COMMODITIES AND THE LOSS AVERSION

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Abstract

Commodity investment has become a popular asset class from the beginning of the 2000s because of their diversification characteristics. Their returns usually have low or negative correlation with the returns of traditional financial assets. This study extended the boundary of researches in commodity investment by applying the Prospect Theory in to the study. The theory suggests that investors are loss-averse. They view gains and losses differently and they are risk averse to the gain and risk seeking in the loss. In this paper, optimal portfolios were estimated for the loss-averse investor according to the Prospect Theory with respect to different degrees of loss aversion. Full-scale optimization allows the author to examine the proportion of portfolio that should be invested in commodities to maximize expected utility. Then, optimal portfolios with commodities were compared to the optimal portfolios that contain only traditional assets to see whether the investment in commodities can enhance portfolio performance. The findings indicated that commodities were attractive among loss-averse investors during the economic downturns and inflationary period. In financial market crisis, investors see commodities as a hedge against inflation and switch their investment from stocks and bonds to commodities with an expectation that the price of commodities increase with inflation. Although all types of commodities in this study become a significant part of the optimal portfolio during inflationary periods, futures contract on gold and physical gold investment are the two types of commodities that maximize optimal portfolio performance when added to the portfolio.

Keywords: Alternative investment, Commodity, Prospect Theory, Loss aversion, Expected Utility, Full scale optimization.

บทคัดย่อ

สินค้าโภคภัณฑ์เป็นสินทรัพย์ที่ได้รับความนิยมมากในกลุ่มนักลงทุนตั้งแต่ช่วงต้นศตวรรษ21เป็นต้นมาเนื่องจากเป็นสินทรัพย์ที่มีคุณสมบัติในการช่วยกระจายความเสี่ยงของกลุ่มหลักทรัพย์ได้เป็นอย่างดี โดยค่าความสัมพันธ์ระหว่างผลตอบแทนของสินค้าโภคภัณฑ์และผลตอบแทนของหลักทรัพย์ทางการเงินอื่นๆมักจะมีค่าต่ำหรือน้อยกว่าศูนย์ บทความนี้ได้พัฒนาต่อจากงานวิจัยที่มีมาก่อนหน้าเกี่ยวกับการลงทุนในสินค้าโภคภัณฑ์โดยนำทฤษฎีความคาดหวัง (Prospect Theory) มาประยุกต์ใช้ ทฤษฎีความคาดหวังนี้เสนอว่านักลงทุนกลัวการสูญเสีย และแต่ละคนประเมินค่าความขาดทุนและผลกำไรต่างกันนักลงทุนต้องการหลีกเลี่ยงความเสี่ยงเมื่อเผชิญหน้ากับผลกำไร แต่จะยินดีที่จะลองเสี่ยงเมื่อเผชิญหน้ากับการขาดทุนเพราะพวกเขาเชื่อว่าความเสี่ยงอาจทำให้ขาดทุนน้อยลงได้ ในการศึกษาครั้งนี้ ผู้วิจัยได้สำรวจกลุ่มหลักทรัพย์ที่เหมาะสมที่สุด (Optimal Portfolio) สำหรับนักลงทุนที่มีระดับการกลัวการสูญเสียต่างๆกันตามเงื่อนไขของทฤษฎีความคาดหวังโดยมีการหาค่าที่เหมาะสมที่สุดแบบเต็มกำลัง (Full Scale Optimization) เพื่อให้ได้ค่าอรรถประโยชน์ที่คาดหวัง(Expected Utility)สูงสุด เพื่อวิเคราะห์ว่ากลุ่มหลักทรัพย์ที่ให้อรรถประโยชน์สูงสุดนั้นควรรวม

สินค้าโภคภัณฑ์อยู่ด้วยหรือไม่ และถ้ารวมควรมีสัดส่วนเท่าใด นอกจากนี้การศึกษานี้ได้เปรียบเทียบสมรรถนะของกลุ่มหลักทรัพย์ที่มีการลงทุนในสินค้าโภคภัณฑ์กับสมรรถนะของกลุ่มการลงทุนแบบดั้งเดิมที่มีเพียงสินทรัพย์ทางการเงินเท่านั้นเพื่อวิเคราะห์ว่าการรวมสินค้าโภคภัณฑ์ช่วยเพิ่มสมรรถนะของกลุ่มการลงทุนหรือไม่การศึกษานี้พบว่าสินค้าโภคภัณฑ์ได้รับความสนใจอย่างมากในกลุ่มนักลงทุนที่กลัวการสูญเสียในช่วงเวลาที่เศรษฐกิจถดถอยและในช่วงเงินเฟ้อ โดยนักลงทุนมองว่าสินค้าโภคภัณฑ์เป็นช่องทางในการบริหารความเสี่ยงต่ออัตราเงินเฟ้อเนื่องจากราคาของสินค้าโภคภัณฑ์นั้นจะปรับตัวไปในทิศทางเดียวกับอัตราเงินเฟ้อ ในจำนวนสินค้าโภคภัณฑ์หลายชนิดที่นำมาศึกษา พบว่ามีเพียงสัญญาซื้อขายทองคำล่วงหน้าและทองคำ ที่เป็นสินค้าโภคภัณฑ์ที่สามารถเพิ่มสมรรถนะของกลุ่มหลักทรัพย์ได้เมื่อนำเข้าไปเพิ่มเป็นส่วนหนึ่งของกลุ่มหลักทรัพย์ที่เคยมีเพียงสินทรัพย์ทางการเงินเท่านั้น

INTRODUCTION

Commodity investment has become popular since the early 2000s. They have attracted remarkable flows of capital from the financial market to the commodities market. The commodities are attractive investments for both institutional and individual investors because they represent an alternative class of assets that offers diversification benefits in the portfolios. Their returns have low or negative correlation with the returns from traditional financial assets such as stocks and bonds and they have been proved in several researches as an efficient hedge when financial markets are under turbulence (Jensen, Johnson, & Mercer, 2000, 2003; Erb & Harvey, 2006; Swamy & Sreejesh, 2011). Most of the prior researches evaluated the benefits of the commodity investment in terms of changes in risk and returns when commodities are added to the portfolios (Ankrim & Hensel, 1993; Erb & Harvey, 2006; Greer 2000; Hoang, 2011; Rzepczynski, Belentepe, Feng, & Lipsky, 2004). Only a few studies examined an expected utility of the portfolio when commodities are added or estimated portfolio with an aim to maximize expected utility. The Theory of Expected Utility, however, has long been introduced in management and psychology as a superior model of decision making under uncertainty. The theory can be applied in the portfolio model with the assumptions that rational investors build their optimal portfolio with the objective to maximize their expected utility (Neumann& Morgenstern, 2004). The portfolio optimization model that aims to maximize expected utility is superior to the mean-variance portfolio model for the fact that it considers all moments of return distributions and allows for various risk preference behaviors.

This study contributes to the research in the area of commodity investment by applying the Prospect Theory into investors' portfolio decision. Prospect Theory was introduced by Kahnemann and Tversky (1979). It extends the idea of Expected Utility Theory to the case that investors are loss-averse. They see the prospect as either gain or loss and they are risk-averse in having gains and risk-seeking in having loss. This paper examined whether the loss-averse investors who make decisions to maximize their expected utility include commodities in their optimal portfolio. And if they invest in commodities, do the optimal portfolios with commodities provide a higher maximum expected utility than what is offered by optimal portfolios that contain only traditional assets. The second set of analysis in this paper focused on sub-sample period between January 2002 and December 2008 to re-examine the benefits of commodity investments during the inflationary period and commodity market expansion.

The rest of the paper is structured as follows. Section two reviews the related literature concerning the Prospect Theory and portfolio optimization problem. Section three describes dataset and methodology. It clarifies expected utility maximization process and provides details

of portfolio performance evaluation. Section four discusses results and the last section gives a summary of the research.

LITERATURE REVIEW

Commodities has become a useful component in portfolios. Many researches have explored the benefits of adding commodity exposure to equity and traditional portfolios (Belousova & Dorflietner, 2012; Hoang, 2011, Jirayutcharoensuk, 2013; Rallis, Michis, 2014; Miffre, & Fuertes, 2013; Skiadopoulos, 2012; Skiadopoulos, 2013; Swamy and Sreejesh, 2011). However, most of the studies in commodity investment are based on the mean and variance approach and consider benefits of commodity only in terms of risk and returns. There are only a few papers focusing on the benefit of commodity investment in terms of expected utility. These papers based their study on an expected utility considering different utility functions and describe various investors' preferences and behaviors. Among the early works are Anson (1999) and Garret and Taylor (2001). The two papers calculated optimal portfolios with an objective to maximize expected utility and measured the utility derived from investing in commodity futures.

The most recent study in commodity investment concerning an expected utility is by Daskalaki and Skiadopoulos (2011). The study examined the benefits of adding commodity investment into the portfolio. They constructed optimal portfolios by maximizing investor's expected utility of wealth and investigated whether the optimal portfolios of investors with different utility functions include commodity investment. The paper took in to account the higher moment of return distribution and described investor preference in various utility functions and degrees of risk aversion. However, this present paper is one of the earliest studies that introduce Prospect Theory into the area of commodity investment. The following literature review discusses the concept of Prospect Theory and the idea of portfolio optimization for loss-averse investors.

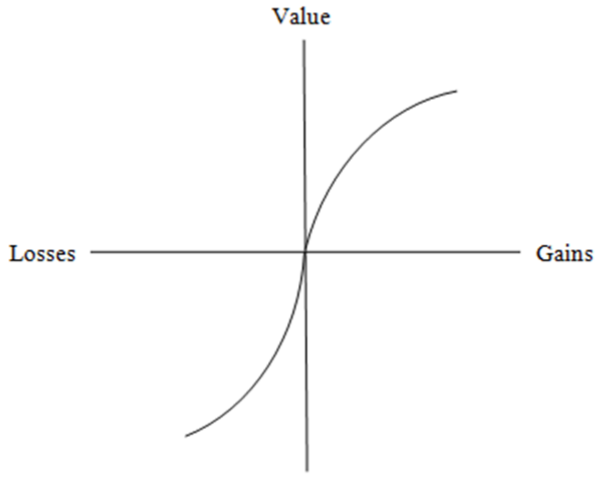
Prospect Theory

Prospect Theory is one of the procedural theories developed from economics and psychological literature (Boer, 2009; Gul, 1991; Haliassos & Hassapis, 2001; Thaler, 1980). It was introduced by Kahnemann and Tversky (1979) and is one of the Non-expected Theories recommended by Allais (1953) who showed his paradox as a counter example of the Expected Utility Theory. In his study, over half of the respondents did not behave according to Expected Utility Theory but they drew on one or more heuristic decision rules when making their choice. Allais (1953) proposed a common consequence problem as a violation of independent axiom of rationality. This violation insists that individual preference is not consistent to what expected utility theory has illustrated.

Prospect Theory models a decision as a two-phase process. In the first phase, an individual edits the prospects using various decision heuristics. It is the stage where an individual is believed to edit or interpret outcomes as gains and losses. In the second phase, the edited gain and loss prospects are chosen with respect to preference function which can be presented simply in the decision-weight utility forms (Starmer, 2000). The experiments by Kahneman and Tversky (1979) and Tversky and Kahneman (1991) demonstrated that after editing the prospect as gains or losses, negative feeling associated with the loss is usually greater than a delight resulted from a proportional gain. This is because most individuals are loss-averse.

They are risk averse in decision involving gains but for decisions concerning a potential loss, they are risk seeking, searching for a chance to minimize their downside prospect. In contrast to an always-concave characteristic of utility function described in Expected Utility Theory, utility function of Prospect Theory has an S shape form, concave for gains and convex for losses (Slovic & Lichtenstein, 1983). It is kinked at a reference point. The shape of utility function in prospect theory is illustrated in figure 1.

Figure 1: Value Function of Prospect Theory



Source: Tversky & Kahneman (1991).

The popularity of Prospect Theory was supported by several studies. Benartzi and Thaler (1995) had observed investors' portfolio holdings and found that investors demonstrate a myopic loss aversion. They regularly evaluate the prospects in terms of gain and loss in short intervals even if they are in the long-term investment horizon. An argument by Rabin (2000) stated that while some attitudes towards small-scale and large-scale risk cannot totally be captured by an Expected Utility Theory, the loss aversion model, instead, can accommodate those behaviors efficiently. Barberis, Huang, and Santos (2001) studied asset prices where investors acquire direct utility from both their consumption and fluctuation of their asset value. Their observation was consistent to the hypothesis that investors are loss-averse and are much more sensitive to the diminishing than to the rising in monetary wealth. They explained their findings further that the degree of loss-aversion varies according to the performance of prior investment. Investors are usually less loss-averse if they gain from the previous investment because the gain acts as a cushion against successive loss.

The formal treatment of portfolio choice in the presence of loss aversion was provided by Ang, Bekaert and Liu (2005) who extended the usual expected utility framework to characterize good and bad outcomes with respect to certainty equivalent. It was concluded that the good outcomes, which are above certainty equivalent, are underweighted relative to bad outcomes. The larger weight given to outcomes, which are bad in relative sense, gives rise to the name "disappointment-averse" preferences, the term implying sharp aversion to losses. Berkelaar, Kouwenberg, and Post (2004) clarifies that another element of prospect theory is subjective

probability distortion. It is suggested that the decision makers subjectively distort the true return distribution and employ subjective decision weights that outweigh or under weigh the true probability.

Functional form of Prospect Theory utility function

Kahneman and Tversky (1979) introduced the following utility function to define utility of wealth over gains and losses with respect to reference point, θ.

$$U(W) = \begin{cases} -A(\theta - W)^{\gamma_1} \; for W \le \theta \\ +B(W - \theta)^{\gamma_2} \; for W > \theta \end{cases}$$

where $U(W)$ denotes utility of wealth (W). As described in section two, A and B are loss-aversion control parameters required to ensure a kink of the function at reference point. The restrictions $A(\gamma_1) > 0$ and $B(\gamma_2) > 0$ are required to ensure that $U(W)$ is an increasing function, $A > B$ has to hold for loss aversion, and $0 < \gamma_1 \le 1$ and $0 < \gamma_2 < 1$ are restrictions for the convex-concave shape (Berkelaar et al., 2004).

Expected Utility Maximization

Most of the portfolio estimation problems are based on mean-variance optimization model since it requires only knowledge on asset's returns, standard deviations, and correlations of the portfolio components (Cremers, Kritzman, & Page, 2005). In principal, the mean-variance approach for portfolio approximation is efficient only if all asset return distributions are normal and when investor's utility can be described by quadratic utility function. However, neither of these assumptions is literally true. Earlier researches found that most of the asset's return distributions are non-normal (Canner, Mankiw, & Weil, 1997; Owen & Rabinovitch, 1983; Sharpe, 2007) and the quadratic utility function is unacceptable because it violates the principle of decreasing absolute risk aversion (Arrow, 1965; Pratt, 1964). These limitations of the mean-variance portfolio approach make it impossible for economists to discard that ever famous classical approach of expected utility maximization which can be applied to fit into various types of investor's behavior and all moments of return distributions. Investor's expected utility is essential in portfolio estimation because it represents satisfaction. An effort to maximize expected utility then becomes equivalent to maximize satisfaction (Simon, 1974).

To express a portfolio optimization more formally, let W_t be the fixed initial wealth of an investor who is given N-asset universe that pays off at time $t+1$. His utility function is assumed to be continuous, increasing, concaved and differentiable ($U'(W) > 0$ and $U''(W) < 0$). The proportion of wealth assigned to asset i over the next period is described by X_i. The optimal portfolio can be constructed at time t to maximize the investor's expected utility of wealth at time $t+1$ with respect to the portfolio weights, i.e.

$$\max E\left[U(W_{t+1})\right]$$

Let $r_{i,t+1}$ be the rate of return on individual asset i and $r_{p,t+1}$ be the rate of return on portfolio. The end-of-period wealth is given by:

$$W_{t+1} = W_t(1+\sum_{i=1}^{N} X_i r_{i,t+1})$$

$$\text{Subject to } \sum_{i=1}^{N} X_i = 1$$

DATA AND METHODOLOGY

To construct the optimal portfolios that maximize expected utility of the investor, this study relies on two groups of asset returns. First, the traditional assets include stocks, bonds, and risk-free assets. The second group of assets in the study is commodity investments, which consists of commodity index, commodity futures, and physical commodities. The proxies of each type of asset are described in table 1. There are 293 monthly returns on stock, bond, risk free assets, and commodity investments from January 1991 to June 2015. This range of data covers the early stage of commodity market financialization and the time it was at its peak during 2008 (Maharakkhaka, 2015). In addition to the whole sample study, this study uses the data set between 2002 and 2008 for a sub-sample analysis. It is the time when the commodity market showed a dramatic expansion and when U.S. inflation was steadily rising until the U.S. subprime crisis (Delatte & Lopez, 2013). The sub-sample study is designed to determine the attractiveness and benefits of commodity investment during the recession and inflationary period in the eyes of loss-averse investors. Appendix A illustrates the rise in prices of the commodity indices from 1991 to 2015. They are the most popular commodity indices and widely used to track the general commodity price movement. The sharp rise in commodity prices began in the early 2002s and reached its peak in 2008. The U.S. inflation rates during 1991 and 2015 are reported in Appendix B, as percentage change in U.S. Consumer Price Index (CPI). During the same time from the early 2000s, U.S. inflation rose gradually until 2008.

Table 1: Data Selection

Assets	Proxies
Stock	Standard &Poor's 500
Bond	Barclay U.S. Aggregate Bond Index
Risk-free Asset	Three-month U.S. Treasury Bill
Commodity Index	Bloomberg Commodity Index
	Standard & Poor's Goldman Sach Commodity Index
Commodity futures	Futures contract on light sweet crude oil (NYMEX)
	Futures contract on gold (COMEX)
	Futures contract on copper (COMEX)
	Futures contract on corn (CME)
	Futures contract on live cattle (CME)
Physical Commodity	London Gold Fixing

Source: Developed for this study.

Table 2 describes basic statistics of the data during the two sample periods. The reports are for average returns, standard deviation, and Sharpe ratio. For the whole sample period, the futures

contract on light sweet crude oil, copper, gold and physical investment in gold offer larger average returns and higher standard deviation, when compared to the investment in stocks and bonds. However, the positive Sharpe ratios indicate that commodities offer average returns that compensate more, than the risk they cause. An analysis of the data during 2002-2008 indicates that between 2002 and 2008 the average return on stock market was negative and the risk in stock investment was more than compensated by the returns offered. It was evidently shown that the futures contract on gold and an investment in physical gold offered attractive returns that were large enough to compensate for the risk. Traditional assets in this study had lower average returns between 2002 and 2008 than during the whole sample period while the returns were higher for all of the commodities in the study. The standard deviations of all commodities were high during 2002-2008 but they were compensated by sufficient rise in average returns.

Table 2: **Descriptive Statistics**

Panel A: 1991-2015

1991-2015	Stock	Bond	T-bill	BCOM	SPGSCI	Crude oil	Gold	Copper	Corn	Live cattle	Gold fix
μ	0.0064	0.0056	0.0026	0.0051	0.0049	0.0094	0.0068	0.0077	0.0074	0.0030	0.0066
σ	0.0430	0.0111	0.0017	0.0433	0.0606	0.0881	0.0448	0.0775	0.0826	0.0470	0.0446
SR	0.0868	0.2655	0.0000	0.0565	0.0373	0.0771	0.0931	0.0657	0.0574	0.0085	0.0888

Panel B: 2002-2008

2002-2008	Stock	Bond	T-bill	BCOM	SPGSCI	Crude oil	Gold	Copper	Corn	Live cattle	Gold fix
μ	-0.0020	0.0048	0.0021	0.0069	0.0072	0.0146	0.0152	0.0136	0.0119	0.0042	0.0150
σ	0.0414	0.0123	0.0013	0.0530	0.0763	0.0978	0.0519	0.0941	0.0898	0.0562	0.0511
SR	-0.0989	0.2198	0.0000	0.0898	0.0660	0.1277	0.2515	0.1217	0.1093	0.0361	0.2524

Source: Developed for this study

This study follows Maharakkhaka (2015) in using full-scale optimization approach of portfolio estimation as introduced by Cremers et al. (2005) and Adler and Kritzman (2007). It calculated portfolio's utility for every period and shifted the asset weight using numerical search procedure to find the asset mix that yields maximum expected utility for the loss-averse investors. In an optimization problem, let there be an investor with fixed initial wealth W_t who faces an asset universe of *N* assets that pays off at time $t+1$. Let X_i stands for the weight of wealth invested in the risky asset *i* over the next period. The optimal portfolio can be constructed at time *t* to maximize the investor's expected utility of wealth at time $t+1$ with respect to the portfolio weights, i.e.

$$\max E\left[U(W_{t+1})\right] \tag{3.1}$$

where

$$W_{t+1} = 1 + \left(\sum_{i=1}^{N} X_i r_i\right)$$

$$\text{Subject to } \sum_{i=1}^{N} X_i = 1$$

This paper examined the attractiveness and benefits of commodity investment for a loss-averse investor whose behavior is described by Prospect Theory. They are risk averse to the gain and risk seeking in the loss. This behavior is expressed by an S-shape or kinked utility function having θ as a reference point. The following kinked utility function was described by Kahneman and Tversky (1979).

$$U(W) = \begin{cases} -A(\theta - W)^{\gamma_1} \; for W \le \theta \\ +B(W - \theta)^{\gamma_2} \; for W > \theta \end{cases} \tag{3.2}$$

where *W* denotes wealth. *A* and *B* are loss-aversion control parameters required to ensure a kink of the function at reference point. The restriction $A(\gamma_1) > 0$ and $B(\gamma_2) > 0$ are required to ensure that $U(W)$ is an increasing function, $A > B$ has to hold for loss aversion, and $0 < \gamma_1 \leq 1$ and $0 < \gamma_2 < 1$ are for the convex-concave shape (Berkelaar et al., 2004). The utility maximization problem of Prospect Theory can be written as

$$\max E\left[U\left(W_{t+1}\right)\right] = \max \sum_{t=1}^{T} \left[\begin{bmatrix} -A\left(\theta - W_{t+1}\right)^{\gamma_1} & for W_{t+1} \leq \theta \\ +B\left(W_{t+1} - \theta\right)^{\gamma_2} & for W_{t+1} > \theta \end{bmatrix} \times \frac{1}{263} \right] \quad (3.3)$$

where

$$\theta = 1 + r_f ,$$

$$W_{t+1} = 1 + \left(\sum_{i=1}^{N} X_i r_{i,t+1}\right),$$

$$t = 1, 2, 3, \ldots\ldots, T \text{ and } i = 1, 2, 3, \ldots\ldots, N$$

Cremers et al. (2005) assumed that references point were equal to a monthly return of 1 percent and 5 percent while Adler and Kritzman (2007) set the threshold level at 0% return. To be more realistic, we follow Barberis et al. (2001) and Daskalaki and Skiadopoulos (2011) to locate the reference point θ are equal to current wealth invested at risk-free rate of return r_f. This implies that an investor perceives a gain when his portfolio return is greater than return on risk-free rate r_f and perceives a loss at the time his portfolio return is less than return on risk-free security. The parameter *A* represents investor's average degree of loss aversion and makes the function kinked at reference point. The value was estimated to be 2.25 by Tversky and Kahneman (1992) in an experiment to obtain information about the value and weighting function using non-linear regression procedure. However, the study follows Barberis et al. (2001) to assume two more values of *A* which are 1.5 and 3.0, since it was proposed in their analysis that after prior gains, the investor does not fear losses very much. His loss aversion is, therefore, less than 2.25. And after prior losses, investors were more sensitive to additional losses. His degree of loss aversion is then higher than 2.25. The parameter *B* is another loss aversion control parameter and is set to equal 1 to satisfy the condition that $A > B$. The value of γ_1 and γ_2 to be 1.0 and 0.8, respectively, as they are proved by Barberis et al. (2001) to be very tractable in their equilibrium setting and belong to the interval [0,1] as suggested by Driessen and Maenhout (2007).

This research added one type of commodity investment to the portfolio at a time and switched to another type of commodity until all eight commodity investments were added into the portfolio. For each degree of loss aversion, optimal portfolios were estimated with and without commodities so that it is possible to examine changes in portfolio performance when commodities are added to the portfolio. When all optimal portfolios with and without commodities were estimated, the performance of the optimal portfolios with commodities were compared to the optimal portfolios that include only traditional assets to examine the benefits of adding commodities to the portfolios. The performance was examined in terms of percentage change in maximum expected utility. The paper didn't consider the classical portfolio performance measurements such as portfolio's average return and variance since these measures were subject to the two-moment and normal distribution of returns which can result in misleading conclusion.

RESULTS

Full Scale Optimization

The optimal portfolios were estimated using the utility functions as described by Prospect Theory, equation (3.3). The full-scale optimization process results in the combination of assets that give the greatest expected utility for loss-averse investors. Therefore, the outcomes are optimal portfolio proportions that maximize expected utility of a loss-averse investor. Table 3 panel A and B show the proportion of optimal portfolios estimated using Prospect utility function for the three levels of loss aversion during 1991-2015 and 2002-2008, respectively. The degrees of loss aversion were set at 1.5, 2.25, and 3.0 respectively.

For the whole sample period between 1991 and 2015, the results showed that commodities represent only a very small part of the portfolio at all degrees of loss aversion. When those commodities are available for investment, investors invest most of their portfolio in the stock market. Commodity indices were not part of the portfolio at all cases. However, rational investors include a little portion of their portfolio in commodity futures and physical gold. Among all types of commodity futures in this study, futures contract on light sweet crude oil occupied the largest proportion of optimal portfolios constructed under Prospect Theory.

There are apparent differences in the proportion of the commodities in the loss-averse optimal portfolios between the time 1991-2015 and 2002-2008. Loss-averse investors invest more in commodities during 2002-2008 when the commodity market is expanding. Almost all types of commodities employed in this study show significant portion in the optimal portfolios. At the lowest degree of loss aversion, almost all commodities represent 99% of the optimal portfolios. The futures contract on live cattle is the only commodity investment that represents less than half of the optimal portfolio at 1.50 degree of risk aversion. The results also show that the loss-averse investors invest less in commodities as the degree of loss aversion increases.

The larger investments in commodities during the 2002–2008 than during 1991–2015 were driven by the expansion of the commodity market and the rise in U.S. inflation. The sub-sample period chosen was the time when the commodity market was rapidly expanding together with the rise in inflation. Since the commodity prices are a component of inflation, investors who expect negative inflationary pressure in financial assets switch part or their entire portfolio from traditional assets such as stocks and bonds to commodities to preserve their wealth. The higher inflation anticipated, the stronger demand for commodity investments, and further the rise in commodity prices.

Table 3: Optimal Portfolio Proportion

Panel A: 1991-2015

Optimal Portfolio Proportion				
1991-2015		**A=1.50**	**A=2.25**	**A=3.0**
BCOM	Stock	0.99	0.2	0.11
	Bond	0.01	0.8	0.89
	T-bill	0	0	0
	BCOM	0	0	0
SPGSCI	Stock	0.99	0.2	0.11
	Bond	0.01	0.8	0.89
	T-bill	0	0	0
	SPGSCI	0	0	0
Crude oil	Stock	0.92	0.27	0.12
	Bond	0	0.69	0.85
	T-bill	0	0	0
	Crude oil	0.08	0.04	0.03
Gold	Stock	0.99	0.22	0.12
	Bond	0.01	0.74	0.87
	T-bill	0	0	0
	Gold	0	0.04	0.01
Copper	Stock	0.99	0.18	0.12
	Bond	0	0.79	0.86
	T-bill	0	0	0
	Copper	0.01	0.03	0.02
Corn	Stock	0.99	0.2	0.11
	Bond	0	0.8	0.89
	T-bill	0	0	0
	Corn	0.01	0	0
Live cattle	Stock	0.99	0.2	0.12
	Bond	0.01	0.8	0.87
	T-bill	0	0	0
	Live cattle	0	0	0.01
Gold fix	Stock	0.99	0.21	0.12
	Bond	0	0.75	0.87
	T-bill	0	0	0
	Gold fix	0.01	0.04	0.01

Panel B: 2002-2008

Optimal Portfolio Proportion				
2002-2008		**A=1.50**	**A=2.25**	**A=3.0**
BCOM	Stock	0	0	0
	Bond	0.01	0.74	0.9
	T-bill	0	0	0
	BCOM	0.99	0.26	0.1
SPGSCI	Stock	0	0	0
	Bond	0.05	0.85	0.93
	T-bill	0	0	0
	SPGSCI	0.95	0.15	0.07
Crude oil	Stock	0	0	0
	Bond	0.01	0.82	0.89
	T-bill	0	0	0
	Crude oil	0.99	0.18	0.11
Gold	Stock	0	0	0
	Bond	0.01	0.01	0.59
	T-bill	0	0	0
	Gold	0.99	0.99	0.41
Copper	Stock	0	0	0
	Bond	0.01	0.8	0.89
	T-bill	0	0	0
	Copper	0.99	0.2	0.11
Corn	Stock	0	0	0
	Bond	0.01	0.84	0.95
	T-bill	0	0	0
	Corn	0.99	0.16	0.05
Live cattle	Stock	0	0	0
	Bond	0.56	0.97	0.96
	T-bill	0	0	0
	Live cattle	0.44	0.03	0.04
Gold fix	Stock	0	0	0
	Bond	0.01	0.01	0.58
	T-bill	0	0	0
	Gold fix	0.99	0.99	0.42

Source: Developed for this study

Portfolio Performance Evaluation

In this paper, the optimal portfolio performance was evaluated by examining the change in maximum expected utility when commodities were added as a part of the portfolio. The expected utility was chosen as a measurement to avoid the limitation of other classical measures, which rely on the two-moment distribution of returns and quadratic utility function. The results of the optimal portfolios performances when commodities were included are consistent with the results in full-scale optimization section. For the whole sample period, commodities can lead to only a small percentage increase in maximum expected utility because the optimal portfolios contain only a very small amount of commodity investments. When commodity indices are available they are not chosen as part of the portfolio. Thus, the optimal portfolios are identical to the traditional portfolios that contain stocks, bonds, and risk-free assets. An investment in commodity futures gives a small increase in expected utility. Futures contract on light sweet crude oil represents the largest proportion of the portfolio when compared to other types of commodities in the study. It offers the greatest positive change in expected utility (1.60 percent) at the highest level of loss aversion. An investment in gold

futures and physical gold also results in positive changes in expected utility of the optimal portfolios at medium and higher degree of loss aversion in this study.

Table 4: Percentage Change in Expected Utility

Panel A: 1991-2015

1991-2015	Change in Expected Utility							
	BCOM	SPGSCI	Crude oil	Gold	Copper	Corn	Live cattle	Gold fix
A=1.50	0.000000%	0.000000%	0.416275%	0.000000%	0.026856%	0.013428%	0.000000%	0.006714%
A=2.25	0.000000%	0.000000%	1.602914%	0.218579%	0.449302%	0.000000%	0.000000%	0.182149%
A=3.0	0.000000%	0.000000%	2.133020%	0.050386%	0.957340%	0.000000%	0.134363%	0.016795%

Panel B: 2002-2008

2002-2008	Change in Expected Utility							
	BCOM	SPGSCI	Crude oil	Gold	Copper	Corn	Live cattle	Gold fix
A=1.50	55.330676%	53.455570%	147.930570%	187.924569%	118.578393%	93.394035%	3.802601%	187.445737%
A=2.25	11.716944%	7.227462%	39.100704%	138.843502%	37.528433%	19.475966%	1.713276%	140.916673%
A=3.0	11.713134%	8.671921%	41.019659%	93.224316%	46.839458%	10.858730%	6.254456%	95.671694%

Source: Developed for this study

As the results in full-scale optimization section suggested, commodities serve as a hedge against inflation and become an alternative investment destination when the financial markets are in turbulence. During the time between 2002 and 2008, the maximum expected utility of the portfolio rose remarkably when commodities were added to the optimal portfolio. The rise in expected utility conforms to the proportion of investment in commodities. During this time, all commodity types in this study represented a significant proportion of the optimal portfolios. An inclusion of commodity indices to the portfolio can increase maximum expected utility of the optimal portfolio significantly at all degrees of loss aversion.

The inclusion of gold futures and physical gold to the portfolio offers the largest increase in portfolios' expected utility followed by an investment in futures contract on light sweet crude oil. At the lowest degree of loss aversion, futures contract on gold and physical gold investment raises approximately 187 percent of the expect utility of the traditional portfolio. At higher degrees of loss aversion, loss-averse investors invest less in commodities and the expected utility decreases. Thus, the changes are smaller for the high degree of loss aversion.

CONCLUSION

From the beginning of the 2000s, commodities have become a popular asset class among both institutional and individual investors. They offer benefits of portfolio diversification because their returns exhibit low or negative correlation with the return of traditional assets. This is from the fact that the prices of commodities are driven by factors such as weather and physical production, which are basically different from the factors that drive the prices of financial assets. This study extended the boundary of research in to commodity investment by applying the Prospect Theory into the study. The Prospect Theory proposes that the rational investors are loss averse. They view gain and loss differently and they are risk averse to the gain and risk seeking in the loss. In the paper, optimal portfolios were constructed using the full-scale optimization problem with an objective to maximize expected utility of the loss-averse investors and examines whether the loss-averse investors invest in the commodities when they are available in the asset universes. Then optimal portfolios with and without commodities were compared to see how an addition of commodities to the portfolio could enhance portfolio performance. The paper included analysis on two sample periods, during 1991- 2015 and 2002

–2008 to examine the difference in benefits of commodities during the different economic conditions.

It was found that, commodities were attractive among loss-averse investors during 2002 -2008 when financial markets was unstable and the commodity market was in a rapid expansion. The results support the prior studies that the investments in commodities are very attractive during the inflationary period (Greer, 2000; Fuertes, Miffre, & Rallis, 2010; Jensen et al., 2002,2003). The rise in commodity prices was a factor for soaring inflation and the expansion of the commodity market during 2000, which was very attractive to investors in the financial market (Irwin & Sanders, 2012; Silvennoinen & Thorp, 2013). Using the data from this sub-sample period, all types of commodities in the study except futures contract on live cattle represented more than 95 percent of the optimal portfolios. When commodities were added to the portfolios, investors' maximum expected utility rose significantly. Futures contract on gold and physical gold investment were the two types of commodities in the study that raised the greatest expected utility of the portfolios. It might be inferred that the loss-averse investors are happier with the benefits of diversification during inflationary period. However, the optimal portfolios that were estimated from the data between 1991 and 2015 contain only a small proportion of commodities. The futures contract on light sweet crude oil was the commodity that occupied the largest proportion of the optimal portfolio. Commodity indices were not a part of the optimal portfolios. Thus, the small inclusion of commodities in the optimal portfolio results in only small change in maximum expected utility of the portfolio.

The present study is conducted with regards to a few limitations. First, by assuming that commodities should exist for a certain proportion in the rational investor's optimal portfolio if it is an attractive investment, it is unclear whether investors are equally aware of the benefits of commodities. The investor's awareness of commodity investment benefits may affect the amount of investment in commodities. Those who know more about how commodities can improve their portfolio have a greater opportunity to enjoy the benefits of such investments. Second, there are newly developed innovative products in recent years such as commodity exchange-traded funds (ETFs) and commodity exchange-traded notes (ETNs), which are not included in the study due to the unavailability of data. Lastly, this study evaluates performance of optimal portfolio only in terms of expected utility because it is the measurement that can be applied to a broader range of investors' preference as well as higher moment of returns distribution. However, this paper does not include the statistical significance of the measurements and does not cover other classical measurements of portfolio performance such as the Sharpe ratio. This is because some of the classical measures are based on the Capital Asset Pricing Model (CAPM) and doesn't totally comply with the Theory of Expected Utility.

To put forward the disquisition in this discipline, future research should look at, first, how specifically commodities can benefit different groups of investors. This study classifies investors based on degree of loss aversion as suggested by Prospect Theory. However, it doesn't address the tangible representative group of investors. The future research could identify the investor group and re-visit benefits of commodity by incorporating other attributes of investors to support the argument. The different information regarding commodity investment to each group of investors can be very useful in portfolio strategy and investment decision.

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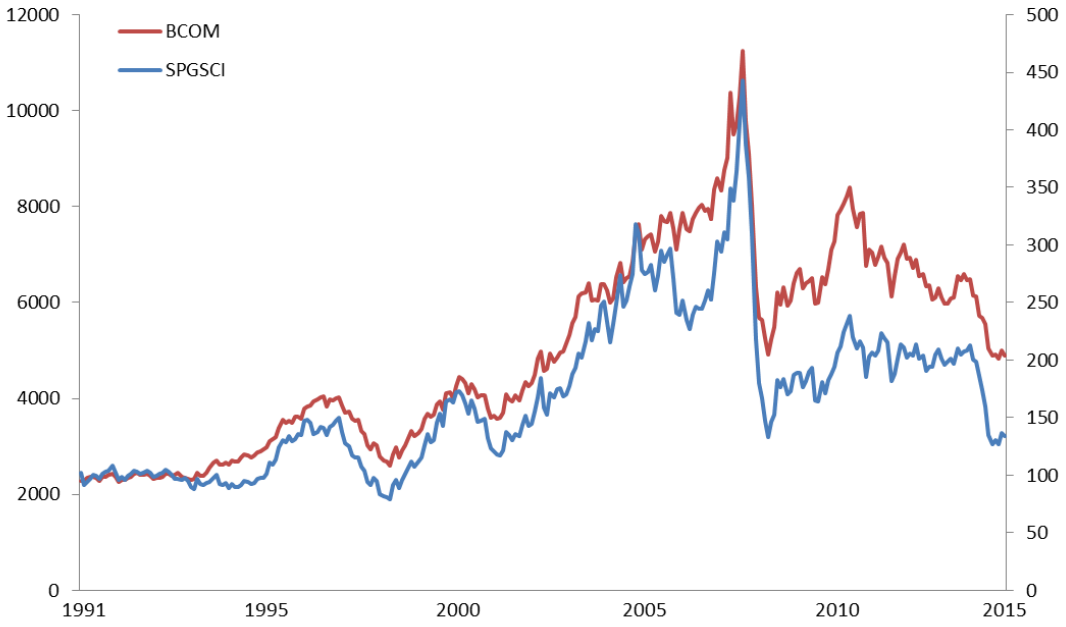
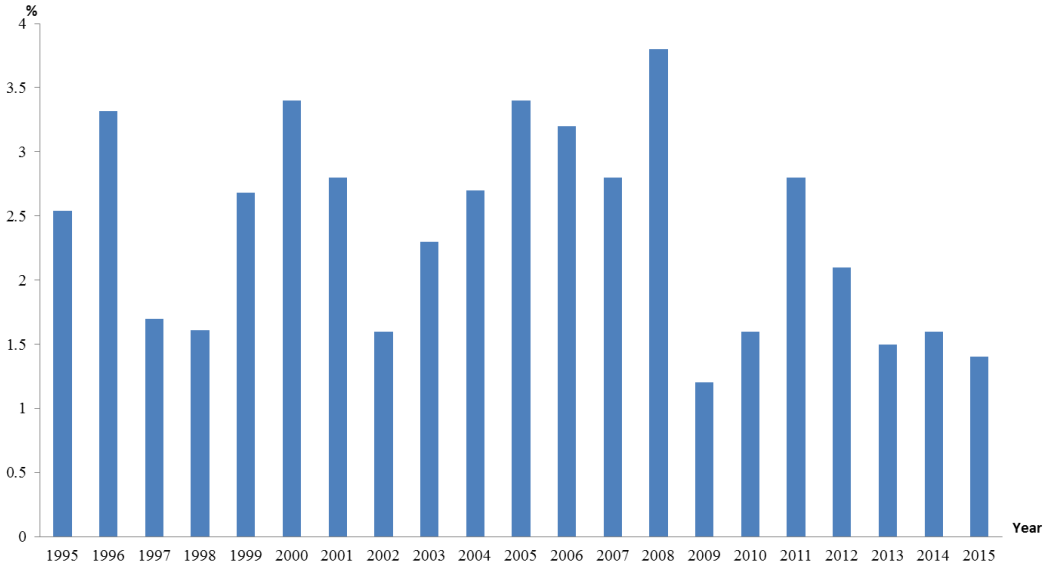
Appendix A
The Rise in Commodity Price Indices 1991 - 2015



Source: Thomson Reuters database. Retrieved November 4, 2015.

Appendix B
U.S. Inflation Rate 1991 - 2015



Source: Thomson Reuters database. Retrieved November 4, 2015.