively studies the efficiency of the APB factor in the risk-factor models to evaluate an actively managed Thai equity mutual fund's performance via alpha estimation, which represents portfolio manager skills. From the available literature on mutual fund performance, we recognize that the explanatory power of the Carhart 4-factor model is quite high. But using the Carhart 4-factor model still exhibits a large commonality in residuals across funds, which reduces the accuracy of the estimation of alpha. As a result, we anticipate that adding the APB factor to the standard Carhart 4-factor model will increase the model's explanatory power.

5.1 performance of active peer group benchmarks

This section studies whether, on average, fund groups are able to generate abnormal returns after controlling for the standard 4 factors. So, from January 2006 to December 2020, we run the standard Carhart 4-factor regressions of the average excess return of the active peer group ($r_{APB_{i,t}}$) for each peer group, over 3-year periods.

Table 6 presents that there are two APB groups that exhibit significant alphas over the three-year period from 2009 to 2011, and also exhibits significant alphas over the entire 2006 to 2020 period, which are the Large Cap & Value peer group and the Mid Cap & Value peer group. From these results, we can imply that there is a significant amount of commonality in residuals among funds within these peer groups, which we expect to be able to capture this commonality with the APB-augmented to Carhart 4-factor model of eq.13. In general, the values of APB's alphas over the entire period seem to be closer to zero than those of many three-year periods.

The estimated 3-year alphas of each APB group can be both significant positive or negative across the periods due to the time-varying of individual fund performance. For example, the APB group for funds in Mid Cap & Value exhibits a statistically significant 4-factor alpha of -0.62% per month during 2009 to 2011 and a 0.44% per month during 2015 to 2017. These time-varying APB alphas could be due to commonalities in time-varying fund performance within an APB group.

The APB alphas across groups, presented in Table 6, tend to be the same sign during a particular three-year period. This indicates that commonality in idiosyncratic risk-taking could exist among funds belonging to different APB groups, which we expect to be able to capture this commonality with the APB-augmented to Carhart 4-factor model of eq.13.

Table 6: In-sample alpha estimates (in % per month) of fund excess returns

This table exhibits fund alpha estimates from average net excess returns when funds are grouped by their APB, then regressions are run over nonoverlapping 36-month periods from of 2006 to 2020. Estimates are for each Thai equity mutual funds peer group regressed on the 4-factor model (eq.10). Alpha estimates are presented on the first row of each APB group with the corresponding t-statistics immediately below in parentheses. Alpha estimates with one asterisk (*), two asterisks (**), and three asterisks (***) are significant at the 90%, 95%, and 99% confidence level, respectively. The last column reports alpha estimates throughout the full sample from 2006 to 2020.

APB Group Criteria	**2006-2008**	**2009-2011**	**2012-2014**	**2015-2017**	**2018-2020**	**2006-2020**
Large Value	0.28%	-0.71%**	-0.36%	0.34%	-0.47%	-0.44%***
	(0.389)	(-2.085)	(-0.948)	(0.773)	(-0.761)	(-3.027)
Mid Blend	-0.42%	-0.36%	0.20%	0.25%	-0.23%	0.20%
	(-0.364)	(-0.731)	(0.337)	(0.284)	(-0.193)	(0.775)
Mid Value	0.10%	-0.62%*	-0.06%	0.44%	-0.48%	-0.33%*
	(0.126)	(-2.024)	(-0.144)	(0.971)	(-0.694)	(-1.955)
Small Blend	-	-	-	-0.76%	0.16%	-0.71%
				(-0.458)	(0.072)	(-0.648)

5.2 Correlation between APB residuals

This test is to examine the efficiency of our active peer benchmark (APB) methodology. In this test, we calculate across-group correlations between equally weighted APB residuals from the Carhart 4-factor regression. We expect of uncorrelated (idiosyncratic) fund strategy styles across different APB groups.

Table 7 exhibits substantial evidence of across-group commonality in idiosyncratic risk-taking. All correlation pairs across APB groups are positive and significant, with five out of six correlation pairs being positively significant at 99%

confidence level, and one out of six correlation pairs being positively significant at 95% confidence level. Some of the correlations are extremely high, such as the residual correlations of 0.78 between the Large Cap & Value peer group and the Mid Cap & Value peer group, and also the residual correlations of 0.80 between the Mid Cap & Blend peer group and the Small Cap & Blend peer group. By the way, this can happen due to the overlap in Morningstar's equity style box (either through the same equities across different funds, different equities in the same industry across funds, or different equities in related industry across funds) or funds that don't fit nicely into a single APB category.

Table 7: Correlations across group residuals.

This table exhibits the pair-wise correlations between APB residuals after regressing the return of each upon the 4-factor model (eq.10) from 2006 to 2020, with the corresponding t-statistics immediately below in parentheses. The APB categories are classified by Morningstar's equity style box. The numbers with one asterisk (*), two asterisks (**), and three asterisks (***) are significant at the 90%, 95%, and 99% confidence level, respectively.

APB Group Criteria	**Large Value**	**Mid Blend**	**Mid Value**
Mid Blend	0.55***		
	(8.826)		
Mid Value	0.78***	0.62***	
	(16.803)	(10.600)	
Small Blend	0.28**	0.80***	0.33***
	(2.446)	(11.157)	(2.919)

5.3 Correlation between individual equity fund residuals

This test is to examine the influence of the APB-augmented model in capturing commonality among funds in the same peer group, compared with the standard 4-factor model. By comparing correlations of individual funds' residuals in the same peer group, from the four-factor model (eq.12) versus the APB-augmented model (eq.13).

Table 8 exhibits the percentage of significant positive and the percentage of significant negative (at the 95% confidence level) pair-wise correlations out of all possible pair-wise correlations between individual fund residuals within the peer group from the four-factor model (eq.12) versus the APB-augmented model (eq.13).

For example, from 2006 to 2008, the results show that the Large Cap & Value APB group exhibits 63% significant positive and 2% significant negative pair-wise correlations out of all possible pair-wise correlations between individual fund residuals within this peer group, using the four-factor model (eq.12). By the way, for the Large Cap & Value APB group, the pair-wise correlations between individual fund residuals from using the APB-augmented model (eq.13) appear to be only 11% significant positive and 10% significant negative. We can see that significant positive pair-wise correlations for this peer group dramatically decreased from 63% to 11% when comparing between the four-factor model (eq.12) and the APB-augmented model (eq.13). So, we can imply that the lower significant positive correlations from the APB-augmented model (eq.13) shows the ability of APB to capture commonality in fund returns in the same peer group, which the extremely high efficiency of APB represents the increasing accuracy of the APB methodology in fund performance evaluation.

Using the four-factor model (eq.12), the percentage of significant positive correlations is always higher than the percentage of significant negative correlations, and it seems to be much higher. Actually, we expect to see the percentage of negatively correlated residuals from randomly occurring correlations. Moreover, this negative and significant percentage is quite constant across time periods, and it is always less than 2%. On the other hand, the percentage of pair-wise correlations that are positive and significant is usually above 20%, and it is often above 30%. But there seems to be no time-trend to the positive correlations. The positive correlation of the four-factor residuals is especially high in the Mid Cap & Blend peer group and the Small Cap & Blend peer group. The average values (see the last column) for these two peer groups are 81% and 100% (see the row labeled "Four-factor model"), respectively. We can imply that there is a high magnitude of cohesiveness in the investment styles in these peer groups. All in all, positive and significant correlations in all peer groups exhibit significant commonalities in the strategic styles of investment across funds that are not captured by the Carhart four-factor model.

To see the results of our APB methodology, focus on the row labeled Four-factor model + APB. We can clearly see a dramatic drop in the percentage of significant positive correlations from the APB-augmented model when compared to the row labeled Four-factor model. In particular, on average for the Mid Cap & Blend peer group, the percentage of significant positive correlations sharply drops from 81% (Four-factor model) to 2% (Four-factor model + APB) and the percentage of significant negative correlations increases from 0% (Four-factor model) to 25% (Four-factor model + APB). Using the APB-augmented model, for the Large Cap & Value peer group and the Mid Cap & Value peer group, the fraction of the percentage of significant correlations is about equal between positive and negative values. We obviously see that adding the APB to the Carhart 4-factor model successfully captures the common idiosyncratic risk-taking by mutual funds within the peer groups.

In summary, Table 7 and Table 8 exhibit the results that enhance the evidence that the Carhart 4-factor model cannot capture a significant degree of unexplained covariation across mutual funds within a peer group and across peer groups. But the APB-augmented model (eq.13), in which we add the APB factor to the Carhart 4-factor, is able to capture a significant part of this covariation within a group. This demonstrates a significant benefit from using the APB-augmented model (eq. 13).

Table 8: Percentage of Thai equity mutual funds with statistically significant residual correlations.

This table exhibits the percentage of significant positive and negative pair-wise residual correlations (with 95% confidence level) in each group from 2006 to2020. The table exhibits results for funds after regressing each individual fund's monthly net excess return on the 4-factor model (eq.12) and the 4-factor model augmented with the APB (eq.13). The last column reports the average of each row's percentages in table.

Correlation pairs model	Significant	2006-2008	2009-2011	2012-2014	2015-2017	2018-2020	Average
Large Value							
Four-factor model	Positive	63%	18%	47%	45%	52%	45%
	Negative	2%	2%	2%	1%	0%	2%
Four-factor model + APB	Positive	11%	7%	11%	8%	11%	10%
	Negative	10%	10%	13%	12%	12%	11%
Mid Blend							
Four-factor model	Positive	100%	100%	83%	62%	61%	81%
	Negative	0%	0%	0%	0%	0%	0%
Four-factor model + APB	Positive	0%	0%	0%	5%	6%	2%
	Negative	0%	0%	67%	29%	28%	25%
Mid Value							
Four-factor model	Positive	66%	37%	56%	33%	39%	46%
	Negative	2%	2%	2%	0%	1%	1%
Four-factor model + APB	Positive	17%	20%	23%	20%	17%	19%
	Negative	10%	19%	24%	31%	19%	20%
Small Blend							
Four-factor model	Positive	-	-	-	100%	100%	100%
	Negative	-	-	-	0%	0%	0%
Four-factor model + APB	Positive	-	-	-	0%	0%	0%
	Negative	-	-	-	50%	19%	35%

5.4 Alpha estimation diagnostics

We consider whether the addition of the APB results in a more accurate separation of funds into positive and negative alphas (the more efficient in evaluating fund manager skills) relative to the standard Carhart 4-factor model. To test the influence of active peer benchmarks (APB) on mutual fund performance assessment via alpha evaluation. To perform this test, we compare these 4 models in many aspects, which all 4 models comprise of:

(1) the model based only on the APB factor [eq. 11]

(2) the standard four- factor model [eq.12]

(3) the APB-augmented models [eq.13]

(4) The APB-adjusted alpha of the augmented model [eq.14]

Table 9 reports the percentage of funds within each APB group having statistically significant market (*rmrf*), small (*smb*), value (*hml*), and momentum (*umd*) loading factors, respectively. Column 9 reports the percentage of funds within each APB group having a statistically significant APB loading factor (λ) from the model of eq. 11, eq.13, and eq.14. The first and third row of each APB group report the percentage of funds with significantly positive and negative alphas, respectively. While the second and the fourth row report the percentage of funds with insignificant positive and negative alphas in each peer group.

The results for market (*rmrf*), small (*smb*), value (*hml*), momentum (*umd*), and APB (λ) factors are below. We can see that the market (*rmrf*) factor for all peer groups is positive significant 100%, which is consistent with what we expect. The APB risk factor (λ) for all peer groups is positive significant above 86%, and especially positive and significant at 100% for the Mid Cap & Blend peer group and Small Cap & Blend peer group. This extremely high percentage of positive significant APB coefficients illustrates the great efficiency of our APB methodology. Furthermore, it is much higher than the percentage of positive significant of standard 4 factors, except for only the market (*rmrf*) risk factor. From these results, we can imply that our APB methodology is more helpful in capturing common idiosyncratic risk-taking in these peer groups.

Table 9: Percentage of funds with significant or insignificant coefficient estimates.

This table shows the percentage of funds with significant (95% confidence level) and insignificant coefficient estimates. When net excess fund returns are regressed on risk-factor models. Regressions are run over 36-month periods from 2006 to 2020. The table exhibits the percentage of Thai equity funds with significant and insignificant estimates of each alpha and coefficient under four different model: (1) the model based only on the APB factor (eq. 10); (2) the standard four- factor model (eq.12); (3) the APB-augmented model (eq.13); and (4) The APB-adjusted alpha of the augmented model (eq.14). The bottom row in each peer reports the average adjusted R^2 that corresponds to the model used to estimate the results presented in that column.

APB Group Criteria	$\alpha_{eq.11}$	$\alpha_{eq.12}$	$\alpha_{eq.13}$	$\alpha_{eq.14}$	**rmrf**	**smb**	**hml**	**umd**	**λ**
Panel A:									
Large Value									
positive significant	6%	6%	2%	3%	100%	0%	6%	3%	89%
positve	43%	43%	37%	43%	0%	16%	35%	54%	9%
negative significant	6%	6%	7%	3%	0%	25%	14%	2%	0%
negative	46%	46%	54%	50%	0%	59%	45%	40%	2%
Adj. R^2	93%	91%	94%	94%					
Mid Blend									
positive significant	8%	8%	4%	0%	100%	28%	8%	0%	100%
positve	29%	29%	38%	50%	0%	22%	17%	46%	0%
negative significant	4%	4%	4%	0%	0%	14%	46%	4%	0%
negative	58%	58%	54%	50%	0%	36%	29%	50%	0%
Adj. R^2	91%	84%	92%	92%					

APB Group Criteria	$\alpha_{eq.11}$	$\alpha_{eq.12}$	$\alpha_{eq.13}$	$\alpha_{eq.14}$	rmrf	smb	hml	umd	λ
Panel B:									
Mid Value									
positive significant	5%	5%	5%	2%	100%	11%	3%	2%	86%
positve	41%	41%	37%	44%	0%	20%	36%	49%	13%
negative significant	6%	6%	6%	1%	0%	15%	14%	4%	0%
negative	48%	48%	52%	53%	0%	54%	47%	45%	1%
Adj. R^2	92%	89%	93%	93%					
Small Blend									
positive significant	9%	9%	9%	9%	100%	70%	0%	6%	100 %
positve	36%	45%	27%	27%	0%	3%	0%	61%	0%
negative significant	9%	0%	18%	9%	0%	12%	88%	6%	0%
negative	45%	55%	45%	55%	0%	15%	12%	27%	0%
Adj. R^2	91%	71%	92%	92%					

We can see that small (*smb*) risk factor for Large Cap & Value peer group tilt towards negative 84 %, divided into 25% negative significant and 59% negative insignificant, which is reasonable because Large cap funds should have negative exposure to small (smb) risk factor. And we also notice that the small (smb) risk factor for the Mid Cap & Blend peer group is a balance between positive and negative exposure, at 50%-50%, which is reasonable for Mid Cap funds. For the Mid Cap & Blend peer group, the value (*hml*) risk factor tilt towards negative for 75%, 46% of negative significant and 29% of negative insignificant, implying that equities in general appear to be growth stocks rather than value stocks. This also happened to the Small Cap & Blend peer group too. The value (hml) risk factor tilt towards negative for 100%, 88% of negative significance and 12% of negative insignificant. This can imply that the equities in the overall seem to be Growth stocks more than Value stocks.

The momentum (*umd*) risk factor, the fraction of positive significant or negative significant, is quite tiny. It's rarely above 10%. The portions of positive insignificant and negative insignificant of momentum (*umd*) risk factor for the Mid cap & Blend peer group are 46% and 50%, respectively, which is 96% insignificant in total. By the way, the momentum (umd) risk factor is quite balanced between positive and negative exposures. For example, in the Mid cap & Value peer group, the momentum (umd) risk factor is positive for 51% (2% positive significant and 49% positive insignificant), and negative for 49% (4% negative significant and 45% negative insignificant).

The first column of Table 9 reports the percentage of funds, within each group, having statistically significant alphas using the model based only on the APB factor of eq. 11 (labeled "$\alpha_{eq.11}$"). And the second, third, and fourth columns (labeled "$\alpha_{eq.12}$", "$\alpha_{eq.13}$" and "$\alpha_{eq.14}$", respectively) reports the percentage of funds with significant alphas using the models of eq.12, eq.13, and eq.14, respectively.

For the Large Cap & Value peer groups, the standard 4-factor model suggests that there could be some skilled fund managers, as the 6% of alphas having a p-value lower than 2.5% is much higher than expected by random chance. In addition, the APB-augmented model alpha ($\alpha_{eq.13}$) is more precisely separated into significantly positive and negative funds, relative to the 4-factor alpha ($\alpha_{eq.12}$), implying that the APB is effective at capturing return variation that is common to many of the For Large Cap & Value funds. Specifically, the frequency of positive significant alphas drops from 6% to 2%, and the frequency of negative significant alphas increases from 6% to 7%, the 4-factor model indicates that there are more alpha outliers on the positive side, relative to the APB-augmented model, especially in the positive alpha tail. By the way, the percentage of positive significant alphas appears to be equal when using the four-factor model and the APB-augmented model, at the values of 5% and 9% for the Mid cap & Value peer group and Small Cap & Blend peer group, respectively.

When we focus on the alpha ($\alpha_{eq.14}$) of APB-adjusted alpha of the augmented model of eq.14, as we find the high frequency of positive APB coefficients (λ). The percentage of significant $\alpha_{eq.14}$ is 2% and 1% of significant positive and negative values, respectively. Thus, almost half of the significant positive alphas from the APB-augmented model is 5%, can be traced to strategies that are used in common by Mid Cap & Value funds (because the remaining significant positive alphas account for 2% of the group). We can easily say that the APB-adjusted alpha of the augmented model (eq.14) can capture more commonality in fund strategy for each peer group relative to the APB-augmented models (eq.13). Another example from the Mid cap & Blend peer group, the APB-adjusted alpha of the augmented model shows the percentage of significant $\alpha_{eq.14}$ is 0% for both significant positive and negative values, respectively. But the significant positive alpha from the APB-augmented model ($\alpha_{eq.13}$) is 4%, implying that the APB-adjusted alpha of the augmented model (eq.14) is able to capture more commonality in fund strategy for each fund group. The values of alphas that are close to zero from the APB-adjusted alpha of the augmented model (eq.14), indicate that commonality in fund returns can be effectively captured by the APB factor.

Finally, we will demonstrate the power of the APB factor alone in explaining fund returns, with the model of eq.11. The first column demonstrates that the model based only on the APB factor (eq. 11) generates an adjusted R^2 above 90% for all peer groups. In comparison, the adjusted R2 using the 4-factor model is typically a few percentage points lower than the model based solely on the APB. Moreover, both the

APB-augmented model (eq.13) and the APB-adjusted alpha of the augmented model (eq.14) generate the same values of adjusted R^2 for each peer group, and these values of adjusted R^2 are higher than the standard four- factor model (eq.12) and the model based only on the APB factor (eq. 11). This result enhances the high effectiveness of our APB methodology in increasing the accuracy of fund performance evaluation, as it reflects those exposures to risk factors as well as idiosyncratic risk that have strong commonalities within the peer group. By the way, there is no difference in the adjusted R^2 between the APB-augmented models [eq.13] and the APB-adjusted alpha of the augmented model [eq.14]. So, the power of these two models in explaining fund returns is the same, and the accuracy of these two models in estimating alphas is also the same.

All in all, to conclude the results for this part, a substantial percentage of fund alphas are illustrated to be both significantly positive and significantly negative, using the APB-augmented models (eq.13). By the way, when we use the APB-adjusted alpha of the augmented model (eq.14), these funds lose their significant alphas when we control for active peer benchmark alphas (α_{APB_i}) that are earned by the common four-factor model (eq.11). For the Mid Cap & Value peer group and the Mid Cap & Blend peer group, the fraction of positive significant alphas and negative significant alphas decreases, indicating that common strategy alphas (controlled by the alpha-adjustment model) are generally positive. We can conclude that this result contributes to the possibility that we could capture superior alpha through a passive strategy by investing in the whole funds within the peer group. There is no need to attempt to identify the best funds in the peer group.

6. Conclusion

This unique project's contribution is an assessment of actively managed Thai equities mutual funds using the active peer benchmark (APB) technique on a monthly basis from January 2006 to December 2020, and to test the efficiency of the active peer benchmark (APB) methodology in capturing commonality (unpriced idiosyncratic risks) taken by mutual funds that cannot be captured by standard 4 risk factors. The endogenous selection of each fund within a group forms the basis of the active peer benchmarks. We use Morningstar's equity style box to categorize funds into each APB, to calculate the fund coefficients and alphas in the Carhart 4-factor regressions, in addition to the exogenously given risk factors. The active peer benchmarks provide a reasonable comparison and help in solving the problem of the fund manager's self-selected benchmarks, which are prospectus benchmarks. The active peer benchmarks, additionally helpful in the absence of style-specific benchmarks in Thailand. For these reasons, Individual and institutional investors will find the best performing mutual funds within a peer group by using the active peer benchmark approach. Furthermore, these active peer benchmarks could be applied to all other kinds of funds besides equity funds, such as fixed income funds, property funds, commodity funds, etc.

The findings demonstrate that when the APB factor is added to the Carhart 4-factor model, the active peer benchmark (APB) dramatically reduces the between-fund residual correlations within each peer group. This research demonstrates that idiosyncratic risk-taking within peer groups can be captured by the active peer benchmark (APB), increasing the efficiency of fund performance evaluation. Finally, we show that adding the APB factor substantially enhances the accuracy of identifying skilled and unskilled portfolio managers within the various equity fund peer groups, with the highest adjusted R^2 and the maximum proportion of funds with a substantial positive coefficient in comparison to the common factors, except only the market risk factor.

REFERENCES

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