BEHAVIORAL APPROACH TO PORTFOLIO SELECTION

Kumnoon Narakornpijit

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Kumnoon Narakornpijit
School of Development Economics

..... Major Advisor
(Associate Professor Pariyada Sukcharoensin, D.B.A.)

The Examining Committee Approved This Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Economics (Financial Economics).

..... Committee Chairperson
(Instructor San Phuachan, D.B.A.)

..... Committee
(Associate Professor Sorasart Sukcharoensin, D.B.A.)

..... Committee
(Associate Professor Pariyada Sukcharoensin, D.B.A.)

..... Dean
(Assistant Professor Amornrat Apinunmahakul, Ph.D.)

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ABSTRACT

Title of Thesis	BEHAVIORAL APPROACH TO PORTFOLIO SELECTION
Author	Kumnoon Narakornpijit
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Behavior plays an important role in people's decision making, for example, different decision making can occur during happy and unhappy time. Behavioral factors also affect the decision making in the investment that cause unreasonable decision making in many investment situations. Many behavioral theories have been developed to explain human's behavior, which some of them are also applied to the investment. This research focuses on studying the portfolio investment in Thailand by two of the well-known theories for portfolio selection, which are prospect theory and mental accounting, by considering two assets, which are risky asset and risk-free asset where Stock Exchange of Thailand Total Return Index (SET TRI) is used as risky asset and the average return of government bond, Treasury bill and Bank of Thailand bond is used as the risk-free asset. The results from prospect theory show that the investment proportion by prospect theory is different from the mean-variance theory resulting in the difference in portfolio return. Additionally, the results from the mental accounting present that the different behaviors by applying the different behavioral parameters also affect the investment proportion in risky and risk-free assets. Consequently, behaviors do affect the investment decision.

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Kumnoon Narakornpijit

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CHAPTER 1

INTRODUCTION

Investment can be considered as a part of our lives. Each person may have different form of investments e.g. saving account (low-risk asset), stock or mutual fund (high-risk asset) or even real estate depending on individual interest and also behavior. Currently, one of the most popular types of investment is stock or stock mutual funds since stocks and stock mutual funds or ETFs have offered the most growth potential compared to bonds or other low-risk assets. However, investment in the stocks or stock mutual funds always comes with higher risk for the investor. The appropriate amount of money to invest in stocks might be a question raised by the investor – there is no exact answer to such question since it can be adjusted to reflect your time frame for investing (short, medium or long terms), risk tolerance, and current financial situation whether in or not in financial crisis period. As one of the abovementioned factors for making decision is risk, Markowitz developed the well-known theory called Mean-variance or Modern Portfolio Theory (MVT) for finding optimal portfolio allocation (Markowitz, 1952). This theory shows how investors construct portfolios to maximize expected return under specified risk. It weighs risk, expressed as variance against expected return. The main method for this theory is to construct the efficient frontier as shown in the Figure 1.1 below. The investor will only select the maximum expected return under specified risk where the main assumptions of this theory are 1. The investor is risk-averse and 2. The investor is reasonable.

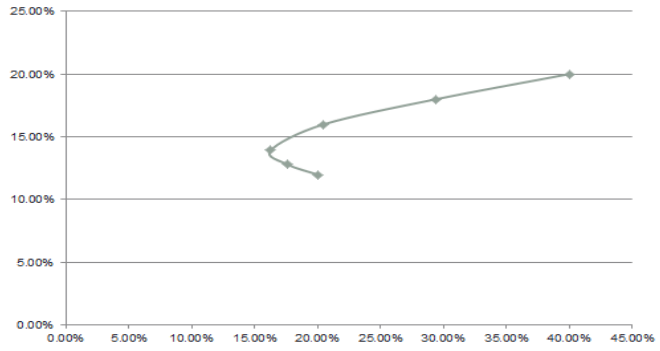

Figure 1.1 Efficient Frontier in Mean-variance Theory

Although, the mean-variance concept seems reasonable and practical by way of considering risk and returns for portfolio selection, mean-variance theory is specific for risk-averse and rational investors. In reality, investors are not reasonable and have behavioral bias in investment and also may not be risk-averse. Due to such reality, many researchers have studied the behavioral theories related to finance to explore the way to explain effect of behavioral bias to the investment as shown in Table 1.1.

Behavioral Theory	**Researcher**
Cognitive Dissonance	Festinger (1957)
Heuristics	Kahneman and Tversky (1974)
	Kahneman, Slovik and et al. (1982)
Prospect Theory	Kahneman and Tversky (1979)
Reflection Effect	Kahneman and Tversky (1981)
Mental Accounting	Thaler (1985)
Regret-aversion Theory	Statman (1988)
Disjunction Effect	Tversky and Shafir (1992)
Herding Behaviors	Shiller (2000)

Table 1.1 Some of Behavioral Finance Theories for Portfolio Selection

According to Table 1.1 above, the detail of each theory can be shown as follows: Prospect Theory – A theory about how people make choices between different options or prospects, is designed to better describe, explain and predict the choices that the typical person makes.

Cognitive Dissonance – a situation involving conflict attitudes, beliefs or behaviors producing a feeling of discomfort. For example, when people smoke, they knows that smoking causes cancer.

Heuristics – method that people use to help them quickly make a decision or solve a problem. This make us arrive at decisions that might not be the best. For example, people would like to assume that the things that works in the past will work in the future.

Reflection Effect - Reversing of risk aversion/risk seeking in case of gains or losses. For example, most people choose a certain gain of $20 over a one-third chance of gaining $60 but they would choose a one-third chance of losing $60 over a certain loss $20.

Regret-aversion Theory – The tendency to avoid taking an action due to fear that it will turn out to have been the worse option

Disjunction Effect – Cannot making decision until knowing the outcome or the uncertainty makes you delay your decision

Herding Behaviors - Tendency for an individual to mimic the actions of a larger group, whether those actions are rational or irrational. For example, parents purchase the toy for their kids after seeing other parents doing it

Mental Accounting – Tendency of humans to develop and make decisions based on purely mental categories. In term of investment, investors have a safe part and risky part of their portfolio. For example, Ms. A allocate $10 bill in the trip jar but even if she is short on her rent by $10, she will not use it because the money in trip jar is more valuable than the money used for the rental fee

The abovementioned behaviors are interesting to be applied to investment. However, in this study will only select two theories that possibly be most related to the real investor's behavior, which are 1. Prospect Theory and 2. Mental Accounting to apply to portfolio investment

Consequently, the objective of this study is to analyze the effect of behavioral factors based on prospect theory and mental accounting theory to the investment decision on portfolio allocation compared with modern portfolio theory. This will show the unrealistic of modern portfolio theory to portfolio allocation and make the awareness to the investor of the differences in investment returns of modern portfolio theory and behavioral theory, which is more realistic to the investor.

CHAPTER 2

PROSPECT THEORY

2.1 INTRODUCTION

Mean-variance or Modern Portfolio Theory (MVT), which is the well-known theory developed by Markowitz (1952), has the main assumptions that 1. The investor is risk-averse and 2. The investor is rational where the investor maximizes the expected return under specified risk under the efficient frontier.

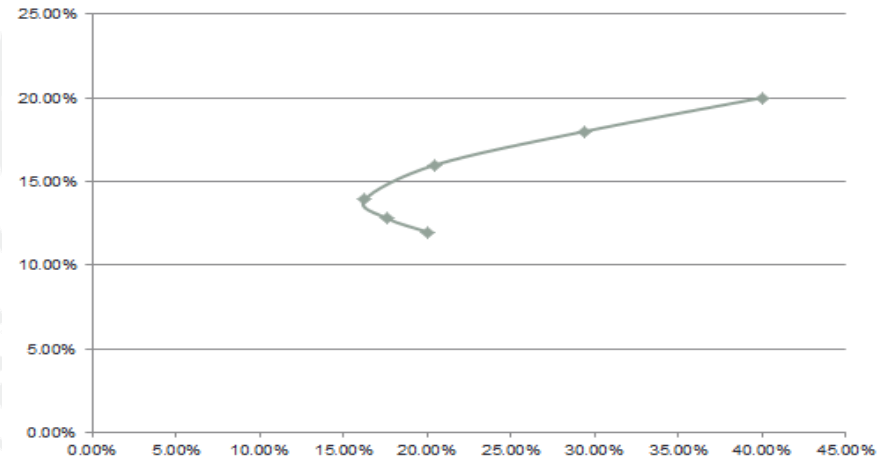

Figure 2.1 Efficient Frontier in Mean-variance Theory

However, modern portfolio theory does not reflect the real investment behavior in the way that people might not be reasonable or people may not be risk-averse. Therefore, researchers have been researching the theory that can explain the different behaviors of investors as some of them can be presented in the Table 2.1.

Behavioral Theory	Researcher
Cognitive Dissonance	Festinger (1957)
Heuristics	Kahneman and Tversky (1974)
	Kahneman, Slovik and et al. (1982)
Prospect Theory	Kahneman and Tversky (1979)
Reflection Effect	Kahneman and Tversky (1981)
Mental Accounting	Thaler (1985)
Regret-aversion Theory	Statman (1988)
Disjunction Effect	Tversky and Shafir (1992)
Herding Behaviors	Shiller (2000)

Table 2.1 Some of Behavioral Finance Theories for Portfolio Investment

One of the theories that is widely accepted in the field of behavioral theory and applied to the investment is the Prospect Theory developed by Kahneman and Tversky (Kahneman & Tversky, 1979), which explains some behavioral aspects of human nature in decision making. This concept is subsequently applied to the investment decision with the belief that this concept reflects the real behavior of the investors compared with the mean-variance theory.

In 1992, Tversky and Kahneman developed the Cumulative Prospect Theory (CPT) to solve the problems of original prospect theory. This theory is one of the most acceptable theories to evaluate the investors' behavior under risky and uncertain conditions. Four main characteristics of cumulative prospect theory identified by Tversky and Kahneman (Tversky & Kahneman, 1992) are:

1. Choices are evaluated relative to a reference point not the final outcome.

2. The shape of value function is concave when the investor gains from investment and is convex when the investor loses from investment and also the shape of loss is steeper than gain. This implies that the investor is risk-averse since only accept the reasonably specific level of return even though the higher rate of return can be achieved and the investor is risk seeking when the losses can be limited at specific level.

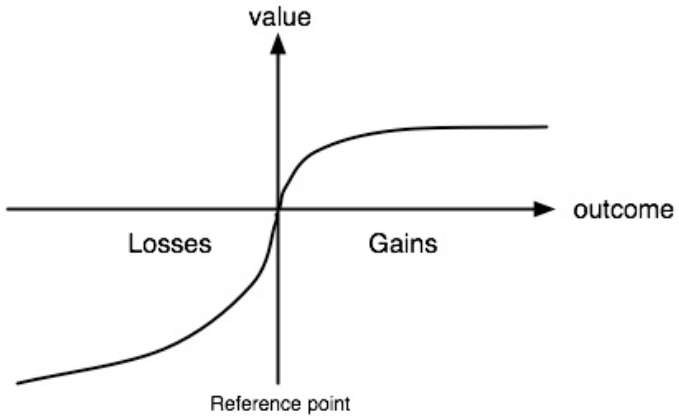

Figure 2.2 Value function of prospect theory (Marko, 2009)

3. Additionally, the greater slope of losses than gains in value function plot represents the loss aversion of the investor.

4. Probability of the incident is nonlinear, the weight assigned to the low-probability incident is too high and the weight assigned to the high-probability incident is too low, which highly affects the very low or high probability. The example of such incident is that the investor decides to purchase lottery that has 99% chance to win much less than the lottery with the same amount of prize that has 100% chance to win. The relationship between weighting function and probability is shown in the Figure 2.3.

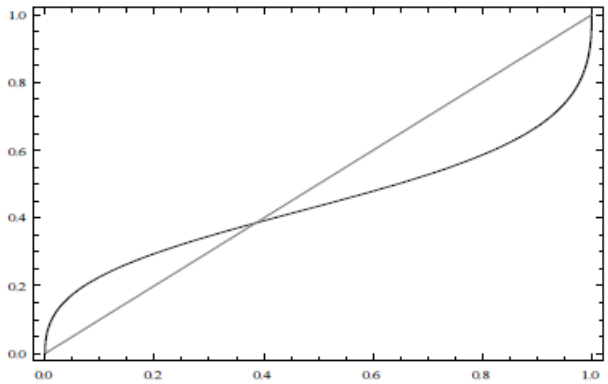

Figure 2.3 Example of relationship between Weighting Function and Probability (Coelho, 2014)

In the real world, investors are not reasonable due to behavioral biases. This research focuses on studying the behavioral factors that affect portfolio allocation in

the Stock Exchange of Thailand Total Return Index (SET TRI) as the proxy of risky asset and government bond, treasury bill and Bank of Thailand bond as the proxy of risk free asset. Cumulative prospect model is implemented to study the behavioral effect on portfolio allocation compared with the standard mean-variance method.

The objective of this research is to apply the concept of behavioral cumulative prospect theory to portfolio allocation in risky and risk-free assets and compare with the modern portfolio theory to present the difference between both theories to show that the behavioral portfolio model are more suitable for application than the standard mean variance model since it can be applied to all people with different behaviors. This research will help the investor to realize about the behavioral effects on investment decision, which is different from the standard mean-variance theory hence each investor can make investment decision that suits each investor's behavior.

2.2 LITERATURE REVIEW

Markowitz (1952) created the prominent mean-variance theory for portfolio allocation under the principal that the investor is reasonable and only expects the highest return under the same risk level. Under the efficiently frontier, the investor will only select the highest return at the same level of risk. This theory has still been extensively used as the main concept for portfolio allocation. However, many researchers are doubtful on this theory whether it really reflects the investor's behavior. Kahneman and Tversky (1979) developed the new theory called prospect theory, which presents the different concept from the mean-variance. This theory believes that the investor is unreasonable. Net amount of gains and losses by way of utility function is used to make investment decision according to the mean-variance theory whereas prospect theory unequally evaluates the value of gains and losses, which losses have more emotional impact than gains at the same level of gains and losses. Additionally, weighting function is used to weigh each incident instead of using the probability function to reflect the behavior of investor. However, prospect theory uses monotonic transformation weighting function, which encounters 2 problems (Tversky and Kahneman (1992)), which are 1. It does not always satisfy stochastic dominance 2. It does not suitable for the prospects with a large number of outcomes. In order to solve such problems, Tversky and Kahneman (1992) developed new theory called

"Cumulative Prospect". In summary, cumulative prospect has four main assumptions to explain the real behavior of investors as follows:

1. Investor evaluates the asset value by considering gains and losses instead of the final wealth
2. Investor is more sensitive to losses than the same amount of gains (Loss Aversion)
3. Investor is more risk-seeking when losses and more risk-averse when gains (Asymmetric Risk Preference)
4. Investor tends to overreact to small probability incident and underreact to large probability incident.

Furthermore, Tversky and Kahneman (1992) also estimated parameter values for cumulative prospect model by recruiting the university students to perform the behavioral analysis test, where the results are presented in Table 2.2. In addition to Tversky and Kahneman (1992), Rieger, Wang and Hens (2011)(Rieger, Wang, & Hens, 2011) also study and estimate the parameter values for cumulative prospect model in 45 countries included Thailand by testing with the university students (Rieger et al., 2011). The testing results are also shown in Table 2.2. Normally, cumulative prospect theory is used to find portfolio allocation when considers the behavioral factors to compare with the mean-variance theory, for instance, the study of Heybati, Roodposhti and Moosavi (2011) (Heybati, Roodposhti, & Moosavi, 2011) and Coelho (2014), which all those studies used cumulative prospect model. Nevertheless, parameter values and asset types are different. The author would like to summarize the model, parameter values and other main data used in the abovementioned researches in Table 2.2 and the meaning of cumulative prospect parameters are shown in Table 2.3

	Tversky and Kahneman (1992)	Heybati, Roodposhti and Moosavi (2011)	Rieger,Wang and Hens (2011)	Coelho (2014)
Parameter Values for Cumulative Prospect Model	$\beta = 0.88$ $\alpha = 0.88$ $\lambda^{+} = 1, \lambda^{-} = 2.25$ $\gamma = 0.61$ $\delta = 0.69$	$\alpha = 3$ $\lambda^{+} = 1, \lambda^{-} = 2.25$ $\gamma = 0.9$	$\beta = 0.90$ $\alpha = 0.65$ $\gamma = 0.55$	$\beta = 1, 0.5, 0.1$ $\alpha = 1, 0.5, 0.1$ $\lambda = 1, 3$ $\gamma = 1, 0.44$ $\delta = 1, 0.77$
Risk and Return Data	N/A (Research to develop the theory)	Tehran Stock Exchange and bank deposit interest rate	N/A (Research to find parameter values)	Assumed data

Table 2.2 Summary of models, behavioral parameters and data of related researches

Paramater: β : Risk Preference in Losses Parameter

α : Risk Aversion in Gains Parameter

λ : Loss Aversion Parameter

γ, δ : Coefficient of Probability Weighting Adjustment

Parameter	Meaning and Detail
α,β	α: Risk aversion in gains parameter β : Risk preference in loss parameter α, β = 1 (Risk neutral) α, β < 1 (Risk aversion) or [Risk lover]
λ	Loss aversion parameter λ =1 (No loss aversion) λ >1 (loss aversion)
γ, δ	Coefficient of Probability Weighting Adjustment γ, δ = 1 (Probability weighting function) γ, δ < 1 (Non-linear probability weighting function)

Table 2.3 Value of CPT parameters

Note: negative of the value function

From the table above, parameters α and β represent risk aversion in gains and risk preference in loss respectively. If the value equals to 1, the investor is risk neutral but if less than 1, the investor is risk aversion in gains and risk preference in loss. λ

represents loss aversion. If loss aversion factor equals to 1, there is no loss aversion but if loss aversion factor is greater than 1, there is loss aversion behavior involved. Finally, the coefficient of probability weighting adjustment is represented by ɣ, δ

According to Table 2.2, Tversky and Kahneman (1992) have developed the cumulative prospect theory model and also explored the parameter value for cumulative prospect model by testing with the university students; however, this study did not apply the model to portfolio allocation. Heybati, Roodposhti and Moosavi (2011) studied the behavioral approach to portfolio selection by also applying the cumulative prospect model to investigate the behavioral effect of the investment in Tehran stock market as the risky asset and bank deposit as risk-free asset. This study also compared the results of cumulative prospect theory with the mean-variance theory, which also showed the differences between two theories as presented in Table 2.4 Regarding the standard model, there were much different in the investment proportion between risky asset and risk-free asset. On the other hand with the behavioral model, the investment proportion between risky asset and risk-free asset were not much different. Considering the investment weight in risky and risk-free assets, in standard model, the weights of risky asset are fluctuating in the range of 45.5% - 87.4%. On the other hand, weight of risky asset in behavioral model is more stable in the range of 34.3% - 59.7%. Additionally, comparing weight of risky asset in each period between standard model and behavioral model, the weight of risky asset in standard model is always higher than behavioral model and the weights of risky and risk-free assets are not much different in the behavioral model meaning that the behavioral factors do affect the portfolio allocation of the investor.

Period	**Standard Model**		**Behavioral Model**	
	Weight Risky	**Weight Risk-free**	**Weight Risky**	**Weight Risk-free**
1	0.874	0.126	0.597	0.403
2	0.720	0.280	0.545	0.455
3	0.758	0.243	0.337	0.663
4	0.763	0.237	0.491	0.509
5	0.816	0.184	0.354	0.646
6	0.674	0.327	0.400	0.600
7	0.455	0.545	0.343	0.657

Table 2.4 Results comparing between standard model and behavioral model from Heybati, Roodposhti and Moosavi's study

Considering the study of Rieger, Wang and Hen (2011), they measured cumulative prospect parameters in 45 countries by surveying the students from departments of economics, finance and business administration with the average age of 21.5 years. Each participant had to answer various questions to evaluate the parameters. This study also uses some results from Rieger, Wang and Hen (2011) that were tested with the students in Thailand for applying to the cumulative prospect model as shown in Table 2.5.

Country	Parameter Values
Thailand	$\alpha = 0.65$
	$\gamma = 0.55$
	$\beta = 0.90$

Table 2.5 Survey results for cumulative parameters in Thailand from Rieger, Wang and Hen's study

Coelho (2014) also applied cumulative prospect model for portfolio selection with assumed risk and return data and also various cumulative prospect parameters to perform the sensitivity analysis of cumulative prospect parameters, which are loss aversion, risk aversion in gains, risk preference in losses and probability weighting function to analyze the effect of such parameters to the portfolio profitability and portfolio variance and also compare the results with the mean-variance method. The results of this paper are increase in loss aversion and risk aversion in gains results in more investment in low risk portfolio. Conversely, increase in risk preference in losses results in more investment in high risk portfolio and also can conclude that the high risk portfolio will be chosen if risk preference in losses is higher than the risk aversion in gains and high risk aversion in gain results in low loss aversion effect.

The parameters from each research are different, which show the different behavioral assumptions for each study. Some studies do not examine the portfolio allocation, which are Tversky and Kahneman (1992) that develops the theory and Rieger, Wang and Hens (2011) that only finds the parameter values in different countries. Additionally, other studies, which study the behavioral portfolio allocation, the risk and return data used are also different. Heybati, Roodposhti and Moosavi (2011)

use real data for risky and risk-free assets but Coelho (2014) uses the assumed data. Results of the above researches show the differences in portfolio allocation between cumulative prospect model and mean-variance model due to the behavioral effects. According to the parameter values in Table 2.2, increase in loss aversion factor (higher λ) and risk aversion factor (lower α) results in more investment in risk-free asset. On the other hand, increase in risk preference factor (lower β) results in more investment in risky asset. However, coefficient of probability weighting adjustment (γ, δ) has insignificant effects to the changes of investment.

Cumulative prospect behavioral parameters are the key factor for the cumulative prospect model. Referring to the abovementioned papers, various cumulative prospect parameter values were used based on different behavioral assumptions. In this study, the parameters from the study of Tversky and Kahneman (1992) and Rieger, Wang and Hen (2011) are applied in this study as shown in the Table 2.6 below. The reasons for using the parameters from both researches are

1. The parameters are obtained from the behavior of real people (university students)

2. Parameters from the study of Rieger et al, are obtained from testing with the university students in Thailand where the investment is focused in this study to be able to represent the behavior of Thai people.

Sources	Parameter Values
Rieger,Wang and Hens (2011) and Tversky and Kahneman (1992)	$\alpha = 0.65$
	$\lambda = 2.25$
	$\gamma = 0.61$
	$\delta = 0.69$
	$\beta = 0.90$

Table 2.6 Cumulative Prospect's Behavioral Parameter Values used in This Research

The parameter values in Table 2.6 that are applied to this research assume that the investor is risk averse in gain and risk seeking in loss since the parameters are less than 1. Considering the loss aversion parameter, the value is more than 1 meaning that the investor is loss aversion. Finally, the γ and δ are not equal to 1, which mean assuming the non-linear probability function.

Additionally, in reference to the literature review above, the behavioral factors in cumulative prospect model do affect the portfolio allocation. Therefore, it is interesting to apply this concept to the investment in many countries to observe the effect of behavior to portfolio allocation. This research focuses on studying the behavioral effects in Thailand by using cumulative prospect model to find the optimal portfolio of risky and risk-free assets, which Stock Exchange of Thailand Total Return Index (SET TRI) is the proxy of risky asset and government bond is the proxy of risk-free asset and the results of behavioral model will also be compared with mean-variance model to analyze the effect of behavioral factors to portfolio allocation.

2.3 METHODOLOGY

This research aims to find the optimal investment allocation in risky and risk-free assets by taking into account the behavioral factors. Cumulative prospect model is used to calculate the investment proportion in 2 assets in this study, which are 1. Risk-free asset, which uses the government bond, Treasury bill and Bank of Thailand bond. Return of risk-free asset is presented as R_f 2. Risky asset, which uses Stock Exchange of Thailand Total Return Index (SET TRI). Return of risky asset is presented as R. The historical return data were used from 2008-2017 for both Risky and Risk-free assets.

2.3.1 Optimization Model

Assuming that the weight of risky asset is theta (θ) and the weight of risk-free asset is 1-θ. Therefore, the return from investment is:

$$x = (1 - \theta)R_f + \theta R \quad \text{(Equation 1)}$$

The total return (x) is the weighted average of the returns of one risky asset and one risk-free asset.

Regarding another assumption of cumulative prospect theory, Investor tends to overreact to small probability incident and underreact to large probability incident. This assumption in this study is represented by the probability weighting function equation below by Goldstien and Einhorn (1987) (Goldstein & Einhorn, 1987) and Gonzalez and Wu (1999) (Gonzalez & Wu, 1999).

$$f^{+}(p) = f^{-}(p) = \frac{\delta p^{\gamma}}{(\delta p^{\gamma}+(1-p)^{\gamma})} \quad \text{(Equation 2)}$$

Where δ,ɣ is the coefficient of probability weighting adjustment, if δ,ɣ = 1, there is no behavioral effect and the function is linear and if less than 1, the function is non-linear.

Considering the calculation method for portfolio allocation by cumulative prospect model, the concept of utility maximization is used where the objective function is equal to the sum of positive and negative components as shown in Equation 3 (Coelho (2014)).

$$V(y) = V(y^{-}) + V(y^{+}) = \sum_{i=-m}^{0} h_i^{-} v(x_i) + \sum_{i=0}^{n} h_i^{+} v(x_i) \quad \text{(Equation 3)}$$

Where: V is expected utility, which need to be maximized, h_i is decision weight and v is value function. The decision weights for positive and negative parts $(h_i^{+} and\ h_i^{-})$ respectively can be calculated by the following equations where the probability weighting function equation is also applied in this equation:

$$h_n^{+} = f^{+}(p_n)\ and\ h_i^{+} = f^{+}(\sum_i^n p_i) - f^{+}(\sum_{i+1}^n p_i)\ if\ 0 \le i \le n-1 \text{ (Equation 4)}$$

$$h_{-m}^{-} = f^{-}(p_{-m})\ and\ h_i^{-} = f^{-}(\sum_i^n p_i) - f^{-}(\sum_{-m}^{i-1} p_i)\ if\ 1-m \le i \le 0 \text{ (Equation 5)}$$

The value function (v) his study is represented by the equation below by Tversky and Kahneman (1992):

$$v(x) = \begin{cases} x_i^{\alpha} \text{ if } 0 \le i \le n \\ -\lambda(-x_i)^{\beta} \text{ if } -m \le i < 0 \end{cases} \quad \text{(Equation 6)}$$

In the value function equations, positive and negative parts are separated as shown in equation 6. The behavioral parameters, which are risk aversion in gain (α), risk preference in loss (β) and loss aversion parameter (λ) are taken into account in the value function.

The optimization method used in this study is Genetic Algorithm, which has the benefit of avoiding the local optima in the non-linear function. The weights of risky and risk-free assets that maximize the utility function with the condition of no short sales allowed $(\theta_i \ge 0)$ are the results from the optimization. Additionally, the results from cumulative prospect model will also be compared with the results from mean-variance model to analyze the differences of the portfolio allocation.

2.3.2 Parameter Values

Regarding the parameter values for cumulative prospect model in this study, the parameter values from the studies of Tversky and Kahneman (1992) and Rieger, Wang and Hens (2011) are applied to the model as stated in the Section 2.2, which are summarized in Table 2.7.

Sources	Parameter Values
Rieger,Wang and Hens (2011) and Tversky and Kahneman (1992)	$\alpha = 0.65$
	$\lambda = 2.25$
	$\gamma = 0.61$
	$\delta = 0.69$
	$\beta = 0.90$

Table 2.7 Cumulative Prospect's Behavioral Parameter Values used in This Research

2.3.3 Research Data

SET TRI as risky asset and the average return of government bond, treasury bill and Bank of Thailand bond as risk-free asset are annually tested from 2008-2017 to find the optimal weights of risky and risk-free assets in each year and also the whole period from 2008-2017. The daily return data are applied to the model for both risky and risk-free assets. The reasons considering the period from 2008-2017 are that 1. This period include both normal situation and crisis situation, for example, financial crisis, flooding situation and political situation in Thailand so this study will observe the behavioral effect in both normal and crisis situations. 2. Able to reflect the long-term investment when considering the whole period from 2008-2017. The returns, variance and calculated Coefficient of Variation (CV) or the ratio of Standard Deviation and the mean risky return of the research data are presented in the following table.

Year	Mean Risk-free Return	Mean Risky Return	Variance	CV
2008	3.34%	-40.51%	10.92%	-0.82
2009	1.43%	74.91%	6.15%	0.33

2010	1.80%	49.42%	3.00%	0.35
2011	3.13%	5.10%	4.92%	4.35
2012	3.02%	41.55%	1.57%	0.30
2013	2.61%	-2.05%	4.26%	-10.1
2014	2.12%	19.80%	1.65%	0.65
2015	1.62%	-9.73%	1.82%	-1.38
2016	1.46%	24.29%	1.96%	0.58
2017	1.47%	17.49%	0.40%	0.36
Total	2.20%	11.2%	3.70%	1.73

Table 2.8 Research Data - Returns, Variances and Coefficient of Variation

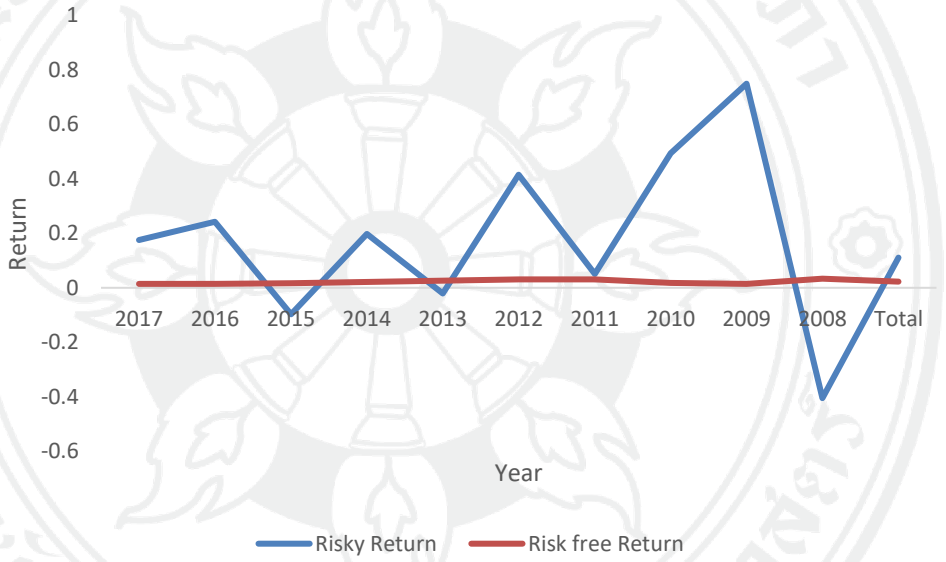

Figure 2.4 Comparison of annual risky and risk-free returns applied in this study

According to the Table 2.8 and Figure 2.4 above, the returns of SET TRI (risky asset) are quite fluctuating and this surely comes with risk for the risky asset as shown in term of variance. Mostly during crisis years, the returns of SET TRI are negative and this will also result in the negative Coefficient of Variation (CV). On the other hand, the 1-year average of Treasury bill, government bond and Bank of Thailand bond government bond (risky-free asset) is quite stable from 2008-2017. In year 2008-2017, the risk free returns are in the range of 1.43% – 3.34% while the risky returns are quite fluctuating from -40.51% - 74.91%. The variance in the range of 0.40% - 10.92%. However, in general the returns of risky assets are basically much more than the returns

of risk-free assets except in some crisis years that the risky-asset returns are lower than the risk-free assets returns. Considering the whole period of 2008-2017, average risk-free asset return is 2.20% much less than the average risky-asset return at 11.2% with 3.70% variance and the coefficient of variation of 1.73.

When the research data are applying to the cumulative prospect model, regarding the risky asset or SET TRI, the daily returns of SET TRI from 2008-2017 are inputted to the model for optimization. Similarly for the risk-free asset, the daily returns are applied to the cumulative prospect optimization model. The daily returns are calculated based on the 1-year average of Treasury bill, government bond and Bank of Thailand bond converted to daily return. Such return data will be applied to the equations in Section 2.3.1 for annual optimization from 2008-2017 and also the whole ten-year period of 2008-2017 are also optimized to consider the long-term investment

Finally, in addition to the optimization to find the portfolio allocation by both mean-variance and cumulative prospect methods. In order to check whether the results from both methods are significantly different. This study will also perform the hypothesis test by way of mean difference in Microsoft excel.

2.4 FINDING AND RESULT

2.4.1 Results

2.4.1.1 Cumulative Prospect Theory

The optimization results to find the weights of risky and risk-free assets for the investment in Thailand by cumulative prospect method are illustrated in Figure 2.5 below.

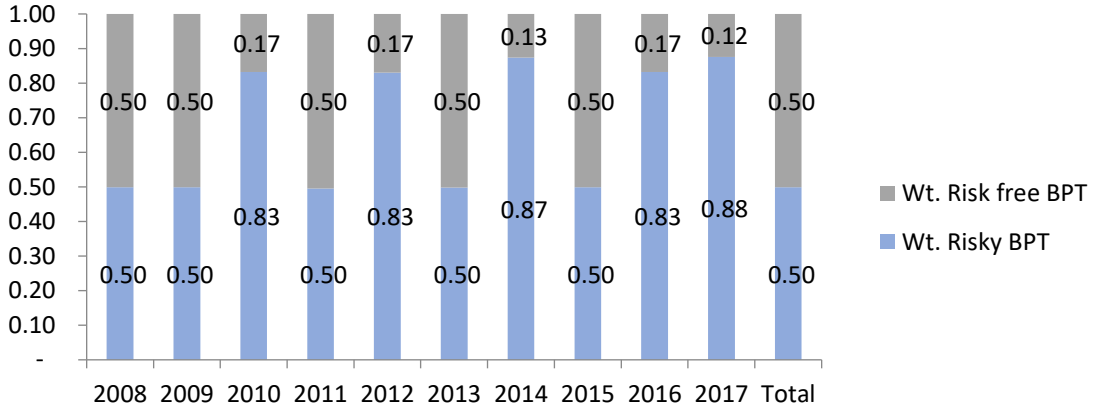

Figure 2.5 Optimization Results (Weights of Risky and Risk-free Assets) from Cumulative Prospect Model

As shown in the graph in Figure 2.5, the investment is allocated in both risky and risk-free assets with most of them in the proportion of 50:50. In 2010, 2012, 2014, 2016 and 2017 when the return of risky assets is much greater than risk-free asset, the portfolio is allocated in risky asset much more than risk-free asset. However, in some crisis years, for example Hamburger crisis in 2008 or political crisis in 2013, the portfolio allocation in risky and risk-free assets is still approximately identical.

Year	Mean Risk-free Return	Mean Risky Return
2008	3.34%	-40.51%
2009	1.43%	74.91%
2010	1.80%	49.42%
2011	3.13%	5.10%
2012	3.02%	41.55%
2013	2.61%	-2.05%
2014	2.12%	19.80%
2015	1.62%	-9.73%
2016	1.46%	24.29%
2017	1.47%	17.49%

Table 2.9 Research Data – Returns of Risky Assets and Risk-free Assets

2.4.1.2 Mean-variance Theory

This study also optimizes portfolio allocation by mean-variance method. The same risky and risk-free assets data as applied in the behavioral cumulative prospect model are also applied to the mean-variance model, which are SET TRI for risky asset and the average of Treasury bill, government bond and Bank of Thailand bond for risk-free asset. The study period is also from 2008-2017 to be able to equally compare with the behavioral model. The optimization results to find the weights of risky and risk-free assets for the investment in Thailand by mean-variance method are illustrated in Figure 2.6 below.

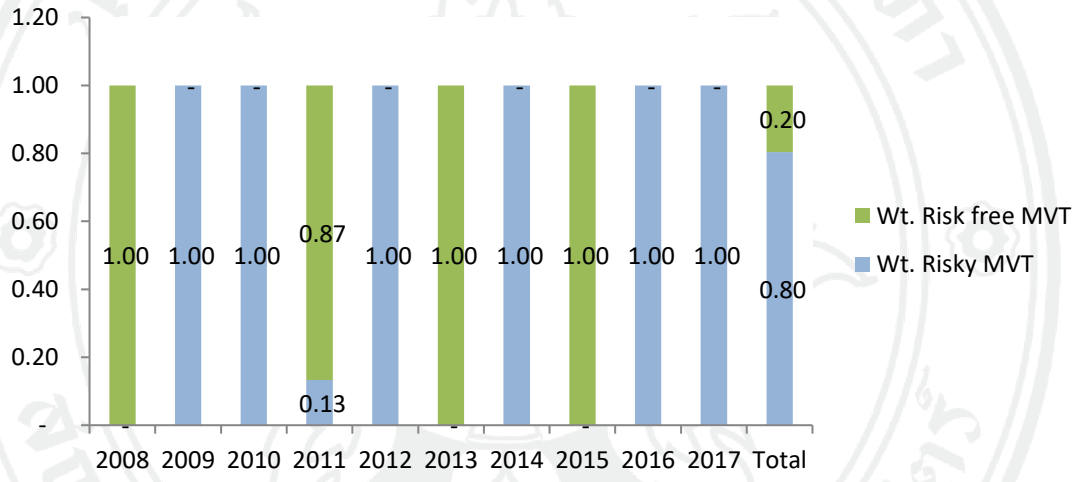

Figure 2.6 Optimization Results (Weights of Risky and Risk-free Assets) from Mean-Variance Model

Regarding mean-variance model as shown in Figure 2.6, the investors have strong decision in either investment in risky or risk-free asset. Only in few years that the investment is shared with significant difference between weight of risky and risk-free assets. In crisis years where the return of risky asset is negative, the investors allocate all investment in risk-free asset. Conversely, much greater return of risky asset than risk-free asset results in 100% allocation in risky asset. The comparison of optimization results for portfolio allocation between behavioral prospect model and mean-variance model are presented in Table 2.10 and Figure 2.7.

Year	Behavioral Model				Mean-Variance Model			
	Weight Risky	Weight Risk-free	Portfolio Return	Variance	Weight Risky	Weight Risk-free	Portfolio Return	Variance
2008	0.4993	0.5007	-18.55%	2.72%	0	1	3.34%	0.00%
2009	0.4993	0.5007	38.12%	1.53%	1	0	74.91%	6.15%
2010	0.8324	0.1676	41.43%	2.08%	1	0	49.42%	3.00%
2011	0.4952	0.5048	4.11%	1.21%	0.1333	0.8667	3.40%	0.09%
2012	0.8308	0.1692	35.03%	1.08%	1	0	41.55%	1.57%
2013	0.4980	0.5020	0.29%	1.06%	0	1	2.61%	0.00%
2014	0.8735	0.1265	17.57%	1.26%	1	0	19.81%	1.65%
2015	0.4989	0.5011	-4.04%	0.45%	0	1	1.62%	0.00%
2016	0.8318	0.1682	20.45%	1.36%	1	0	24.29%	1.96%
2017	0.8761	0.1239	15.51%	0.31%	1	0	17.49%	0.40%
Total	0.4990	0.5010	6.65%	0.92%	0.8038	0.1962	9.37%	2.39%

Table 2.10 Comparison of Portfolio Allocation between Cumulative Prospect Model and Mean-Variance Models

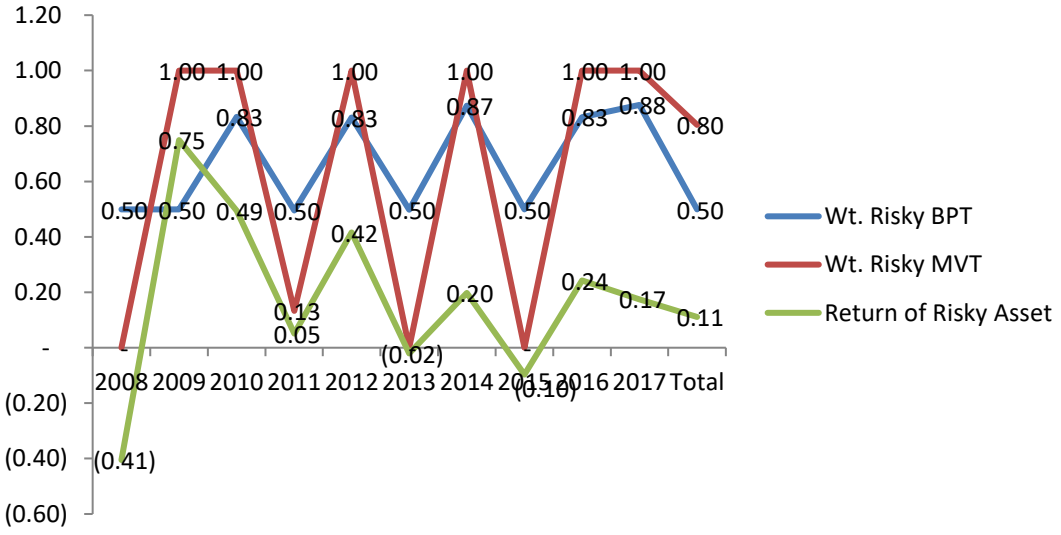

Figure 2.7 Weights of Risky Asset Comparison between Prospect Model and Mean-Variance Models

Table 2.10 and Figure 2.7 illustrates the differences between behavioral cumulative prospect model and mean-variance model. Whereas mean-variance method mostly invest in either risky or risk-free asset, which can be observed from the 100% allocation in either risky or risk-free assets, with behavioral factors, the proportion that the investor decides to invest in risky and risk free assets is in between the mean-variance model results in lower risk level but also lower return. However, in the crisis years, the mean-variance method mostly invests in the risk-free assets but the behavioral method still invests in both risky and risk-free assets resulting in higher risk and lower returns for the behavioral method during such period. Considering the whole period from 2008-2017, the behavioral investors also allocates the investment in between the investment by mean-variance method resulting in lower return but also lower risk than mean-variance model. This shows the effect of behavioral bias that the investors only decide to share the investment in both risky and risk-free assets while without the behavioral bias, the investors either invest in risky asset or risk-free asset.

2.4.2 Hypothesis Test

Additionally, the hypothesis test by way of the mean difference is performed in this study to test whether the results between standard model and behavioral are significantly different. The null hypothesis and alternative hypothesis are presented below where the test is conducted in Microsoft Excel.

Null Hypothesis (H_0): weight of risky return based on mean variance model and behavioral model are not different.

Alternative Hypothesis (H_1): weight of risky return based on mean variance model and behavioral model are different.

The results from hypothesis test are shown in the Table 2.11 below. The results are shown annually from 2008-2017 and also the whole period of 2008-2017.

Year	**P-Value (two tail)**	**Interpretation (Significance Level = 0.05)**
2008	6.4E-286	Reject H_0
2009	6.1E-286	Reject H_0

2010	6.9E-242	Reject H_0
2011	8.0E-289	Reject H_0
2012	3.0E-278	Reject H_0
2013	1.8E-280	Reject H_0
2014	9.1E-270	Reject H_0
2015	1.2E-222	Reject H_0
2016	5.4E-272	Reject H_0
2017	1.3E-269	Reject H_0
2008-2017	1.2E-276	Reject H_0

Table 2.11 Hypothesis Test the Difference of Risky Asset Weight between Mean-Variance Model and Behavioral Model

According to Table 2.11 above, all P-Values yearly and whole period from 2008-2017 are less than the significance level at 0.05. Therefore, the null hypothesis (H_0) is rejected meaning that the weights of risky asset from mean-variance model and behavioral model are significantly different resulting in the conclusion that the behaviors do affect the investors' decision in portfolio allocation.

2.5 DISCUSSION AND RECOMMENDATION

This research studies the effect of behavioral factors to the optimal portfolio allocation in risky asset (SET TRI) and risk-free asset (average of Treasury bill, government bond and Bank of Thailand bond). Ten-year period historical data from 2008-2017 are considered in the cumulative prospect model to find the optimal portfolio allocation that provides the maximum utility to the investor. The cumulative prospect parameter values used in this study are the combination from the previous studies of Rieger, Wang and Hens (2011) and Tversky and Kahneman (1992). The advantages of using the parameter values from these studies are 1. They were investigated from the real behavior of the sample group of people. 2. The study of Rieger, Wang and Hens (2011) in different countries also includes Thailand, where the investment is considered in this research and so such parameters studied with the people in Thailand are selected to apply in this study. However, there are still the weaknesses regarding the parameters, which are

1. Only small group of people were tested so this might not be able to represent the behavior of every person. The future research should increase the size of sample group for more accurate behavioral parameters outcome.

2. Specific occupation, which is student, were tested. More various occupations should be tested to make the outcomes better represent the whole group of people and also if possible to find parameters by occupation, this would possibly enhance the accuracy of the study and can further investigate the investment behavior of each occupation.

The results of this study also present the significant difference in optimal portfolio allocation between behavioral cumulative prospect model and mean-variance model where from the hypothesis test results in the objection of null hypothesis stated that the results from both methods are not different.

The modern portfolio theory has the assumptions of risk-averse and rational people, which cannot represent the whole groups of investor. Irrational behavior can be widely observed in the investment, for example, the herding behavior that the individual will mimic the actions of the larger group. Additionally, the risk-seeking behavior can also be observed in the investors. Therefore, the use of modern portfolio theory for portfolio optimization might not be appropriate since it is impossible to find the solution for the risk-seeking and also behavioral-biased people and the result has already shown that the behavioral factors do affect the investment decision of the investors. On the other hand, by using the behavioral model, the behavioral parameters can individually be adjusted for each investor and this is important because this shows that the behavioral portfolio model can serve every individual investor with different behaviors and finally the optimization results from behavioral model will be the portfolio weights that suit the investment purposes of the investors.

The differences of this research compared to others is that the previous studies of the cumulative prospect theory were mostly studied in other countries. However, this study can be considered being one of the first few researches considering the portfolio allocation in Thailand by applying the behavioral model. Additionally, the behavioral parameters mostly used in previous studies were used the parameters from Kahneman and Tversky and the assumed data, which might not be able to explain the real behavior of the people in the countries that the investment was considered. However, this study applies the parameters that were tested with the people in Thailand to ensure that the behavioral parameters can reflect the behavior of the investment market in this study.

However, the disadvantages of this study are 1. It does not reflect the real investment behavior of the investors since this study only assume the investment in one

risky and one risk-free assets but people normally invest in the many assets so the future study can be further developed to reflect the real investment behavior of the investor that does not only invest in one risky and one risk-free asset but invests in many risky and risk-free assets to diversify portfolio, for example, study the investment in many stocks in the stock market. 2. The cumulative prospect parameters were tested long time ago and only specific with the university students. The recommendation for future research is to investigate the current cumulative prospect parameters with the various groups of people e.g. student, working people or even the old people to ensure that the parameters can represent all groups of people and once obtain the parameters by occupation the study can be expanded to observe the difference in investment behavior by occupation.

CHAPTER 3

MENTAL ACCOUNTING

3.1 INTRODUCTION

Regarding the field of portfolio investment, mean-variance theory (Markowitz (1952)) is considered to be well-known theory for portfolio allocation. The concept of mean-variance portfolio is that the investors are reasonable in investment and also risk averse in that the highest return is expected under the given level of risk under the efficient frontier.

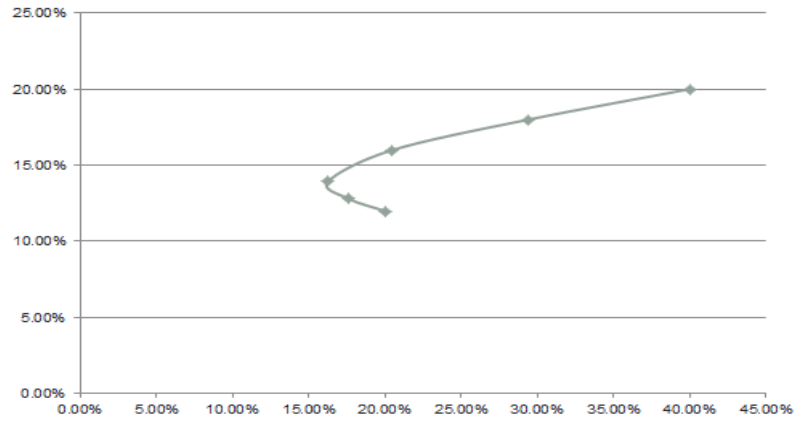

Figure 3.1 Efficient Frontier in Mean-variance Theory

Although, the mean-variance concept seems reasonable and practical by way of considering risk and returns for portfolio allocation, mean-variance theory is specific for risk-averse investor. In reality, investors are not reasonable and have behavioral bias in investment. Many researchers have studied the behavioral theories related to finance and one of the most popular theories to explain the behavioral bias of the investors is prospect theory. Other interesting behavioral theories are presented in the table below.

Behavioral Theory	Researcher
Cognitive Dissonance	Festinger (1957)
Heuristics	Kahneman and Tversky (1974) Kahneman, Slovik and et al. (1982)
Prospect Theory	Kahneman and Tversky (1979)
Reflection Effect	Kahneman and Tversky (1981)
Mental Accounting	Thaler (1985)
Regret-aversion Theory	Statman (1988)
Disjunction Effect	Tversky and Shafir (1992)
Herding Behaviors	Shiller (2000)

Table 3.1 Some of Behavioral Finance Theories for Portfolio Selection

In addition to the prospect theory, another theory, which also be able to explain one interestingly real behavior of the investors, is Mental Accounting Theory. Mental accounting theory (Thaler, 1985), which is the psychological theory to see the effect of cognition limitation to individual spending, saving and other household behavior. This theory basically discuss about the behavior of people that normally allocate their expenditure into different categories e. g. food, cloth, entertainment with different reference point, which mean that the value of money is different in different account but actually the money should be fungible and spend in whatever way to maximize utility. Therefore, this behavior is also considered not reasonable in the way that the people do not spend their money to maximize utility.

Same situation occurs with the financial investment where people normally invest not only in one portfolio but in many subportfolios with different risk attitudes due to different goals. Because of such behavior, the concept of "Mental Accounting" is applied to the field of portfolio investment. Mental accounting was introduced by Richard Thaler (1985) to explain consumer behavior as mentioned above. Subsequently, this concept is applied to the portfolio investment. In term of finance, mental accounting is the behavior of people to allocate the money into different accounts for different objectives, for example, one account for low risk investment and another account for high risk investment. This behavior is also considered to be irrational since there is the behavioral bias involved in setting up each account. For example, the people consider that some investments are more important than others and therefore, they decide not to surrender such money to solve other problem even though it might overall be more beneficial. Considering mental accounting in investment aspect, it is quite common that people always invest in various accounts for different objectives with different risk

appetite e.g. one investment account for retirement (low risk) and another account for speculative investment (high risk).

The objective of this research is to apply the concept of mental accounting to portfolio allocation in risky and risk- free asset with different mental accounting parameters, therefore, can represent the investment allocation in many accounts with different risk appetites in order to consider the effect of mental accounting in investing. Consequently, the results from this study will show the investors the illogical behavior in performing the mental accounting behavior.

3.2 LITERATURE REVIEW

Thaler (1985) introduced the mental accounting concept with the consumer behavior that the consumer always allocates their money into different categories with different reference point and subsequently this concept has been applied as one of behavioral finance concept. Mental accounting reflects the normal investment behavior of the people in the way that normally people invest in many subportfolios due to different investment goals.

To understand this behavior and how this behavior affects the expected outcomes of the investors, the researchers have been studying this concept on the investment. Das et al. (2010) applied mental accounting concept to portfolio optimization (Das, Markowitz, Scheid, & Statman, 2010). Mean-variance theory cannot explain the investors with different goals that have many risk attitudes while in reality the investors consider the portfolio as the collections of mental accounting subportfolios where each subportfolio is subject to specific threshold level and risk, for example, the portfolio is divided into one retirement subportfolio where expected lower return with lower risk and another speculative investment subportfolio where expected higher risk with higher risk appetite.

The main components of mental accounting theory are:

1. The consideration of portfolio as subportfolios

2. Risk of each subportfolio defined by the probability of failing to reach the threshold level in each mental account and attitudes toward risk that vary by account Threshold return in each subportfolio.

Das et al. (2010)'s study, three subportfolios were considered with different risk appetites as presented in Table 3.2.

Subportfolio	Threshold Return (H)	Probability (α)	Implied Risk Aversion
Retirement	-10%	0.05	3.9750
Education	-5%	0.15	2.7063
Bequest	-15%	0.20	0.8733

Table 3.2 Threshold Return, Probability of Failing to Reach Threshold Return

Where the threshold return (H) is the minimum return that an investor can expect to achieve when investing in a project and probability of failing to reach the threshold return is the probability that cannot achieve such threshold return.

Three subportfolios represent different risk appetites based on different mental accounting parameters, which are threshold return and probability of failing to reach threshold return. From the table, the investors cannot accept high risk resulting in highest risk aversion for retirement portfolio. On the other hand bequest portfolio has lowest risk aversion, which mean the investors can accept highest risk in this case and the education portfolio is in between.

The results of this study as presented in this Figure 3.2 show that

1. Without short selling constraint – the aggregate portfolios composed of mean-variance efficient subportfolios are also mean-variance efficient. However, these portfolios are not identical to portfolios optimized by mean-variance theory with a weighted average of risk-aversion coefficients across mental accounts

2. With short selling constraints each subportfolio is on the constraint portfolio frontier. However, aggregate portfolios are inefficient

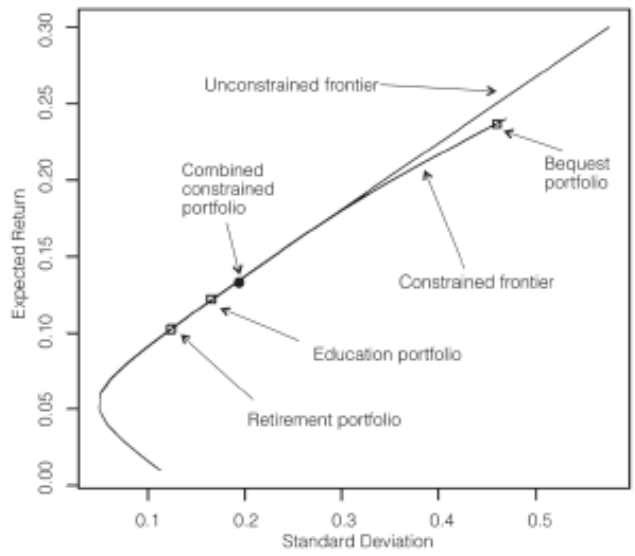

Figure 3.2 Efficient Frontier in Mean-variance Theory

In reference to the literature review above, the concept of mental accounting reflect the actual investment of normal people. Therefore, this research focuses on studying the mental accounting concept on portfolio investment to find optimal portfolio of risky and risk-free asset, which Stock Exchange of Thailand Total Return Index (SET TRI) is the proxy of risky asset and government bond is the proxy of risk-free asset based on different threshold returns and probability of failing to reach threshold returns.

3.3 METHODOLOGY

This research aims to find the optimal investment allocation in risky and risk-free assets by taking into account the behavioral factors. Mental Accounting portfolio optimization is used to calculate the investment proportion in 2 assets in this study, which are 1. Risk-free asset, which uses the average return of government bond, treasury bill and Bank of Thailand bond. Return of risk-free asset is presented as R_f 2. Risky asset, which uses Stock Exchange of Thailand Total Return Index (SET TRI). Return of risky asset is presented as R. The historical return data were used from 2009-2017 for both Risky and Risk-free assets

3.3.1 Optimization Model

Assuming that the weight of risky asset is theta (θ) and the weight of risk-free asset is 1-θ. Therefore, the objective function and constraints for optimization are:

$$\max_{\theta} \quad (1-\theta)R_f + \theta R_k \qquad \text{(Equation 1)}$$

Subject to constraints

$$\theta' R + \emptyset^{-1}(\propto)\sqrt{\theta' \sum \theta} \geq H \qquad \text{(Equation 2)}$$

$$\theta' 1 = 1 \qquad \text{(Equation 3)}$$

$$\theta \geq 0 \qquad \text{(Equation 4)}$$

$$\theta \leq 1 \qquad \text{(Equation 5)}$$

Where θ = Weight of risky asset, $\emptyset(\propto)$ = Cumulative standard normal distribution function, α = Probability of failing to reach the threshold return, Σ = Covariance matrix of returns and H = Threshold return.

This optimization method is used to find the weights of risky and risk-free assets that maximize return under specified threshold returns (H) and probability of failing to reach threshold return (α) with the condition of no short sales allowed ($\theta \geq 0$).

The constraints are shown in Equation 2 to Equation 5. Equation 2 is based on the assumption that the portfolio returns are normally distributed. Equation 3 to Equation 5 are applied to ensure the total weight is equal to 1 and also the short selling is not allowed.

The optimization method used in this study is Genetic Algorithm, which has the benefit of avoiding the local optima in the non-linear function. The weights of risky and risk-free assets that maximize the return with the condition of no short sales allowed ($\theta \geq 0$) are the results from the optimization.

3.3.2 Parameter Values

Regarding the parameter values for mental accounting model, the scenario analysis is performed in this study to observe different mental accounting parameters

to portfolio allocation in risky and risk-free assets. The parameter values applied to this study are presented in the Table 3.3.

Threshold Return (H)	Probability (α)
-20%	0.05,0.1,0.15 and 0.2
-15%	0.05,0.1,0.15 and 0.2
-10%	0.05,0.1,0.15 and 0.2
-5%	0.05,0.1,0.15 and 0.2

Table 3.3 Threshold Return and Maximum Probability of Failing to Reach the Threshold Return in This Study

The threshold returns (H) in the range of -5% to -20% are applied to this study and maximum probabilities of failing to reach the threshold return are 0.05, 0.1, 0.15 and 0.2 for each threshold returns. These parameter values will be applied to the optimization model in 3.3.1 to find the investment weights in risky and risk-free assets of each scenario for the investment period of 3 years, 5 years and 9 years.

3.3.3 Research Data

SET TRI as risky asset and the average returns of government bond, Treasury bill and Bank of Thailand bond as risk-free asset are applied to find the optimal weights of risky and risk-free assets. The average returns of three periods are presented in Table 3.4.

Year	Risk free	Risky
3 years (2015-2017)	1.52%	9.73%
5 years (2013-2017)	1.85%	9.19%
9 years (2009-2017)	2.07%	22.26%

Table 3.4 Research Data – 3-year, 5-year and 9-year Average Returns of Government Bond and SET TRI

The returns of both risk-free and risky assets for 3-year, 5-year and 9-year period are not much different but this paper will investigate all periods to observe the effect of short term (3 years), medium term (5 years) and long term (9 years) investment whether the investment period results in any differences in the investment.

3.4 FINDING AND RESULT

3.4.1 Results

3.4.1.1 Three-year Investment (2015-2017)

For three-year investment, the weights of risky and risk-free assets from mental accounting model based on different threshold returns (H) and maximum probabilities of failing to reach threshold returns (α) for are presented in the following table and additionally, Figure 3.3 and Figure 3.4 presents the different weights of risky asset and risk-free assets respectively under different mental accounting parameters (Threshold return and maximum probability of failing to reach the threshold return).

3 Years	**Portfolio Weight**							
H	-20%		-15%		-10%		-5%	
α	Risky	Risk Free	Risky	Risk Free	Risky	Risk Free	Risky	Risk Free
0.05	0.4291	0.5709	0.3551	0.6449	0.2272	0.7728	0.1583	0.8427
0.1	0.5409	0.4591	0.4677	0.5323	0.3022	0.6978	0.2071	0.7929
0.15	0.761	0.239	0.5951	0.4049	0.4293	0.5707	0.2634	0.7366
0.2	0.9717	0.0283	0.7599	0.2401	0.548	0.452	0.3362	0.6639

Table 3.5 Portfolio Allocation with Different Mental Account Parameters for 3-year Investment

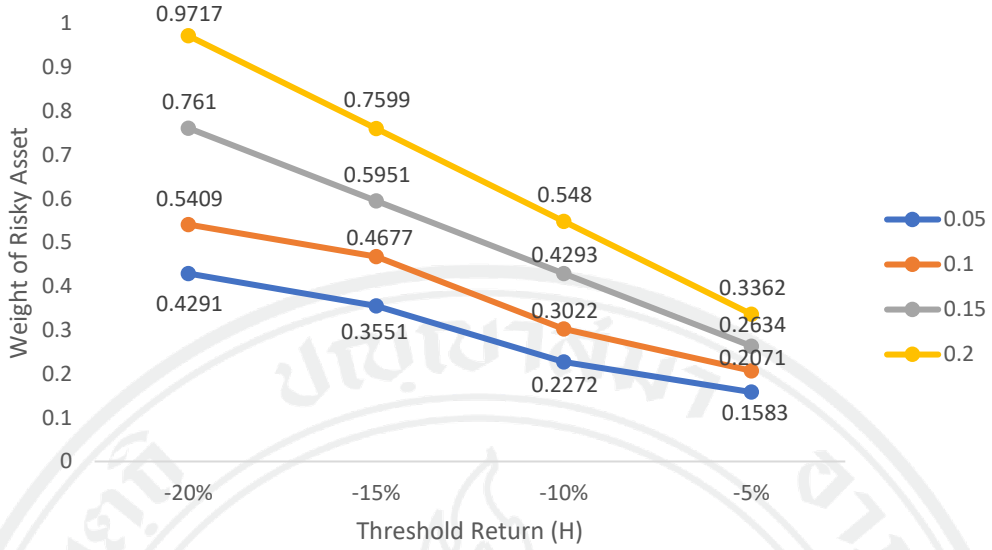

Figure 3.3 Weights of Risky Asset under Different Mental Accounting Parameters for 3-year Investment

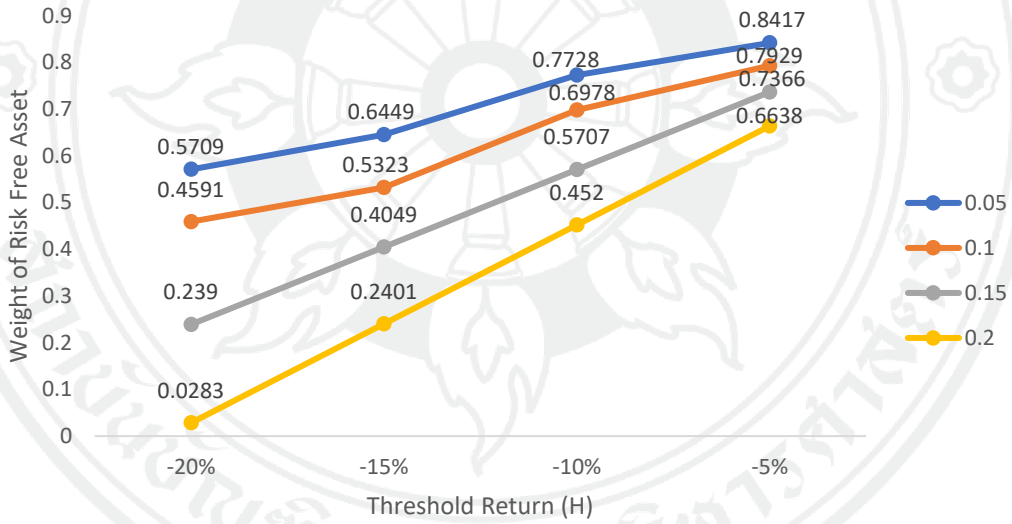

Figure 3.4 Weights of Risk Free Asset under Different Mental Accounting Parameters for 3-year Investment

The results illustrate the effects of different risk appetites to the portfolio selection based on different threshold return and maximum probability of failing to reach the threshold return. The yellow line with the probability of failing to reach the threshold return of 20% is the highest line, which means most investment in risky asset compared with other values of probability. This can also imply that lowest threshold return and lowest probability of failing to reach the threshold return results in highest

risk appetite. The lowest probability of 5% is the blue line results in lowest investment in risky asset.

Considering the threshold return, at threshold return equals -20%, the investment proportion in risky asset is higher than -15%, -10% and -5% respectively as presented in Figure 3.3. On the other hand, the investment proportion in risk-free asset is increasing with the threshold returns keep increasing when the threshold returns are increasing (less negative).

Therefore, this can be summarized that lower threshold return (more negative) results in lower investment in the risky asset and the increase in probability results in more investment in risky asset as can be shown for the threshold return of -20% and 20% of probability of failing to reach the threshold return that the investment in risky asset is very high at 97.17%.

3.4.1.2 Five-year Investment (2013-2017)

For five-year investment, the weights of risky and risk-free assets from mental accounting model based on different threshold returns (H) and maximum probabilities of failing to reach threshold returns (α) for are presented in the following table and additionally, Figure 3.5 and Figure 3.6 presents the different weights of risky asset and risk-free assets respectively under different mental accounting parameters (Threshold return and maximum probability of failing to reach the threshold return).

5 Years	**Portfolio Weight**							
H	-20%		-15%		-10%		-5%	
α	Risky	Risk Free	Risky	Risk Free	Risky	Risk Free	Risky	Risk Free
0.05	0.3811	0.6189	0.3011	0.6989	0.221	0.779	0.1407	0.8593
0.1	0.3967	0.6033	0.3402	0.6598	0.2364	0.7636	0.1695	0.8304
0.15	0.6156	0.3844	0.4861	0.5139	0.2815	0.7185	0.227	0.773
0.2	0.7286	0.2714	0.6056	0.3944	0.4442	0.5558	0.2827	0.7173

Table 3.6 Portfolio Allocation with Different Mental Accounting Parameters for 5-year Investment

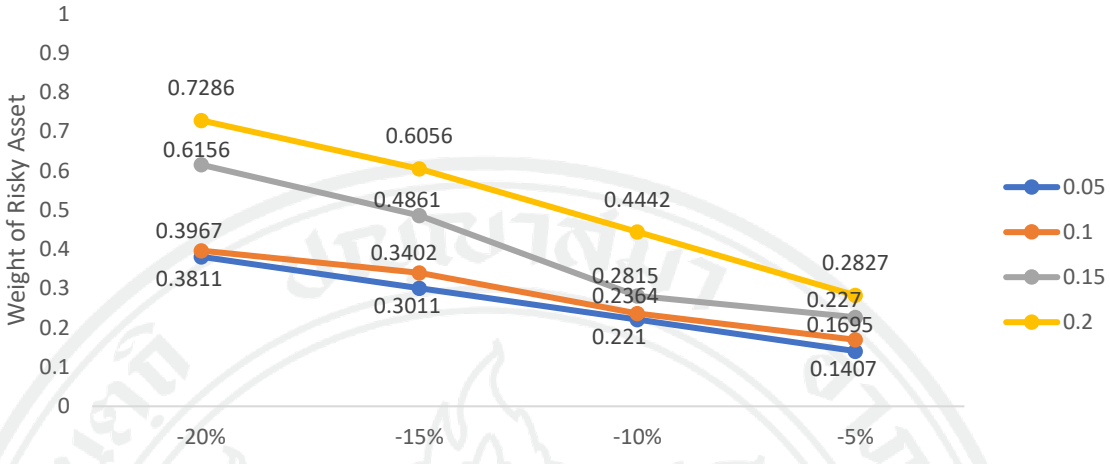

Figure 3.5 Weights of Risky Asset under Different Mental Accounting Parameters for 5-year Investment

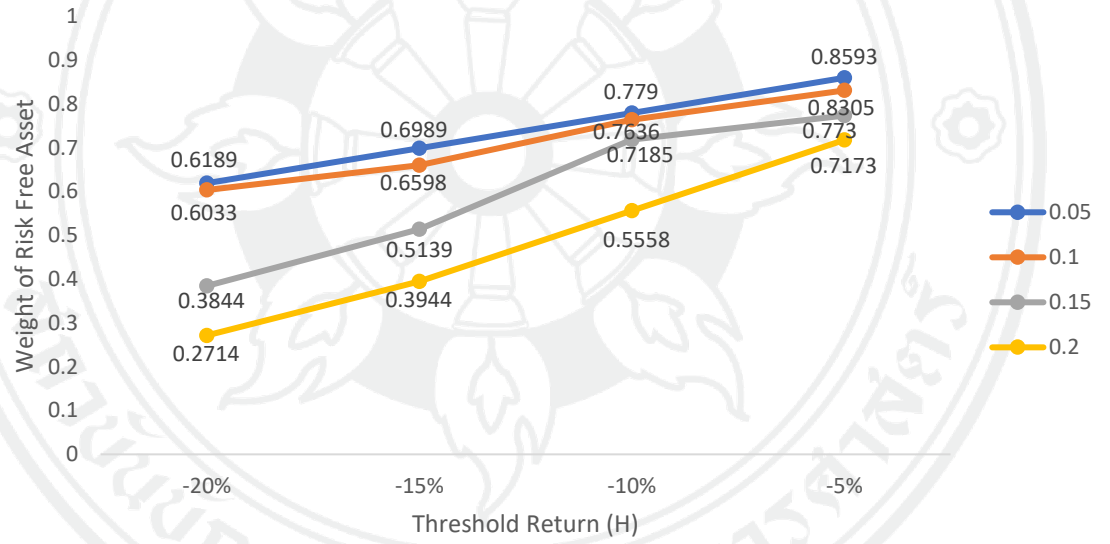

Figure 3.6 Weights of Risk Free Asset under Different Mental Accounting Parameters for 5-year Investment

The results present the effects of different risk appetites to the portfolio selection based on different threshold return and maximum probability of failing to reach the threshold return. The yellow line with the maximum probability of failing to reach the threshold return of 20% is the highest line, which means most investment in risky asset compared with other values of probability. This can also imply that lowest threshold return and lowest maximum probability of failing to reach the threshold return results in highest risk appetite. The lowest probability of 5% is the blue line results in

lowest investment in risky asset and highest investment in risk-free asset as shown in Figure 3.5 and Figure 3.6 respectively.

Considering the threshold return, at threshold return equals -20%, the investment proportion in risky asset is higher than -15%, -10% and -5% respectively as presented in Figure 3.5. On the other hand, the investment proportion in risk-free asset is increasing with the threshold returns keep increasing when the threshold returns are increasing (less negative).

Therefore, this can be summarized that lower threshold return (more negative) results in lower investment in the risky asset and the increase in probability results in more investment in risky asset as can be shown for the threshold return of -20% and 20% of probability of failing to reach the threshold return that the investment in risky asset is high at 72.86%. The results from 5-year investment show the same trend in the investment in risky and risk-free asset as 3-year investment when applies the same mental accounting parameters.

3.4.1.3 Nine-year Investment (2009-2017)

The weights of risky and risk-free assets based on different threshold returns (H) and maximum probabilities of failing to reach threshold returns (α) for 9-year investment are presented in Table 3.7 and also Figure 3.7 and Figure 3.8 presents the different weights of risky asset under different mental accounting parameters (Threshold return and maximum probability of failing to reach the threshold return).

9 Years	**Portfolio Weight**							
H	-20%		-15%		-10%		-5%	
α	Risky	Risk Free	Risky	Risk Free	Risky	Risk Free	Risky	Risk Free
0.05	0.3072	0.6928	0.2444	0.7556	0.1813	0.8187	0.1181	0.8819
0.1	0.4090	0.5910	0.2712	0.7288	0.2414	0.7586	0.1574	0.8526
0.15	0.4907	0.5903	0.3917	0.6083	0.2996	0.7004	0.2028	0.7972
0.2	0.6404	0.3596	0.5422	0.4574	0.4026	0.5974	0.2296	0.7704

Table 3.7 Portfolio Allocation with Different Mental Account Parameters for 9-year Investment

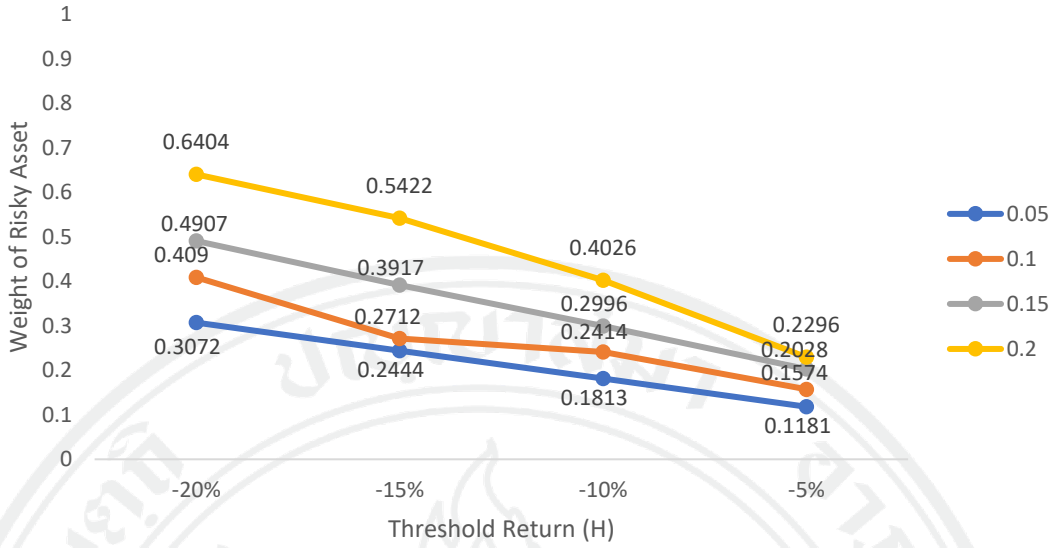

Figure 3.7 Weights of Risky Asset under Different Mental Accounting Parameters for 9-year Investment

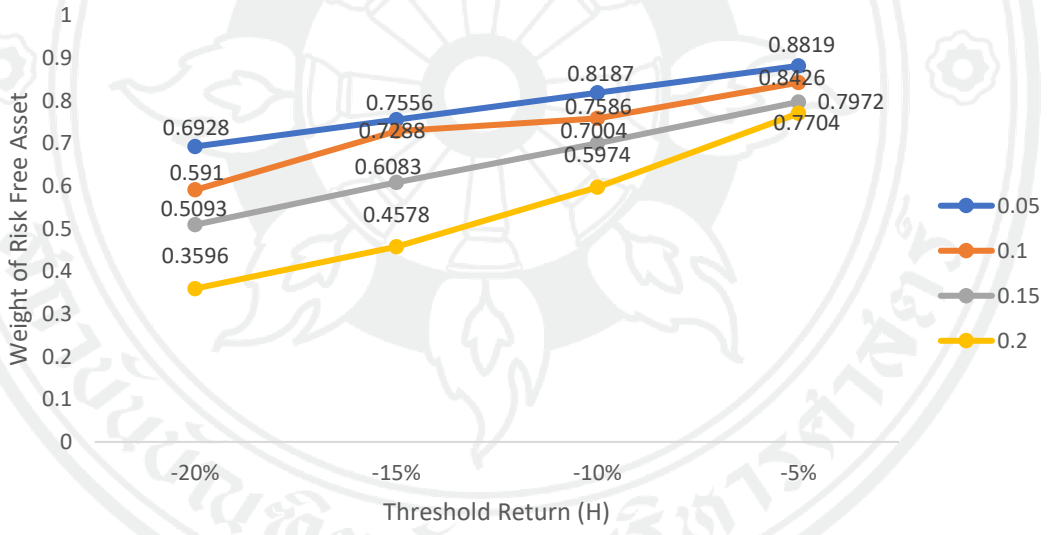

Figure 3.8 Weights of Risk Free Asset under Different Mental Accounting Parameters for 9-year Investment

The results present the effects of different risk appetites to the portfolio selection based on different threshold return and maximum probability of failing to reach the threshold return. The yellow line with the maximum probability of failing to reach the threshold return of 20% is the highest line, which means most investment in risky asset compared with other values of probability. This can also imply that lowest threshold return and lowest maximum probability of failing to reach the threshold return

results in highest risk appetite. The lowest probability of 5% is the blue line results in lowest investment in risky asset and highest investment in risk-free asset as shown in Figure 3.7 and Figure 3.8 respectively.

Considering the threshold return, at threshold return equals -20%, the investment proportion in risky asset is higher than -15%, -10% and -5% respectively as presented in Figure 3.7. On the other hand, the investment proportion in risk-free asset is increasing with the threshold returns keep increasing when the threshold returns are increasing (less negative).

Therefore, this can be summarized that lower threshold return (more negative) results in lower investment in the risky asset and the increase in probability results in more investment in risky asset as can be shown for the threshold return of -20% and 20% of probability of failing to reach the threshold return that the investment in risky asset is high at 64.04%. The results from 9-year investment show the same trend in the investment in risky and risk-free asset as 3-year and 5-year investment when applies the same mental accounting parameters.

Additionally, if consider the 3-year, 5-year and 9-year investment, the results from this study show that the investment in risky asset for longer time is less than shorter time, for example, for H = -15% and α = 5%, investment weights in risky asset equal 35.51%, 30.11% and 24.44% for 3-year, 5-year and 9-year respectively.

Considering the portfolio returns from Table 3.8 to Table 3.10, 9-year investment has greatest return for same mental accounting parameters used in this study due to much higher return of risky asset and the return of 3-year investment is a bit higher than the return of 5-year investment.

3 Years	**Portfolio Return**			
	Threshold Return (H)			
α	-20%	-15%	-10%	-5%
0.05	5.04%	4.44%	3.39%	2.82%
0.1	5.96%	5.36%	4.00%	3.22%
0.15	7.77%	6.41%	5.05%	3.68%
0.2	9.50%	7.76%	6.02%	4.28%

Table 3.8 Portfolio Return with Different Mental Account Parameters for 3-year Investment

5 Years	Portfolio Return			
	Threshold Return (H)			
α	-20%	-15%	-10%	-5%
0.05	4.65%	4.06%	3.48%	2.89%
0.1	4.77%	4.35%	3.59%	3.10%
0.15	6.37%	5.42%	3.92%	3.52%
0.2	7.20%	6.30%	5.11%	3.93%

Table 3.9 Portfolio Return with Different Mental Account Parameters for 5-year Investment

9 Years	Portfolio Return			
	Threshold Return (H)			
α	-20%	-15%	-10%	-5%
0.05	8.27%	7.01%	5.73%	4.46%
0.1	10.33%	7.55%	6.95%	5.27%
0.15	11.98%	9.98%	8.12%	6.17%
0.2	15.00%	13.02%	10.20%	6.71%

Table 3.10 Portfolio Return with Different Mental Account Parameters for 9-year Investment

3.5 DISCUSSION AND RECOMMENDATION

This research studies the effect of mental accounting behavioral bias to the portfolio allocation of the investment in Thailand. Two assets are considered, which are risky asset and risk-free asset. SET TRI is used as the proxy of the risky asset and the average return of government bond, Treasury bill and Bank of Thailand bond is used as the proxy of risk-free asset. The historical data from 2009-2017 are divided to three periods of time and applied to the mental accounting model:

1. 3 years (2015-2017) for the short-term investment
2. 5 years (2013-2017) for the medium-term investment
3. 9 years (2009-2017) for the long-term investment

Threshold return and the maximum probability of failing to reach the threshold return are the mental accounting parameters, which represent different risk appetite. The mental accounting parameters in this study are assumed to generate various scenarios to execute the scenario analysis to generate the results that can represent different behaviors and therefore, the investors can consider the scenario that suits

individual behavior for each objective of subportfolios. The mental accounting model in this study are from the study of Das et al. (2010). In the mental accounting optimization model, the total return is maximized to find the weights of risky and risk-free assets.

The results of this study present the portfolio allocation in risky and risk-free assets based on different threshold returns and risk appetites as represented by the maximum probabilities of failing to reach the threshold returns. Considering the threshold return, the increase in threshold return (less negative) results in more investment in risk-free asset. On the other hand, the increase in probabilities of failing to reach the threshold returns results in more investment in risky asset since the investors are more risk-seeking. This study also considers different time periods, which are 3 years, 5 years and 9 years to represent short-term, medium-term and long-term investment. The results in term of different time periods also show similar tendency when the threshold returns and maximum probability of failing to reach the threshold return are adjusted.

The differences of this research compared to other researches are that other researches were mostly studied in other countries but this research consider the mental accounting behavior for the investment in Thailand. Therefore, the investors in Thailand and also other countries can consider and apply this research to the individual behaviors for investment, which can make the investors realize the effect of the mental accounting. Additionally, this research can also be applied to the investment in other countries.

However, this research only studies how mental accounting parameters, threshold return (H) and probability of failing to reach the threshold return (α), affect the portfolio allocation in case that people invest in various subportfolios with different objectives based on mental accounting concept by conducting the scenario analysis. To compare with the mean-variance and to test with the real investment of the investors in the future research would also enlighten the investors regarding the effect of mental accounting behavior. Additionally, this research only considered only two assets, which are one risky and one risk-free assets but in the real investment normally, people invest in various asset. Therefore, the recommendations for future researches are 1. To compare the results with mean-variance method to see the differences of mental accounting behavior 2. To increase more assets to make it more applicable to the real investment.

CHAPTER 4

DISCUSSION AND RECOMMENDATION

This research focuses on studying the effect of behavioral bias on portfolio selection. Two theories has been studied, which are prospect theory and mental accounting theory. The results from prospect theory shows significantly different results between prospect theory and mean-variance theory where the portfolio allocation based on prospect theory will always in between the mean-variance method, which mostly invest in either risky or risk-free asset.

However, in order to make it reflect more to the real investment, the future study can increase number of assets since people normally invest in several assets not only one risky and one risk-free assets. Also, since the parameters used in this study were tested long time in the past with only the groups of students, the author would also recommend to test the parameter again with diversified groups of people e.g. various ages, occupations to be able to represent the current behavior of most investor.

Regarding the mental accounting theory, the scenario analysis by varying the mental accounting parameters is executed to observe the effect of different investment behaviors to portfolio allocation to stimulate investors to realize that to invest in various subportfolios under different criteria results in different portfolio allocation in risky and risk-free assets because of different risk appetite based on different mental accounting parameters and this finally leads to different return between subportfolios.

However, the future study should also compare with the mean-variance theory to analyze the differences between two theories and to obviously understand the effect of behavioral bias in mental accounting theory.

Finally, the author does expect that this study will be useful to everyone who is interested in the field of portfolio investment and also hope that this study can be one

of the initiatives for further development in the field of behavioral portfolio investment to enhance the awareness to the investors regarding the effect of such behavioral factor in the investment.

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BIOGRAPHY

NAME	Kumnoon Narakornpijit
ACADEMIC BACKGROUND	Bachelor of Engineering Chulalongkorn University 2009
	Master of Science Stanford University 2013
EXPERIENCES	2009 - Present Engineer PTT Public Company Limited Chatuchak, Bangkok, 10900