SENIOR RESEARCH

Topic: Behavioral Portfolio Analysis: Evidence from the Stock Exchange of Thailand

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Abstract

This research aims to integrate behavioral economics into portfolio construction methods that reflect different kind of preferences. Using data from the Stock Exchange of Thailand, I find many evidences that violate classical theory, i.e. Markowitz's Modern Portfolio Theory. While optimal efficiency frontier of risk-return tradeoff is easy to achieve theoretically, practical ways of using the data and crafting the solution suggest the opposite direction of optimal frontier. Specifically, high-risk portfolios often result in low return of that portfolio instead. The results from this research also show that market anomalies and behavioral biases do exist in the case of the Stock Exchange of Thailand. The methodologies used in this research are flexible as many things can be easily adjusted to make further study and results found leave big room for more detail investigation in the future.

Keywords: Behavioral economic, portfolio construction, market anomalies and behavioral biases.

1 Introduction

Markowitz portfolio selection theory has been a groundbreaking approach to explain how an investor should act when investing his/her money. Even though Markowitz approach can be used to find the best reward relative to risk portfolio when investing, but this approach is somewhat impractical because the combination of assets weight that gives the optimal risk to reward ratio in this period does not guarantee that the same combination of assets weight will yield the same result in the next period and in order to know exactly what is the optimal combination of asset weight of that period, investor can only find it out through the ex post process. So, instead of trying to find the optimal risk to reward portfolio for each investment period, I want to explore different aspect of financial economics, by incorporating the behavioral aspect into it and construct different type of portfolio focusing in different fields of financial economics. Contrast to the core model of financial economics and other field of economics which assume people preference to be risk aversion, Prospect theory points out that people is actually loss averse, when facing with a decrease in their wealth they feel uncomfortable and demand a much higher gain in order to offset their bad feeling, most of the time it can be as much as twofold of the loss (Kahneman and Tversky, 1992). Unlike classic expected utility theory, Prospect theory is underappreciated in the field of financial economics, even though it is a more realistic model that describe how people actually make decision, and in order to find out the most suitable investment portfolio for each investor, behavioral aspect is a very crucial ingredient that should be incorporated in. I expect that this research can capture some behavioral aspect and biases that exist in the Stock Exchange of Thailand while providing the investment strategy that is practical, objectively and subjectively satisfies investors.

The goal of this research is to construct different type of portfolios and incorporating Prospect theory as one of the subjective performance measurement of the portfolio and also using other objective performance measurement tools such as compound annual growth rate, volatility, etc., to see the tradeoffs between portfolios that focus on subjective goal and objective goal. If we measure the performance as return generated by portfolio, I hypothesize that the traditional Markowitz or the optimal risk to reward portfolio will outperform the portfolio that is construct to satisfy the loss aversion investor or trying to prevent investors from losing their money. On the other hand, if portfolio performance is measured by the “comfortability” of the investor or utility provide, portfolio with loss aversion seems more likely to outperform Markowitz traditional portfolio in this case. Even though the base hypothesis seems obvious, the interesting part of this research is the tradeoff between subjective based portfolio and objective based portfolio, how much volatility and compound annual growth rate have to be foregone to obtain the highest utility portfolio or how much utility have to be foregone to obtain the best risk and return tradeoff portfolio and will this research able to capture the behavioral biases exist in Stock Exchange of Thailand or not.

2 Literature review

Portfolio selection theory introduced by Markowitz (1952) stated that investor should not concern only the return generated by invested assets, but should also focus on its risk as well. When taking risk into account, there will be a benefit from investing in many assets rather than focusing on the only one that yield the highest return which is called diversification benefit. Diversification benefit arises when investor invests in 2 or more assets as the portfolio expected return is given by $E(R_p) = \sum_i w_i E(R_i)$,where R_P is the return on the portfolio, R_i is the return on asset i and w_i is the proportion of asset i invested in portfolio, and portfolio variance is given by $\sigma_p^2 = \sum_i w_i^2 \sigma_i^2 + \sum_i \sum_{i \neq j} w_i w_j \sigma_i \sigma_j \rho_{ij}$, where σ is the sample standard deviation, w_i is the proportion of asset i invested in portfolio, ρ_{ij} is correlation coefficient between the returns on assets i and j, the generated portfolio which composed of 2 or more assets will have lower variance than a portfolio that composed of only 1 asset, if the correlation between assets is lower than 1. The goal of Markowitz portfolio is to invest in a portfolio that yield the highest return given each level of risk or variance.

Although there are many works that seek optimal investment portfolio or the equity pricing method, but in the end they cannot really find the answer to all the financial phenomena that exist in the market. Barberis and Thaler (2002) point out that traditional models that assume agents are rational are convenient, but their predictions are not accurate and data found from the market cannot be explain under rational paradigm. Models in Behavioral finance that assume some irrationality among agents could be a way to explain those financial phenomena. Their work review the biases that are useful in the field of financial economics as some specific types of irrationality are potential answer to some unexpected phenomena that happened in the market. In my research, the market anomalies and biases found will be based on some points mentioned by Barberis and Thaler (2002) paper, but cannot cover most of its as most behavioral biases and market anomalies require specific and thorough study.

The idea of portfolio construction by Markowitz is closely related to a dominated economic theory of decision making which is expected utility theory. According to Kahneman and Tversky (1979), the expected utility theory is based on three building blocks,

1. Expectation: States that the overall utility is the combination of expected utility of each outcome. Which can be seen in the Markowitz aspect as risk to reward ratio of portfolio. A reward part is the expected return provided by portfolio, higher expected return will provide more utility to investor, on the other hand, a risk part or volatility of return of the invested portfolio is what investor dislike, lower volatility means higher utility for investor.
2. Asset integration: Integrating is preferred to one assets alone if and only if the integration provided more utility than one asset alone. Which can be seen in the Markowitz aspect as diversification benefit because investing in one more assets is preferred to focusing investment when it provides better risk and return tradeoff,

thus yield higher utility to the investor.

3. Risk aversion: A person is considered to be risk averse if he prefer a certain choice that yield return of x than a risky choice that yield expected return of x. As in Markowitz, this is the first idea that has been mentioned even though two assets yield the same return, risk should be the factor taking into account when making decision, asset that has lower risk or volatility of return is preferred over asset that has higher volatility of return if both assets has the same expected return.

Kahneman and Tversky (1979) also provide the evidences that violate expected utility theory. The problems ask to choose between 2 choices with different return and probability, the number in [ ] represent the percentage of people choosing each choice.

TABLE I

PREFERENCES BETWEEN POSITIVE AND NEGATIVE PROSPECTS

	Positive prospects			Negative prospects		
Problem 3:	(4,000, .80)	<	(3,000).	Problem 3′:	(−4,000, .80)	>	(−3,000).
$N = 95$	[20]		[80]*	$N = 95$	[92]*		[8]
Problem 4:	(4,000, .20)	>	(3,000, .25).	Problem 4′:	(−4,000, .20)	<	(−3,000, .25).
$N = 95$	[65]*		[35]	$N = 95$	[42]		[58]
Problem 7:	(3,000, .90)	>	(6,000, .45).	Problem 7′:	(−3,000, .90)	<	(−6,000, .45).
$N = 66$	[86]*		[14]	$N = 66$	[8]		[92]*
Problem 8:	(3,000, .002)	<	(6,000, .001).	Problem 8′:	(−3,000, .002)	>	(−6,000, .001).
$N = 66$	[27]		[73]*	$N = 66$	[70]*		[30]

As can be seen by the table above, when confronting with gain, people mostly behave according to expected utility theory which having a risk aversion preference, but when facing with negative gain people turn out to be more of a risk seeker and the preferred choice is a complete mirror image of the choices that offer positive return. The probability when forming an expectation seems to be overweighted if it is a certain outcome as can be seen in problem 3, while problem 4 behave according to the expectation hypothesis. Also in problem 3', it seems that certainty and higher expected value is not always preferred when it comes to loss which is contradict to the expected utility theory. Also in problem 8 and 8' provide evidences that people behave oppositely to the expected utility theory when facing with very low probability choices. As the expected utility theory has been challenged by a contradictory evidences, instead of using formal concave utility function, Kahneman and Tversky (1992) have developed S-shape utility function that better describe how people make decision. The theory has 2 main implications, first, utility function focuses on gain and loss according to the reference point, which is a point that separate gain from loss, if the reference point is said to be 1% then a value x to put in utility function is actual return minus 1%, instead of using final return of asset. In the area of gain utility function is concave just like the normal risk aversion, but in the area of loss the function become convex and much steeper than the area of gain, implying a loss aversion preference, which can be written as

$$V(x) = \begin{cases} x^{\alpha} \; if \; x \; \geq 0 \\ -\lambda(-x^{\beta}) \; if \; x \; \leq 0 \end{cases}$$

Second, this theory describe that people have biases in using probability when making decision, so instead of using actual probability when forming an expectation, people will weight each probability differently according to this equation. Where p is the actual probability.

$$w(p) = \frac{p^{\gamma}}{(p^{\gamma} + (1-p)^{\gamma})^{1/\gamma}}$$

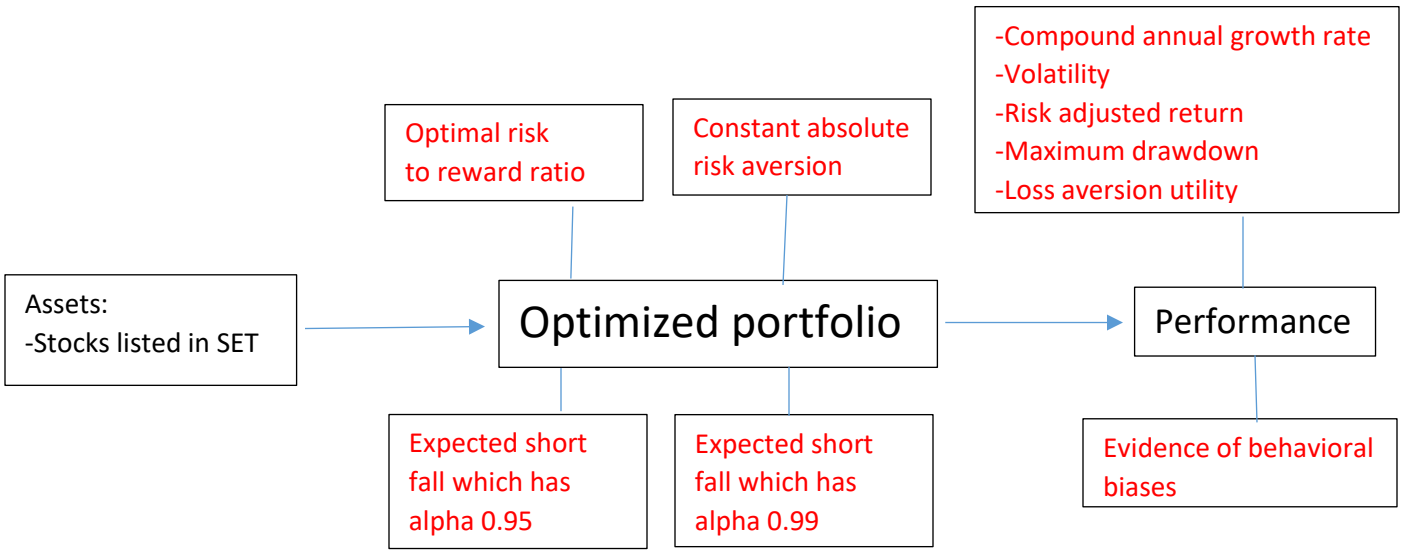
The implications of Prospect theory have been well known and considered as an important theory for behavioral finance. Shefrin and Statman (2000) have constructed a behavioral portfolio with multiple account using idea of reference point to divide investor portfolio into two parts, a part with low reference point and a part with very high reference point which is completely separated from each other in a sense of managing, but combined together to maximize the investor utility. The portfolio weight is allocated heavily to the very high reference point part, but has the idea of safety first, if the utility of the low reference point part is zero then the whole utility provided by this portfolio is also zero, but it is not the case for the high reference point part. They conclude that the optimal choice of portfolio under behavioral portfolio theory with multiple account is that the low reference point allocate most of its money to very safe security like government bond because it want to maintain the positive return while the high reference point will allocate most of its money to very risky security like lottery to maximize the chance of obtaining its high reference point wealth.

Shefrin and Statman (2000)'s finding also partly related to the finding by Barkelaar and Kouwenberg (2004) as the latter group seeks to find the optimal assets choice for portfolio with loss aversion preference. Barkelaar and Kouwenberg (2004) state that portfolio with this kind of preference has 2 stages of strategy implementation, the first is aiming at maximizing the probability of reaching the reference point and the second stage is aiming at growing the portfolio. The optimal assets choice for the investor in dynamic situation is to first buying safe security insuring that his/her wealth is positive and stay above the reference point and then the growth strategy kicks in producing demand for riskier asset to further improve their wealth, but if the risky investment goes wrong, the first strategy will get into action generates incentive for investor to invest in risky asset to increase the chance of getting back into their reference point. Both Shefrin and Statman (2000) and Barkelaar and Kouwenberg (2004) seem to agree that this type of portfolio starts with safe asset and then allocate most of its proportion to the risky one.

WERNER and SJÖBERG (2016) also use Prospect theory as an approach to find the most suitable portfolio for each investor, but instead of using the original value function by Kahneman and Tversky (1992), they use the piecewise quadratic value function by Bachmann & Hens (2011) as an optimization model for portfolio. The advantages of using piecewise quadratic function is that it provide different curvature and has a

special property when $\beta = 1$, $\alpha^{+} = \alpha^{-}$ and reference point is equal to portfolio expected return this function will create the same portfolio as mean-variance portfolio of Markowitz. WERNER and SJÖBERG (2016) also show the way to measure each parameter from the function by using questionnaire in order to produce the portfolio that optimally suit for each investor preference. In the end, they perform out of sample experiment using historical data of different asset classes from January 1999 to March 2011 to construct each optimal portfolioes and then see the perfomance of those portfolioes from April 2011 to March 2016 and find that the yearly return of those portfolioes are below the expectation, but the risk factors of those portfoilio which are maximum drawdown and standard deviation are lower than the portfolioes estimated as well, so they conclude that these portfolioes may not be the most satisfactory one, but it is still the most comfortable and most suitable for each investor as the parameters' value are consistent with their preferences.

3 Conceptual framework



The conceptual framework is based on the stages on how my research paper will be developed. First, I will define the assets that will be used to construct investment portfolio by looking into the stocks listed in Stock Exchange of Thailand. After the assets have been defined, I will proceed to the optimization process based on 4 different methods which will be discussed further in the Methodology session. Finally, we will compare the performance of each portfolio based on compound annual growth rate, volatility, risk adjusted return and utility provided and try to find the evidence of behavioral biases that shown in the results.

4 Data

The data set used is daily return from 3rd January 2001 to 3rd March 2017 of 20 stocks that have the largest market capitalization listed in Stock Exchange of Thailand in 3rd January 2001 extracted from Bloomberg terminal which are KTB, ADVANC, PTTEP, INTUCH, KBANK, THAI, BEC, TRUE, BBL, SCC, SCCC, DELTA, RATCH, EGCO, CPF, SCB, HANA, THCOM, MAKRO and BIGC. The rationale behind selection of these stocks as an investment pool is because they have large market capitalization, so their price cannot be easily manipulated through the money technique and the statistic results of these stocks have a higher chance of reflecting its true value than the smaller stocks. I also extracted the daily return of Stock Exchange of Thailand during of the same period to use as a benchmark for each portfolio. The table below present the variables that are necessary to use in this research.

Variable type	Variable	Measurement
Dependent	Assets weight	Number
Dependent	Portfolio's compound annual growth rate	Number
Dependent	Portfolio's volatility	Number
Dependent	Loss aversion utility	Number
Control	Assets return	Number
Control	Standard deviation of return	Number
Control	Coefficient correlation of return	Number
Control	Exponent when confront with loss	Number
Control	Exponent when confront with gain	Number
Control	Degree of risk aversion (CARA optimization)	Number
Independent	Gain (loss) relative to the reference point	Number

5 Methodology

The approach will be based on 4 types of optimized portfolios as mentioned in the conceptual framework session which are Constant Absolute Risk Aversion portfolio (CARA), Optimal risk to reward portfolio (Max sharpe), Conditional Value at Risk which has alpha of 95% and 99% (CVaR 95 and CVaR 99). The rationale behind each type of portfolio will be discuss later in each portfolio section.

In order to fully explore and minimize the biases from each type of portfolios, this research will use the results obtained from the optimization in 5 different ways. The first way is **simulation results**, which use the optimized portfolio weight in the investment period to invest back in that same period, so this way of analyzing the result is impractical in real world, but it can reflect the true purpose of each type of portfolio in the most accurate way. The other ways of using the results are through rebalancing of portfolio every **quarter**, **6 months**, **1 year** and **3 years** by using 5 years of data prior to the investment period, **so the first day of the investment**

period is 3rd January 2006 for every solution including simulation results, to solve for the optimal weight and using that weight to invest in the investment period. The latter ways of using the result is practical in real world situation and should be used in order to justify the desired portfolio for each criteria or **to justify the behavioral biases that exist in the Stock Exchange of Thailand**. To make the optimization results as realistic as possible, I use the commission fee of 0.157% every time rebalancing take place to reflect the fee most investors have to pay when placing orders through online channel.

The performance measurement part of each portfolio is done using 5 different criteria which are **1.Compound annual growth rate 2.Portfolio's volatility** measured in annual horizon using daily volatility multiply by $\sqrt{250}$ **3.Risk adjusted return** using sharpe ratio with risk free rate equal to 1.5% **4.Maximum drawdown 5.Loss aversion utility** using equation introduced by Kahneman, D., & Tversky, A. (1992) which is written as

$$V(x) = \begin{cases} x^{0.88} \; if \; x \geq 0 \\ -2.25(-x^{0.88}) \; if \; x \leq 0 \end{cases}$$

where x is a change in wealth compare to the reference point of each investor, but for simplicity of this research, I set the reference point to be 0 and other parameters using the median value mentioned in their paper. The first 4 measurements are the common measurement that are widely used to measure the performance of investment, but the Loss aversion utility is introduced in this research is used to capture the behavioral aspect of the investment decision and measure some of the behavioral biases shown in the result. Next section I will go through each approach of optimizing the portfolio and discuss the rationale behind them.

Constant Absolute Risk Aversion

The first type of portfolio is based on the Constant Absolute Risk Aversion approach as to see the result from classic preference utility function described in many economics related topic. To solve for the optimal weight for this type of portfolio, I use *parma* and *nloptr* packages of R. The solution can be described as

Maximize a_n: Investor utility

$$U(w) = -e^{-\lambda w}$$

Where

$$w = a_1(1 + x_1) \; + \cdots + \; a_n(1 + x_n)$$

Where U(w) is the investor constant absolute risk aversion utility, λ is investor degree of risk aversion which I set it as 3 in this solution because it is the median value as described by most paper, a_n is the proportion of asset n invested in portfolio and x_n is the return of asset n.

Optimal Risk to Reward Ratio

The second type of portfolio is the standard Markowitz portfolio optimization approach using the *parma* and *nloptr* packages of R to construct the maximum risk to reward portfolios. This solution has the purpose to see how well the standard and widely used type of optimization can perform when taking into account the loss aversion preference.

Maximize w: Portfolio's sharpe ratio

$$\frac{E(R_p - R_f)}{\sigma_p}$$

Where

$$\sigma_p^2 = \sum_i w_i^2 \sigma_i^2 + \sum_i \sum_{j \neq i} w_i w_j \sigma_i \sigma_j \rho_{ij},$$

$$\mathrm{E}(R_p) = \sum_i w_i \, \mathrm{E}(R_i)$$

Where σ is the sample standard deviation, w_i is the proportion of asset i invested in portfolio, ρ_{ij} is correlation coefficient between the returns on assets i and j, R_P is the return on the portfolio, R_i is the return on asset i and R_f is the risk free rate.

Subject to: Portfolio's maximum weight

$$\sum_{w_i} = \mathbf{1} \ , w_i \geq \mathbf{0}$$

Conditional Value at Risk

The third and fourth portfolios use Conditional Value at Risk which has alpha of 95% and 99% respectively, which are two of the three commonly used values of alpha in CVaR that are stated in Rockafellar and Uryasev (2000) research, as an optimization objective because the concept of these types of portfolios is to protect the investor from losing money not the fluctuation of the money, so it can be used to mimic the objective of loss aversion preference investor very well. Using ROI, ROML and ROMLportfolio package of R to solve for the optimal weight. The solution which are the same method used by Rockafellar and Uryasev (2000) can be described as

$$\begin{aligned} \min_{x \in \mathbb{R}^N, z \in \mathbb{R}^S, \gamma \in \mathbb{R}} \quad & \gamma + \frac{1}{(1-\alpha)} \sum_{s=1}^{S} p_s z_s \\ s.t. \quad & z_s \geq -r_s^\top x - \gamma, \\ & z_s \geq 0, \end{aligned}$$

where

γ is a level of loss that occur in each random scenario which is being minimize specific to a fix level of probability of α and can be written as

$$\gamma = \min\{\gamma \in \mathbb{R} : \alpha\}$$

z_s is a scenario where loss generated by portfolio exceed the minimize γ.

x is return generated from invested assets

p_s is a probability of scenario z_s

$-r_s^T x$ is expected loss of investment portfolio in each scenario

α is a probability that z_s not exceed γ and is initially defined in this research as 0.95 and 0.99 which can be written as

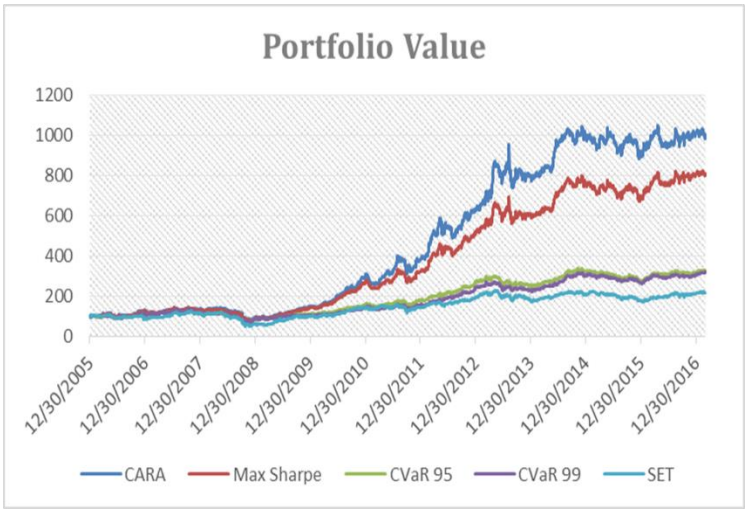
$$\alpha = \int_{-r_s^T x \leq \gamma} -r_s^T x \, \mathrm{p(x)dx}$$

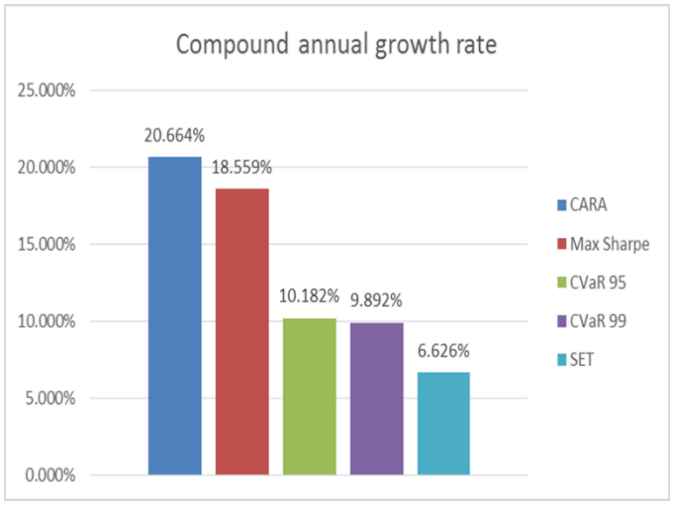
6 Results and findings

In this section, I will present and discuss about the results found using the method mentioned in the previous section which is divided into 3 subsections which are the simulation results, actual investment results and findings. The actual investment results are results found by using the optimized assets weight to invest in the next period and have different frequency of portfolio rebalancing, further information is provided in each subsection.

Simulation results

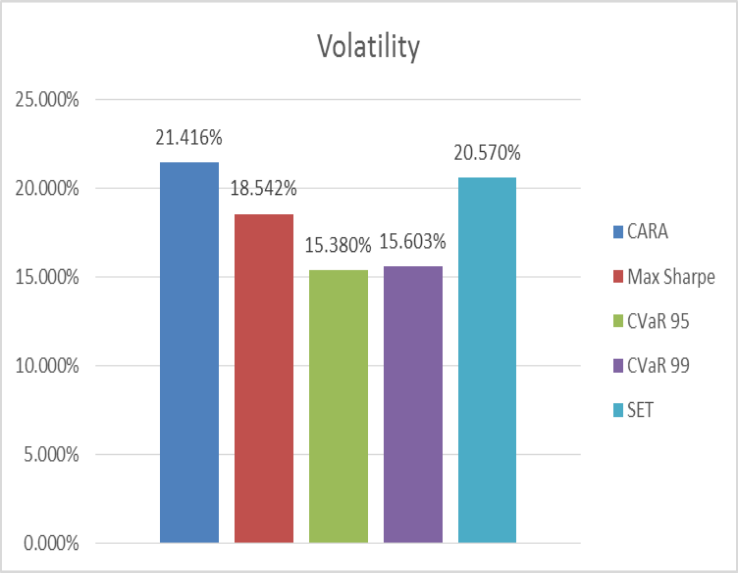
Simulation results are obtained by using the data from 3rd January 2006 to 3rd March 2017 for optimization and using the optimal weight found to invest in that same time horizon. The purpose is to see whether the coding for the optimization program works as intended or not and to see whether the optimization solutions serve it purpose or not.

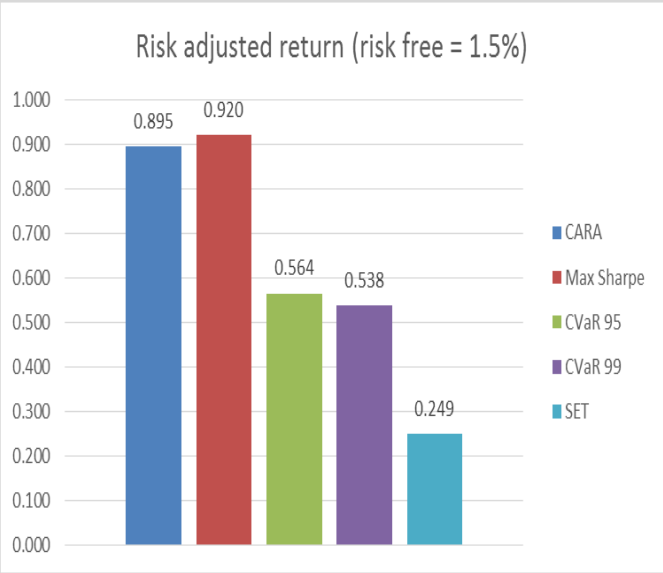




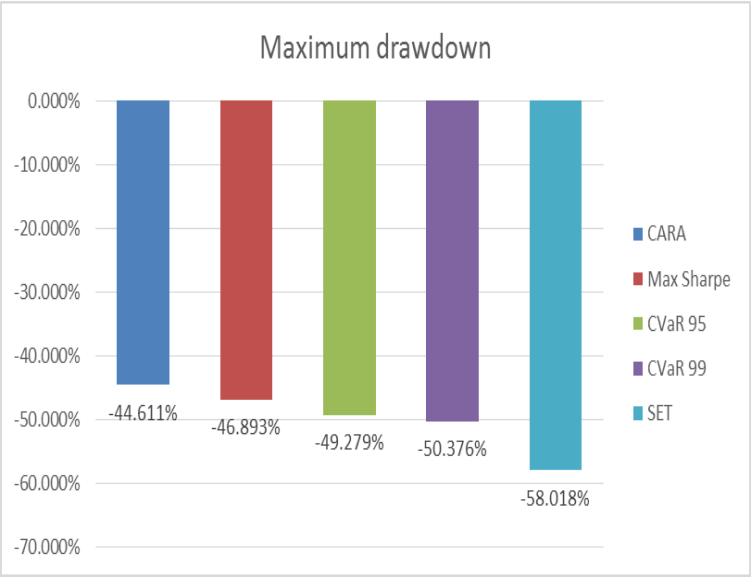
Portfolio value at the end of the investment period and compound annual growth rate show that the optimization programs are working as expected from its equations mentioned in methodology session. CARA is the portfolio that yield the highest compound annual growth rate at 20.664% and has the final value of 998.41 baht when using the initial capital of 100 baht because most of its capital are invested in MAKRO at 40.95% which is the stock that has the highest compound annual growth rate during the investment period and the rest of the capital are put into BIGC at 27.14%, DELTA at 16.92% and CPF at 14.98% which are the three stocks that have highest compound annual growth rate after MAKRO during the investment period. On the other hand, Max Sharpe portfolio which has the objective of maximize risk to reward ratio should have lower compound annual growth rate and final portfolio value than the one that focus on return like CARA which is confirmed by the result shown above. Invested assets preferred by Max Sharpe are more diversified than CARA as it invests in 6 assets which are DELTA, EGCO, CPF, HANA, MAKRO and BIGC. 4 out of 6 assets that are also preferred by CARA have very high compound annual growth rate compare to other stocks in the investment pool, so it make the reward side of the objective equation that aim at maximizing risk to reward ratio increase a lot, while EGCO and HANA are not so volatile in its nature so they are preferred in this type of portfolio in addition to the CARA type portfolio with a tradeoff of lowering the overall return, but better risk to reward ratio. Finally the CVaR 95 and CVaR 99 portfolios have the lowest compound annual growth rate among all the portfolios type as they have the purpose of minimizing expected short fall of the portfolio, so return is not the priority for them. Assets preferred by these portfolios are also the most diversified which CVaR 95 invests in ADVANC, INTUCH, BEC, SCC, RATCH, EGCO, CPF, HANA, MAKRO and BIGC a total of 10 assets while CVaR 99 preferred less asset which are ADVANC, INTUCH, DELTA, RATCH, EGCO, HANA, MAKRO and BIGC, but the compound annual growth rate of CVaR 99 is still lower than CVaR 95 which is contradict to the old traditional belief that more diversification, in this case CVaR 95 is more diversified, would yield lower

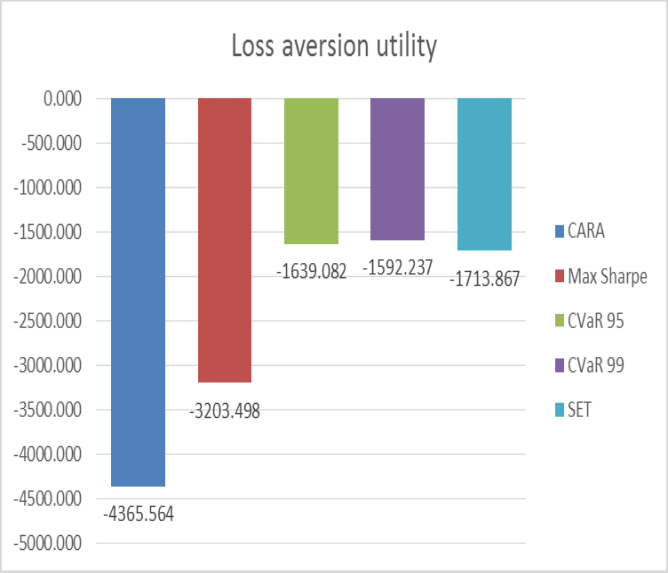
return, but it is still consistent with the CVaR equation of trying to lower the money lost. More discussion about each portfolios volatility will be made below.





Volatility and risk adjusted return also show no sign of unexpected result from the program. CARA portfolio which yield the highest return among all the portfolio types has the highest volatility and is the only portfolio that is more volatile than SET's volatility as its invested assets are the least diversify, which consist only 4 stocks, but due to its high compound annual growth rate, its risk adjusted return only a little bit less than Max Sharpe portfolio. Max sharpe portfolio which has the purpose of maximizing the risk to reward ratio has to make a tradeoff between return and volatility, so when looking into each aspect separately, it is not the one with has the highest return or lowest volatility, but the return offered per risk is the highest among all the portfolios. CVaR type portfolios with are constructed to minimize the expected loss of money also have the lowest volatility, even though the risk measurement used to construct these portfolios are different from other portfolios, this is the byproduct of the preferred optimal assets weight from the optimization program as these portfolios are more diversify and more than half of portion of the capital of CVaR 95 and CVaR 99 portfolios are put into RATCH and EGCO at 23.1% and 30.7% respectively for CVaR 95 and 20.7% and 37.6% respectively for CVaR 99 which are the two stocks that have lowest annual volatility in the investment assets pool at 24.5% for RATCH and 22.06% for EGCO. As CVaR 95's and CVaR 99's purpose are not concentrate on return when combine with their volatility result in risk adjusted return that are lower than other types of portfolios, but still significantly higher than SET as both compound annual growth rate and volatility are better than SET.





In conclusion, the simulation results do not seem to show any unexpected result even though the maximum drawdown of CVaR 95 and CVaR 99 are highest, the purpose of these types of portfolio are to minimize the expected lost that exceed the alpha quantile while maximum drawdown's concept is to capture only one highest lost in the investment horizon. Every portfolios give out negative loss aversion utility because the investment assets used are very volatile in its nature, especially when we look into its daily return, but the CVaR 95 and CVaR 99 provide significantly higher loss aversion utility than the other 2 portfolios as expected. Even though CVaR 99 portfolio has higher volatility than CVaR 95 portfolio, the loss aversion utility generated from CVaR 99 is still higher than CVaR 95's which proof that the amount of money loss of CVaR 99 during the investment horizon is lower than CVaR 95 portfolio and show that optimization program is working as intended.

Simulation results should only be used to see whether the optimization program is working as intended or not and should not be used to check for the market anomalies and biases that can possibly exist in the market because the optimal assets weights obtained from this method are invested back in the same period of the data used for optimization which is in impractical, so it cannot reflect any real world investment nature. From the results above, my optimization seems to work as intended because the optimal weight generated from each type of portfolio reflect the purpose of each portfolio very well. The results found in the next section, which is the actual investment results, will be used to determine the findings of this research which focus on the anomaly and biases that are well known in the field of finance and behavioral economic.

Actual investment results

Actual investment results are obtained through practical way of using the results found from the optimization programs. Using the data from 3rd January 2001 to 3rd March 2017 and each investment period will use the data that is 5 years prior to the investment period to solve for the optimal weight and then using the weight found to invest in the investment period, for example if the investment period starts from 3rd January 2006 to 29th December 2006 the data used to find the optimal assets' weight to invest in that period will be daily return from 3rd January 2001 to 30th December 2005. The investment period for these results start from 3rd January 2006 to 3rd March 2017, but different in frequency of rebalancing. The table below show the summary version of the result, further discussion will be made separately for each type of portfolio later. Each portfolio discuss will be presented together which their 3-Years rebalancing weight table as it is the easiest table to read and can reflect the nature of each portfolio in the long run very well, if there is some special detail in the portfolio that has higher frequency of rebalancing I will put part that has special detail of that portfolio weight table and use it to discuss the evidence found later.

	Portfolio Value	**CAGR**	**Volatility**	**Risk adjusted return**	**Maximum drawdown**	**Loss Aversion Utility**
SET	219.439	6.626%	20.570%	0.249	-58.018%	-1713.867
CARA						
3-Years rebalancing	143.015	2.964%	26.799%	0.055	-63.922%	-2297.287
1-Year rebalancing	236.231	7.270%	24.842%	0.232	-54.342%	-2921.770
6-months rebalancing	221.074	6.690%	25.955%	0.200	-55.540%	-2990.588
3-months rebalancing	268.242	8.388%	25.659%	0.268	-53.297%	-3184.417
Max Sharpe						
3-Years rebalancing	372.879	11.342%	23.261%	0.423	-53.355%	-2889.139
1-Year rebalancing	436.883	12.791%	21.202%	0.533	-46.554%	-2869.384
6-months rebalancing	383.726	11.603%	21.810%	0.463	-50.743%	-2760.033
3-months rebalancing	422.150	12.476%	21.737%	0.505	-49.647%	-2925.074
CVaR 95						
3-Years rebalancing	542.154	14.796%	17.383%	0.765	-44.422%	-2473.473
1-Year rebalancing	495.439	13.955%	16.307%	0.764	-46.254%	-2201.509
6-months rebalancing	453.075	13.127%	16.332%	0.712	-47.514%	-2135.891
3-months rebalancing	428.839	12.620%	16.233%	0.685	-47.790%	-2070.840
CVaR 99						
3-Years rebalancing	592.650	15.634%	17.569%	0.804	-43.665%	-2602.238
1-Year rebalancing	389.355	11.736%	16.703%	0.613	-48.178%	-2012.821
6-months rebalancing	363.073	11.100%	16.974%	0.566	-48.630%	-2006.859
3-months rebalancing	367.727	11.216%	16.664%	0.583	-49.261%	-1953.171

CARA

3 Years portfolio

	KTB	ADVANC	PTTEP	INTUCH	KBANK	THAI	BEC	TRUE	BBL	SCC
3rd Jan 2006 – 30th Dec 2008			0.2308							0.7692
5th Jan 2009 – 30th Dec 2011										
4th Jan 2012 – 30th Dec 2014										
5th Jan 2015 – 3rd March 2017								0.1777		

	SCCC	DELTA	RATCH	EGCO	CPF	SCB	HANA	THCOM	MAKRO	BIGC
3rd Jan 2006 – 30th Dec 2008										
5th Jan 2009 – 30th Dec 2011									0.3022	0.6978
4th Jan 2012 – 30th Dec 2014					0.9003					0.0997
5th Jan 2015 – 3rd March 2017		0.0024						0.1333	0.5442	0.1425

The actual investment results of CARA portfolio are not consistent with the hypotheses made in the introduction section, which speculated that the portfolio which has the purpose of generating high return rather than lowering the volatility of the investment portfolio would have highest compound annual growth rate compare to every type of portfolios. Objective speaking, CARA type portfolios have the poorest performance among all types of portfolio because they have the lowest compound annual growth rate in every methods of rebalancing, which 3-Years rebalancing method is the only investment portfolio that has lower compound annual growth rate than SET's compound annual growth rate, their volatilities are also very high, highest among all the portfolios used, as well as their maximum drawdown. The results are very contradict to the simulation result which showed that CARA type portfolio has the highest compound annual growth rate and lowest maximum drawdown, the simulation result also show a point that support the traditional belief of high risk investment portfolio will generate high return, but the actual investment result proof traditional belief wrong as CARA type portfolio has the highest volatility among all the type of portfolio, but their return are also the lowest as well.

I suspect that the poor performance of CARA type portfolio is due to the data used to find the optimal assets weight. The look back period of the data is 5 years before the actual investment take place as well as when the rebalancing occur which is a very long period of time for the daily return data. As discussed in the simulation results section, CARA type portfolio optimization programing is likely is to choose the assets that yield very high return during the data period used, if during that 5 years of data one stock have 1 years which yield very high return and then the price of that one stock just doesn't go up or down very much, but when averaging out the return to compound annual growth rate term it is still higher than other assets in investment

assets pool, that stock is likely going to be picked by CARA optimization program even though the slow price movement in the period after its high return may indicate the signal of price going down afterward. The look back period of 5 years is too long for this type of optimization as discussed earlier that the return generated during that time period is not up to date and the momentum of that stock price movement is likely to be over before the actual investment start.

The evidence of not up to date stock return can be clearly seen from the 3-Years rebalancing portfolio of CARA as it utilize the 5 years looking back data for 3 years and generated the poorest performance, for example the first investment period of this portfolio take place during 3rd January 2006 to 30th December 2008 and has the optimal weight of assets preferred by this portfolio are 23.08% on PTTEP and 76.92% on SCC. During the data period (3rd January 2001 to 30th December 2005) PTTEP has a total compound annual growth rate of 36.397% while SCC has 53.967%, but during the actual investment period the compound annual growth rate of PTTEP is only 3.682% which is almost ten times lower than the data period and SCC compound annual growth rate is very depressing at -25.39% which is a big reversal from its data period. Stocks that used to perform very well in the past does not confirm that it will perform at the same rate or better in the future. It is highly possible that stocks return will be the opposite of what it used to be if its return used to be very high in the past long run period (5 years is long enough for to be considered as "long run") as confirmed by the evidence of optimal assets weight preferred by 3-years rebalancing CARA portfolio when one asset is highly preferred in one investment period, it will not be preferred in the next period of investment or the next 3 years, even if it is preferred the weight put are very small compare to the period before as can be seen from SCC during the first investment period (3rd January 2006 to 30th December 2008) which is preferred at 76.92% of the total capital and 0% for the rest of the investment period available, BIGC which is highly preferred in the second investment (5th Jan 2009 to 30th Dec 2011) period at 69.78% is preferred only 9.97% in the next period and CPF which is preferred at 90.03% in the third investment period (4th Jan 2012 to 30th Dec 2014) is not preferred in the next period like SCC's case. This reverse in return of stocks is an evidence of **long-term return reversal** market anomaly which I will discuss further in detail in the biases and market anomalies section..

CARA type portfolio is more suitable with data set that is shorter and have high frequency of rebalancing as can be seen from the CARA portfolio that has 3 months rebalancing horizon, its objective performance is much better than the 3-years rebalancing one as its suffer less from not up to date stock return data, for example its first investment period start from 3rd January 2006 to 31st March 2006 has the same preferred assets weight as the first period of 3-years rebalancing type because the data set used has the same time horizon (3rd January 2001 to 30th December 2005) the compound annual growth rate during the actual investment period of both PTTEP and SCC are at 74.865% and -17.995% which is much better than compound annual growth rate of the 3-years rebalancing type even though both of them used the same data set, but do keep in mind that compound annual growth rate of invested assets in the first investment period of 3-months

rebalancing portfolio are calculated using only 3 months of data. Shorter looking back data can increase the possibility of maintaining stock price trend during the investment period and high frequency of portfolio rebalancing also work as a data updater which make the investment portfolio react faster to change in stock price movement, but the question of how long the period of looking back and how often the CARA portfolio should be rebalanced that are the most optimal needed further investigation and not in the scope of this research. The results obtain from CARA type portfolio also show that its optimal weight are highly sensitive to changes in factors as I did not use the optimal weights to invest in the same period like the simulation result and the results obtained by changing investment period just collapse the results and show very opposite result from what is expected in the first place.

Max Sharpe

3 Years portfolio

	KTB	ADVANC	PTTEP	INTUCH	KBANK	THAI	BEC	TRUE	BBL	SCC
3rd Jan 2006 – 30th Dec 2008		0.0184	0.1830						0.0217	0.3518
5th Jan 2009 – 30th Dec 2011		0.0065	0.0065							
4th Jan 2012 – 30th Dec 2014		0.0188					0.0217			
5th Jan 2015 – 3rd March 2017		0.0420		0.0141				0.0600		

	SCCC	DELTA	RATCH	EGCO	CPF	SCB	HANA	THCOM	MAKRO	BIGC
3rd Jan 2006 – 30th Dec 2008	0.0333		0.2562	0.0410					0.0118	0.0828
5th Jan 2009 – 30th Dec 2011									0.2969	0.6901
4th Jan 2012 – 30th Dec 2014					0.5820				0.1783	0.1992
5th Jan 2015 – 3rd March 2017		0.1385		0.2293			0.0226	0.0874	0.2882	0.1179

The actual investment results of Max sharpe portfolio also show unexpected results from the hypotheses made in the introduction of this research because Max sharpe is the portfolio type that seeks the highest risk adjusted return. The actual investment results show that Max sharpe portfolio always rank at the 3rd in term of risk adjusted return unlike its counterpart simulation result that have significantly higher risk adjusted return than other type of portfolio. Max sharpe portfolios still have high compound annual growth rate when compare with other type of portfolio, but their volatilities are also very high as well. One can see that Max sharpe portfolio nature is like a middle point between CARA portfolio and CVaR portfolio, where CARA is more likely to focus more on return of stocks rather than its volatility while CVaR only try to minimize the loss of invested money. The actual investment results of Max sharpe also have the same bad trait of CARA actual investment result as can be seen from high volatility of the investment period, but the return during the

investment period is still not the highest like CARA case which is another evidence that proof the traditional belief that mention about high risk investment will generate high return wrong. Part of the problem that make risk adjusted return of Max sharpe so low is due to its nature which is partly the same as CARA portfolio, this problem can be seen from the yellow highlighted cell in the table above, the largest portion of capital in each period are put into the same asset that is the most preferred by CARA portfolio in that same period, but with less amount than CARA.

Even though the actual investment results of Max sharpe portfolios are not as being hypothesize in the first place, but their objective performance are not as bad as the performance of CARA portfolio, and the results do not show any sign of how to improve performance of this type of portfolio unlike CARA that has evidence which point to the time horizon of data used to do optimization and frequency of portfolio rebalance can be adjusted to make performance better. Unlike CARA, Max sharpe portfolios preferred more diverse invested assets, for example in the first investment period (3rd January 2006 to 30th December 2008) of 3-years rebalancing portfolio assets preferred by CARA consist only PTTEP and SCC which put more weight into SCC as it has the highest compound annual growth rate during the data used period, but Max sharpe is more diversified because it preferred 9 assets during the same period which are ADVANC at 1.84%, PTTEP at 18.30%, BBL at 2.17%, SCC at 35.18%, SCCC at 3.33%, RATCH at 25.62%, EGCO at 4.10%, MAKRO at 1.18% and BIGC at 8.28%. The biggest portion of Max sharpe's capital are also put into SCC like in CARA case because compound annual growth rate of SCC in the data period is so high that it can improve the risk adjusted return a lot, but the amount put into is still two time smaller than CARA. Unlike CARA, the second largest portion of capital of Max sharpe is not put into PTTEP, but put into RATCH instead because RATCH has annual volatility of 25.37% while PTTEP has much higher annual volatility at 32.31%.

The performance of Max sharpe is better because the assets preferred are not as concentrated as preferred by CARA, when one stock price drastically goes down Max sharpe portfolio will suffer less than CARA, Max sharpe also not highly focus on the return of assets as CARA does, which will have an effect of long-term return reversal anomaly and will damage the return of portfolio in the actual investment period as discussed in CARA section before, result in the overall actual investment performance of Max sharpe better than CARA. Max sharpe portfolio value at the end of the first investment period for 3-years rebalancing type is at 80.57 baht while CARA portfolio value is at 54.97 baht as it suffer less from the bearish period of SCC due to more diverse invested assets.

CVaR 95

	KTB	ADVANC	PTTEP	INTUCH	KBANK	THAI	BEC	TRUE	BBL	SCC
3rd Jan 2006 – 30th Dec 2008		0.054	0.136				0.079			0.009
5th Jan 2009 – 30th Dec 2011		0.035								0.095
4th Jan 2012 – 30th Dec 2014		0.076		0.077			0.007			
5th Jan 20015 – 3rd March 2017		0.032	0.031	0.078					0.040	

	SCCC	DELTA	RATCH	EGCO	CPF	SCB	HANA	THCOM	MAKRO	BIGC
3rd Jan 2006 – 30th Dec 2008	0.125	0.017	0.201	0.062	0.094				0.082	0.142
5th Jan 2009 – 30th Dec 2011			0.130	0.113	0.178		0.065		0.085	0.300
4th Jan 2012 – 30th Dec 2014		0.003	0.223	0.255	0.156		0.014		0.101	0.088
5th Jan 2015 – 3rd March 2017	0.042	0.021	0.320	0.292			0.121		0.023	

The actual investment results of CVaR 95 portfolios are also not consistent with the value found in simulation result just like the other portfolios mentioned before. Although the actual investment results of CVaR 95 are different from the simulation result, some objective value is better than what is found from simulation result which is different from CARA and Max sharpe portfolios because those portfolios have poorer objective performance when test using the actual investment method. The only objective value that is poorer, for CVaR 95 case, is volatility. Improvement in objective value does not suggest that the optimization program should not be used as a mean of portfolio construction or the program was not working as intended because the loss aversion utility generated from the actual investment results increase in every case which can be used to conclude that the amount of money loss during the actual investment period is higher than the simulation result portfolio and the main purpose of CVaR 95 still hold in the simulation result. Objective speaking, CVaR 95 portfolios are the best type of portfolio in every method of rebalancing because it has the highest compound annual growth rate, lowest volatility which result in highest risk adjusted return and maximum drawdown is also the lowest except for 3-years rebalancing method which CVaR 99 has better objective values except for volatility of CVaR 99 which is a little bit higher. This superior performance of CVaR 95 portfolio also indicate that portfolio with low volatility can achieve higher return than portfolio with high volatility, in this case CARA and Max sharpe portfolios.

CVaR 95 portfolio preferred assets are the most diversify among every types of portfolio as can be seen from the table above during the investment period (3rd January 2006 to 30th December 2008), CVaR 95 portfolio has 11 preferred assets which are ADVANC at 5.4%, PTTEP at 13.6%, BEC at 7.9%, SCC at 0.9%, SCCC at 12.5%, DELTA at 1.7%, RATCH 20.1%, EGCO 6.2%, CPF at 9.4%, MAKRO at 8.2% and BIGC at 14.2%. Low volatility of CVaR 95 is likely due to its nature of choosing assets weight as it choose the most variety assets among other types of portfolio, the portion of capital invested in each assets is also very different

from CARA and Max sharpe as CVaR 95 portfolio show no sign of asset concentration, no asset is invested more than 32% of the total portfolio capital, unlike CARA and Max sharpe which their results show that some period asset concentration can be more than 50% of the total capital and can go as high as 90% which cause the total volatility of the whole portfolio to be very high.

The actual investment results show a clear trend that CVaR 95 portfolio can perform better objectively the longer investing period is when using optimal weight produced by the data used, this finding can be seen from the summary table above as 3-months rebalancing portfolio has the lowest objective performance in every value aspect, 6-months rebalancing portfolio has better performance than 3-months rebalancing method, but lower objective value than 1-year rebalancing method and 3-years rebalancing method has the best objective performance. This result of long run performance improvement of CVaR 95 portfolio is like a counterpart of CARA **long-term return reversal**, which cause by a return of stock that used to be very high in the past long run and then follow by bad return in the next long run period, CVaR 95 long run performance improvement's reason is harder to explain than CARA because there are many factors that are considered in the optimization process of CVaR and the process is much more complex. Further study can be made to find the reason for the long run performance improvement for this type of portfolio and to find optimal investment period together with the suitable return looking back data set. At the moment I speculate that improvement in long run performance is an opposite reason from the **long-term return reversal**, stock that does not cause investor to lose large amount of money, but does not have high return at the same time have a possibility that it will generate high return in the long run, the reason why I make this speculation will be discussed more in CVaR 99 section.

CVaR 99

3 Years portfolio

	KTB	ADVANC	PTTEP	INTUCH	KBANK	THAI	BEC	TRUE	BBL	SCC
3rd Jan 2006 – 30th Dec 2008		0.051	0.168				0.073			0.009
5th Jan 2009 – 30th Dec 2011						0.058				
4th Jan 2012 – 30th Dec 2014		0.087		0.165						
5th Jan 2015 – 3rd March 2017		0.074	0.110							

	SCCC	DELTA	RATCH	EGCO	CPF	SCB	HANA	THCOM	MAKRO	BIGC
3rd Jan 2006 – 30th Dec 2008		0.017	0.105	0.027	0.121				0.122	0.307
5th Jan 2009 – 30th Dec 2011			0.117	0.215	0.026		0.043		0.137	0.405
4th Jan 2012 – 30th Dec 2014			0.242	0.250			0.041		0.215	
5th Jan 2015 – 3rd March 2017	0.104	0.022	0.207	0.372			0.078		0.034	

CVaR 99 is once again a portfolio that show no consistency between the simulation result and actual investment result because the objective values of CVaR 99 portfolio are very different from its simulation result. Like CVaR 95, different in objective values of CVaR 99 indicate an improvement in overall portfolio performance except for volatility which has only one objective value that is worse than the simulation result. These inconsistency of results in every type of portfolio lead to a conclusion that the optimal assets weight which serve the purpose of each type of portfolio are very sensitive to a change in investment period because it is the weights that are optimal during the data set period, but I use those weight to invest in the next period, in the actual investment period instead, so the obtained weights are not necessary the optimal weights. CVaR 99 has the highest return and risk adjusted return when invest in the long run (3-years rebalancing method) and the improvement in long run performance is much higher than CVaR 95 as a different between objective values of 1-year rebalancing portfolio and 3-years rebalancing portfolio is larger, compound annual growth rate increase by 3.898% and risk adjusted return increase by 0.191 while CVaR 95 has compound annual growth rate increase by 0.841% and risk adjusted return only increase by 0.001.

The nature of CVaR 99 portfolio is closely related to the CVaR 95 as the base equation is the same only some parameter is changed. CVaR 99 preferred assets are less concentrated than CVaR 95 as can be seen for example from the first investment period of 3-years rebalancing method (3rd Jan 2006 to 30th Dec 2008) CVaR 99 has 10 preferred assets while CVaR 95 has 11 preferred assets with a different that SCCC is preferred by CVaR 95, but CVaR 99 preferred assets are still more diversified than CARA's and Max sharpe's. Weights preferred by 3-months rebalancing method of CVaR 99 also show that the optimization method is not very sensitive to small changes in return of data set as can be seen from the table below.

	SCCC	DELTA	RATCH	EGCO	CPF	SCB	HANA	THCOM	MAKRO	BIGC
2nd Jul 2009 – 30th Sep 2009			0.203	0.241			0.084		0.125	0.346
1st Oct 2009 – 30th Dec 2009			0.203	0.241			0.084		0.125	0.346
4th Jan 2010 – 31st Mar 2010			0.203	0.241			0.084		0.125	0.346
1st Apr 2010 – 30th Jun 2010			0.203	0.241			0.084		0.125	0.346

The preferred assets weights are the same in 4 consecutive investment periods, this is the longest period of time that the weights preferred are the same, but there are many periods that have same weights preferred consecutively, out of 45 investment period for 3-months rebalancing method, there are 21 periods that have the same assets weights preferred more than one period. This finding show that a small change in data used cannot change the result of the optimal weight, the reason can be the loss that exceed alpha quintile of portfolio cannot be reduce further given the change in data set of stock return of the data set because it is not impactful enough to reduce the loss suffer facing investment portfolio. CVaR 99 portfolio also show a clear trend of performance improvement when investing in long run, just like CVaR 95, but the trend is much stronger as can be seen from

the improvement of objective values from 1-year rebalancing method to 3-years rebalancing method. CVaR 99 portfolio way of minimizing the loss that exceed alpha quintile is more extreme than CVaR 95 as it leave the room of only 1%, theoretically speaking CVaR 99 is safer than CVaR 95 in term of protecting the amount of money loss. I hypothesize that this safer approach of finding optimal assets weights resulted in a high return of the selected assets in the long run because CVaR 95 optimization objective is the same as CVaR 99, but less extreme and show the improvement of long run performance while CVaR 99 show the same direction of long run performance improvement, but with higher values change. Further study has to be made in order to know if my hypotheses hold or not and to get more insightful reason of why does it happen, but as for the scope of this study I will leave this finding of long term performance improvement at this stage.

Biases and market anomalies found

The results show evidence of market anomaly which is **long-term return reversal** and behavioral bias which is **myopic loss aversion**. The long-term return reversal anomaly is first found by De Bondt and Thaler (1985) as they made an attempt to predict market overreaction base on 2 hypotheses 1) Extreme movement in stock price will be followed by opposite price movement later 2) More extreme initial price movement will make the later adjustment more extreme as well. By using 3 years of looking back data, De Bondt and Thaler (1985) constructed 2 portfolios of winner and loser, winner portfolio is a portfolio of 35 stocks in NYSE that yield the highest cumulative return from the data period while the loser portfolio is constructed through 35 stocks in NYSE that yield the lowest cumulative from the data, and compare the average return of those portfolios 3 years subsequent to the looking back data period. They found that loser portfolio yield higher return than the winner portfolio by about 25 percent at the end of sample period, even though the winner portfolio has significantly higher volatility than the loser portfolio.

The long-term return reversal can be clearly seen from the actual investment result of CARA portfolios as its optimal assets' weights are generated using the stocks that yield high return from the past 5 years (data set period). Consistent with result found by De Bondt and Thaler (1985), 3-years rebalancing method of portfolio construction of CARA type portfolio show clear evidence of long-term return reversal because its compound annual growth rate generated from the whole investment horizon is the lowest, which in this case 3 years per investment period and is also a long enough time to be considered as long term by by De Bondt and Thaler (1985), and the asset that is put a lot of capital into in one period will not be heavily invested as much or preferred by the optimization program in the next investment period which indicate that the return of that asset is very low during the investment period and not as high as it used to be before the investment period (data set period). Even though CARA type portfolios have the highest volatility among all the type of portfolio used in this research, its returns do not turn out to be the highest like what is found by De Bondt and Thaler (1985). I hypothesize that behavioral biases cause the stock to undergo a price cycle of boom and bust, the stock that used to perform very well in the past usually perform poorly in longer run. If the window of looking back is smaller

than 5 years and higher frequency of portfolio rebalancing is used, CARA portfolio will possibly be able to yield more impressive result as it will suffer less from long-term return reversal anomaly.

The other finding is the myopic loss aversion bias which mention about poor decision making of investors who evaluate their portfolio frequently. Myopic loss aversion is defined by Thaler et al. (1997) as a combination of loss aversion preference that makes investor more sensitive to loss than to gain and myopia which is a short framing of decision and short framing of outcome. The chance of observing a loss is higher when frequency of performance evaluation is higher, so overtime, investor who exhibit myopic loss aversion bias will be more attracted to investment that has smaller loss per time than the one which has higher expected return over the whole investment horizon, but the loss of that investment is tend to be higher per time. This bias is found by calculating the loss aversion utility generated from daily return, weekly return and monthly return of CVaR 99 portfolio which has 3-years rebalancing frequent as it is the portfolio that yield the highest objective outcome and compare it with loss aversion utility generated from daily, weekly and monthly return of SET index.

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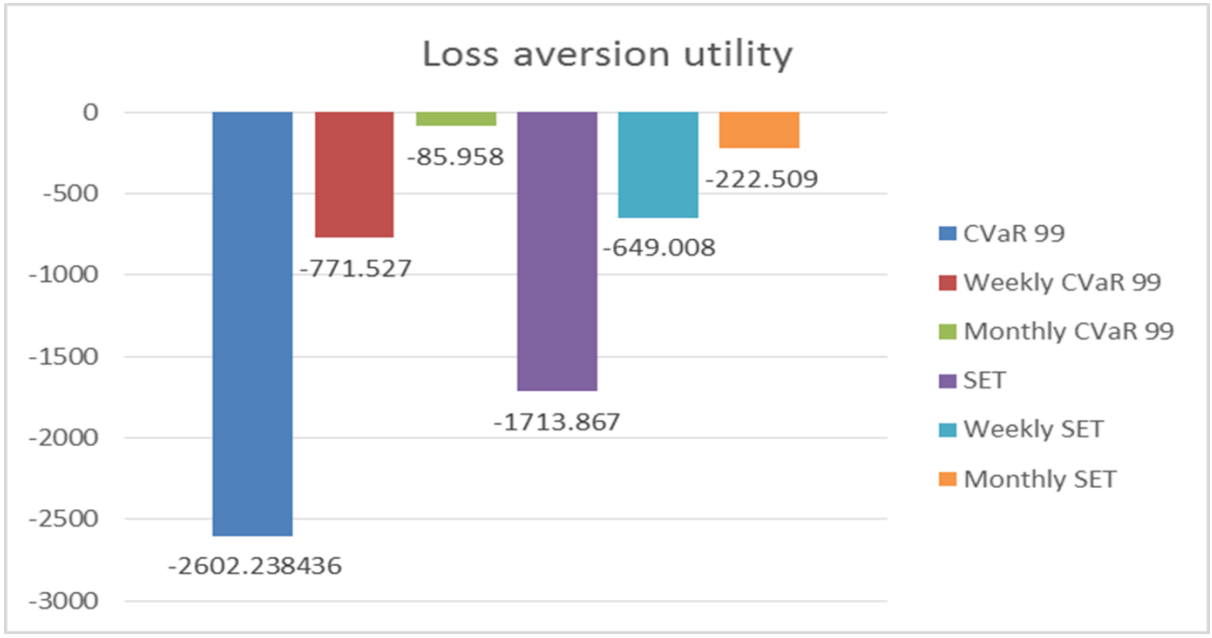

As can be seen from the bar chart, if the performance evaluation is not done in a monthly manner, investor will choose to invest in SET index instead of CVaR 99 portfolio as the SET index yield higher utility than CVaR 99 portfolio which will lead investors to have poor objective performance. Amount of loss investor that investor has to take each time from SET is tend to be lower than the one generated from CVaR 99 because the CAGR of SET is lower, so the total asset of the portfolio that invests in SET is lower than CVaR 99. 1% loss from SET portfolio is smaller than 1% loss from CVaR 99 in term of absolute asset value, which cause SET portfolio to be more attractive to myopic loss aversion investor than CVaR 99 portfolio.

The results found using the actual investment method are interesting, CARA which is the portfolio that yields the highest return in the simulation results always yield the lowest return, have the highest volatility, lowest risk adjusted return and highest maximum drawdown which is not as appeal as its simulation counterpart. While CVaR 95 which has the lowest volatility in the simulation results usually perform the best except in the 3-years rebalancing method. In simulation results, it may be true that high risk will always yield high reward like what CARA show, but in the actual investment situation, we can never know the optimal weight and optimal frontier of the assets that will make the theory of high risk high reward hold becase optimal weight and optimal frontier of any portfolio can only be obtained through the ex post process, which already provide the return of each assets during that period, like the simulation technique.

7 Conclusion and further development

This research has developed a way to integrate behavioral aspects into a field of financial economics using different kind of portfolios to reflect different belief and preference in economics which are constant absolute risk aversion, optimal risk to reward ratio and conditional value at risk. Each portfolio serves it purpose very well in the test environment, but the results from real investment environment are significantly different from their initial objectives which proof that optimal assets weights are very sensitive to change in time horizon, the assets weights that used to serve its purpose very well are not necessary serve the same purpose well in other period. Even though the results obtained from the actual investment method are unexpected, it still provide a good amount of useful information which suggest that portfolio that has low volatility in theory, in this case the CVaR 95, has high chance of outperforming the portfolio that has high volatility and expected return in theory, in this case CARA, when doing actual investment. The results of safe type portfolios (CVaR 95 and CVaR 99) exhibit a trend that the objective performance can be improved if the optimal assets weights suggested are used for long run investment, but the question of what should be the optimal investment period and optimal looking back data period for this type of portfolio need further study. The results found also prove that behavioral bias and market anomaly exist in Stock Exchange of Thailand as it point out to the long-term return reversal and myopic loss aversion bias. The long-term return reversal is found from the poor performance of long term investment in CARA portfolio because this type of portfolio seem to perform better when rebalancing occur frequently, the question of what is optimal rebalancing period for this type of portfolio and should the looking back data be shorter or not if investor wants to improve the performance of this portfolio also need further study like the CVaR portfolios' case. I believe more biases can be found, if further study is made.

Further development of this research could be made by incorporating the loss aversion utility itself to the optimization program which would be able to provide a more insightful information about the behavioral aspect and more suitable portfolio for investor. Other improvements could be also made by changing the parameter of

the optimization solutions to reflect different preferences or change the investment assets pool to see the effect of market capitalization on stock price also has a potential to find different conclusion from this research as well.

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