Stochastic Dominance and Investors' Behavior towards Risk: The Hong Kong Stocks and Futures Markets

Kin Lam and Hooi Hooi Lean and Wing-Keung Wong

Hong Kong Baptist University, Universiti Sains Malaysia, Asia University

9 October 2016

Stochastic Dominance and Investors' Behavior towards Risk:
The Hong Kong Stocks and Futures Markets

Kin Lam
Department of Finance & Decision Sciences
Hong Kong Baptist University

Hooi Hooi Lean
School of Social Sciences
Universiti Sains Malaysia

and

Wing-Keung Wong
Department of Finance, Asia University
Department of Economics, Lingnan University

September 2016

Correspondence author: Wing-Keung Wong; address: Department of Finance, College of Management, Asia University, 500, Lioufeng Road., Wufeng, Taichung, Taiwan. Tel: +886-4-2332-3456X1946, Fax: +886-4-2332-1190, email: wong@asia.edu.tw

Acknowledgement: The authors are grateful to the Editor in Chief, Professor Dilip Ghosh, for his substantive comments and suggestions that have significantly improved the manuscript. The third author would like to thank Robert B. Miller and Howard E. Thompson for their continuous guidance and encouragement. The research has been partially supported by Hong Kong Baptist University, the Universiti Sains Malaysia, Asia University, Lingnan University, and the Research Grants Council (RGC) of Hong Kong (projects Nos. 12502814 and 12500915). The second author would like to acknowledge the Universiti Sains Malaysia RU Grant No. 1001/psosial/816094.

Stochastic Dominance and Investors' Behavior towards Risk: the Hong Kong Stocks and Futures Markets

Abstract

This paper applies stochastic dominance (SD) tests to examine the dominance relationships between the futures and spot markets in Hong Kong. We also analyze the preferences for the risk averters, risk seekers, prospect investors, and Markowitz investors with further in dept of their positive and negative domains in these markets. We find that for the risk averters, spot dominates futures while for the risk seekers, futures dominate spot. This implies that the risk averters prefer to buy indexed stocks, while risk seekers are attracted to long index futures to maximize their expected utilities, but not necessary their wealth. We also conclude that in general, the prospect investors prefer spot in the positive domain and prefer futures in the negative domain while the Markowitz investors prefer spot in the negative domain and prefer futures in the positive domain.

KEYWORDS: stochastic dominance; stock index futures; risk preference; S-shape utility functions.

JEL CODES: C14, G12, G15

1. Introduction

The relationships of the stock index and index futures have been long debated among academics and practitioners. Index futures are highly leveraged speculative instruments. Bullish traders may go long in index futures; on the other hand, bearish speculators would have short futures. If the futures price is above (below) its fair value, there is an index arbitrage opportunity; an arbitrageur may buy (sell short) the underlying asset and sell short (buy) the futures (Fung, 2007).

The objective of this paper is to examine the dominance between spot and futures and investors risk preferences behavior in the Hong Kong markets. We are interested in the Hong Kong markets because Hong Kong is one of the largest developed markets in the world. The openness of the market, the absence of controls on foreign exchange, and the market's high liquidity also make the Hong Kong market a suitable candidate for study. Moreover, Hong Kong is an important international financial center, as well as being the "gateway" to China. Paralleling China's development, the Hong Kong stock market has played a crucial role in channeling this investment capital. Therefore, an understanding of the Hong Kong stock market is also essential to the international investor's understanding of China's business (So and Tse, 2004). In addition, Hang Seng Index (HSI) futures are among the most liquid contracts in the world. HSI represents over 75% of the total market capitalization of stocks listed in Hong Kong (Fung and Yu, 2007).

This paper uses stochastic dominance (SD) methodology to identify dominant types of risk preferences in the Hong Kong's spot and futures markets. Our findings could also be used to relate the utility theory of gambling and behavioral finance. First, we examine the preferences of risk averters and risk seekers for their preferences between Hong Kong's spot and futures markets. Second, we use the implied risk preferences to test two competing theories of choice under risk. The first is the prospect theory of Kahnemann and Tversky (1979) and Tversky and Kahnemann (1992), which has been applied recently to behavioral finance, see, for example, Barberis et al. (2001). The second theory, which stems from the experimental work of Thaler and Johnson (1990) and Levy and Levy (2002), indicates that contrary to prospect theory, investors are risk seeking over gains and risk averse over losses. The utility function under prospect theory is S-shaped with a concave segment over gains and a convex segment over losses. On the other hand, Thaler and Johnson (1990) show that subjects are more risk seeking following gains and more risk averse following losses (Dillinger et al., 1992). This implies that, in a dynamic context, a reverse S-shaped utility function may be more descriptive of actual behavior (Fong et al., 2008).

If a utility function is globally concave, the investor is considered to be risk averse. Conversely, a global convex utility function indicates risk seeking behavior (Hartley and Farrell, 2002). However, investors' risk preferences may depend on whether returns are in the positive or negative domain of an empirical return distribution. Risk-seeking behavior in the positive domain and risk-averse behavior in the negative domain infer the existence of reverse S-shaped utility functions. Alternatively, risk-averse behavior in the positive domain and risk-seeking behavior in the negative domain infer the existence of S-shaped utility functions. We call investors with the S-shape utility functions prospect investors or investors with prospect preferences and investors with the reverse S-shape utility functions Markowitz investors or investors with Markowitz preferences. The SD tests allow us to simultaneously identify the assets preferred by risk averters and risk seekers in both positive and negative return domains. Incorporating this result leads to a complete test framework that can be used to infer risk-averse and risk-seeking behaviors in the entire domain as well as in the positive and negative domains. This enables us to draw preferences for risk averters, risk seekers, prospect investors, and Markowitz investors. We apply this framework to examine different types of their risk preferences associated with the index spot and futures returns in Hong Kong. The research will shed some light on the relationships between the Hong Kong stocks and futures markets and provide useful information to investors, the exchange, and policymakers.

We brief literature review in the next section, followed by a description of the data and the methodology in Section 3. We display our empirical results with discussion in Section 4 and Section 5 concludes.

2. Literature Review

Examining the linkages between the stock market index and the futures market index, Stoll and Whaley (1990) and others find that the futures market led the spot market. On the other hand, many studies have focused on the effect of futures trading on the volatility of the underlying spot market (Kyriacou and Sarno, 1999). In addition, Bae et al. (2004) show that futures' trading in Korea increases the volatility of spot prices. Investigating the effects of returns and volatility on the Malaysian market, Pok and Poshakwale (2004) find that futures' trading increases the spot market's volatility. The above studies show that the effect of futures trading on the volatility of spot markets varies in different time periods and depends on the model specifications and the countries examined.

A number of literatures examine the Hong Kong futures market. For example, Ho et al. (1992) investigate the intra-day arbitrage opportunities and price behavior of the Hang Seng Index Futures, Fung et al. (1997) examine the intra-day patterns of the Hang Seng Index Futures, Fung and Draper (1999) study the mispricing of the Hang Seng Index Futures under short sales constraints, and Cheng et al. (2000) examine the impact of the 1997 Asian financial crisis on index futures markets. In addition, So and Tse (2004) examine the price discovery process among the Hang Seng Index markets. They find that the volatilities of the index and futures markets spill over to each other with a stronger effect from the futures to the index markets and the futures market dominates the spot market in the price discovery process.

Bookstaber and Clark (1985) point out that when evaluating portfolios include options, mean-variance (MV) rules are not applicable because the normality assumption is violated.[1] Booth et al. (1985) show that SD rules are appropriate criteria for ranking portfolios containing options and other assets. Several papers (see, for example, Brooks et al. 1987) adopt SD to evaluate the performance of portfolios containing derivatives.

[1] We note that recently Leung and Wong (2008) apply the technique of the repeated measures design to develop a multivariate Sharpe ratio statistic to test the hypothesis of the equality of multiple Sharpe ratios, whereas Bai, et al.(2009a,b) develop new bootstrap-corrected estimations for the optimal return and its asset allocation and prove that these bootstrap-corrected estimates are proportionally consistent with their theoretic counterparts. They improve the MV criteria by relaxing the normality assumption. In addition, Wong and Ma (2008) show that under some conditions, the results drawn from MV criterion could be equivalence to those from SD.

Trennepohl et al. (1988) find that portfolios insured with options stochastically dominate uninsured assets. Brooks (1989, 1991) apply SD to compare various trading strategies for index options. Conover and Dubofsky (1995) examine similar issues on currency markets. Further studies along this line can be found in Brooks and Levy (1993) and Bhargava and Brooks (2002).

In addition, some academics apply SD tests to examine stock, warrant, and future markets. For example, Chan, et al. (2012) apply both SD and likelihood ratio tests to examine the efficiency of the UK covered warrants market. They do not find any dominance between covered warrants and the underlying shares. Qiao, et al. (2012) apply SD tests to examine investors' preferences with respect to the Taiwan stock index and its corresponding index futures. They find that spot prices dominate futures for risk averters, whereas futures dominates spot for risk seekers. Nonetheless, Qiao, et al. (**2013)** find that there are no SD relationships between spot and futures markets in the mature market. However, for the emerging markets, spot dominates futures for risk averters and futures dominate spot for risk seekers in the second- and third-order SD. Lean, et al. (2015) reveal that risk-averse investors prefer the spot index, whereas risk seekers are attracted to the futures index to maximize expected utility, though not their expected wealth for the entire period or for the sub-period (pre-GFC) before the 2008 Global Financial Crisis (GFC) and the sub-period during and after the GFC (GFC). On the other hand, Clark, et al. (2016) evaluate the preferences of risk averters, risk seekers, and investors with S-shaped and reverse S-shaped utility functions for the Taiwan spot and futures markets. They find that risk averters prefer spot to futures, whereas risk seekers prefer futures to spot. Moreover, investors with S-shaped utility functions prefer spot (futures) to futures (spot) when markets move upward (downward), and investors with reverse S-shaped utility functions prefer futures (spot) to spot (futures) when markets move upward (downward).

3. Data and Methodology

This study uses daily spot and futures indices[2] for the period from January 3, 1995 to December 31, 2007. The daily closing prices of the Hang Seng Index (HSI) and Hang Seng Index Futures (HSIF) are collected from Datastream. HSI is a value-weighted index based on 33 stocks of the largest companies in Hong Kong. It is the benchmark of Hong Kong stock market and is widely used by fund managers as their performance reference (So and Tse, 2004). The HSIF contract was introduced in 1986 and is cash settled. It has developed gradually into one of the most active futures contracts in the world. Daily log returns, $R_{i,t}$, for both the spot and futures indices are calculated as $R_{i,t} = ln\ (P_{i,t} / P_{i,t\text{-}1})$, where $P_{i,t}$ is the daily index at day t for index i with $i = S$ (Spot) and F (Futures), respectively[3].

Figure 1 here

Besides analyzing the entire period, we analyze the data for several sub-periods based on some major events in Hong Kong. Fung (2007) documents that Asian financial crisis (AFC) rocked the Hong Kong markets on October 22, 1997. The HSIF plummeted 1,300 points in an hour from 11,300 at the open. Following Fung (2007), we first set the "pre-AFC" sub-period from January 3, 1995 to October 22, 1997 and the "AFC"

[2] We also analyze the weekly data in order to examine any effect of non-synchronous trading when daily indices are in use. As the results from weekly data are similar to those from daily data, we report only the results of daily data in this paper, since they possess higher power in testing.
[3] These definitions are commonly used; see, for example, So and Tse (2004) and Pok and Poshakwale (2004).

sub-period from October 23, 1997 to March 31, 2000. Some researchers argue that the AFC ends at 1998. However, in this study, we extend the sub-period until the date before the internet bubble. The collapse of technology stocks or internet bubble burst happened in the spring of year 2000. Thus, we set April 2, 2000 to April 30, 2003 as another sub-period to capture the impact of internet bubble and we call this period "internet bubble" sub-period. Since May 2003, Hong Kong markets are performing well and bullish. The period of May 2, 2003 to December 31, 2007 is defined as a "bull-market" sub-period. Figure 1 depict the up and down trends of the Hong Kong spot and futures markets over the sample period. As the sub-periods studied in our paper include bull run, bear market, and mix market; the inference drawn in our paper could apply to all these market conditions.

Stochastic Dominance Approach

Hadar and Russell (1969) and others recommend applying the SD rules to compare different prospects. The SD approach differs from the conventional asset pricing models as it studies the entire distribution of returns directly and imposes minimum assumptions on the investor's utility function.[4] SD theory provides a general framework for ranking risky prospects based on utility theory. Another advantage for using SD is that it enables us to infer different types of investors' preferences between futures and spots. Let F and G be the cumulative distribution functions (CDFs) and f and g the corresponding probability density functions (PDFs) of two prospects X and Y, respectively, supported by

[4] More explanations about the advantages of SD approach can be found in Lean et al. (2007), Wong et al. (2008), and Sriboonchita et al. (2009).

[a, b]. For any integer j, we follow Guo and Wong (2016) and others to define, :

$$H_0^A = H_0^D = h,\ H_j^A(x) = \int_a^x H_{j-1}^A(t)\,dt,\quad H_j^D(x) = \int_x^b H_{j-1}^D(t)\,dt,\ \ h = f, g; H = F, G. \quad (1)$$

We call the integral H_j^A the j^{th} order ascending cumulative distribution function (ACDF) or simply the j^{th} order cumulative distribution function (CDF), and the integral H_j^D the j^{th} order descending cumulative distribution function (DCDF). The most commonly used SD rules (Quirk and Saposnik 1962) correspond with three broadly defined utility functions: first-, second-, and third-order ascending SD (ASD) for the risk averters, denoted by FASD, SASD, and TASD, respectively, defined as follows:

Definition 1: X dominates Y by FASD (SASD, TASD), denoted by $X \succ_1 Y$ or $F \succ_1 G$ ($X \succ_2 Y$ or $F \succ_2 G$, $X \succ_3 Y$ or $F \succ_3 G$) if and only if $F_1^A(x) \le G_1^A(x)$ ($F_2^A(x) \le G_2^A(x)$, $F_3^A(x) \le G_3^A(x)$) for all x, and the strict inequality holds for at least one value of x.

SD for Risk Seekers

Contrary to the SD for the risk averters, that counts from the worst return to the best return, the SD for risk seekers counts from the best return to the worst return. Thus, we call the latter descending stochastic dominance (DSD) as defined in the following:[5]

Definition 2: X dominates Y by FDSD (SDSD, TDSD) denoted by $X \succ^1 Y$ or $F \succ^1 G$ ($X \succ^2 Y$ or $F \succ^2 G$, $X \succ^3 Y$ or $F \succ^3 G$) if and only

[5] See Hammond (1974), Wong and Li (1999), and Anderson (2004) for more details.

if $F_1^D(x) \geq G_1^D(x)$ ($F_2^D(x) \geq G_2^D(x)$, $F_3^D(x) \geq G_3^D(x)$) for all possible x, where FDSD (SDSD, TDSD) stands for first- (second-, third-) order DSD.

SD analysis is important because investigating the SD relationships among different prospects is equivalent to examining the choice of prospects by expected utility maximization (Li and Wong, 1999; Wong, 2007; Wong and Chan, 2008; Sriboonchita et al. 2009). The existence of SD implies that the investor's expected utility is always higher when investors hold the dominant asset than when they hold the dominated asset, and consequently, the dominated asset would not be chosen. We note that a hierarchical relationship exists in SD: first-order SD implies second-order SD, which in turn implies third-order SD. However, the converse is not true. Thus, only the lowest dominance order of SD is reported.

SD techniques have been used since the 1970s to analyze many financial puzzles, see, for example, Porter and Gaumnitz (1972) and Porter (1973). Davidson and Duclos (DD, 2000), Barrett and Donald (BD, 2003), Linton et al. (LMW, 2005) and others attest to their usefulness in SD tests for the risk averters. Lean et al (2008) and others have demonstrated that the DD test is powerful and is less conservative in size.[6] In addition, DD test is easy to compute. The DD test is conducted by comparing cumulative distribution functions over an arbitrary grid of points. An advantage of this test is that it can be applied to both dependent samples and independent samples. We briefly describe the test set-up in the following.

[6] We note that the SD test developed by Linton et al. (2005) is also powerful. In this paper, we have also conducted their SD test in our analysis. As the results obtained from applying the LWM test draw the same conclusion as those obtained from applying the DD test. We only display the results of the DD test in the paper.

Davidson and Duclos (DD) Test

Let $\{(f_i, s_i)\}$ be pairs of observations drawn from the futures and spot indices with CDFs F and G, respectively. For a grid of pre-selected points $x_1, x_2 \ldots x_k$, the j^{th} order DD test statistic for the risk-averters, T_j^A (j = 1, 2 and 3), is:

$$T_j^A(x) = \frac{\hat{F}_j^A(x) - \hat{G}_j^A(x)}{\sqrt{\hat{V}_j^A(x)}} \tag{2}$$

where $\hat{V}_j^A(x) = \hat{V}_{F_j}^A(x) + \hat{V}_{G_j}^A(x) - 2\hat{V}_{FG_j}^A(x)$,

$$\hat{F}_j^A(x) = \frac{1}{N(j-1)!}\sum_{i=1}^{N}(x-f_i)_+^{j-1}, \quad \hat{G}_j^A(x) = \frac{1}{N(j-1)!}\sum_{i=1}^{N}(x-s_i)_+^{j-1},$$

$$\hat{V}_{H_j}^A(x) = \frac{1}{N}\left[\frac{1}{N((j-1)!)^2}\sum_{i=1}^{N}(x-z_i)_+^{2(j-1)} - \hat{H}_j^A(x)^2\right], H = F, G; z = f, s; \text{ and}$$

$$\hat{V}_{FG_j}^A(x) = \frac{1}{N}\left[\frac{1}{N((j-1)!)^2}\sum_{i=1}^{N}(x-f_i)_+^{j-1}\left(x-s_i\right)_+^{j-1} - \hat{F}_j^A(x)\hat{G}_j^A(x)\right];$$

in which the integrals F_j^A and G_j^A are defined in (1) for $j = 1, 2, 3$.

We test the following hypotheses:

$$H_0 : F_j^A(x_i) = G_j^A(x_i), \text{ for all } x_i,\ i = 1, 2, ..., k; \quad H_A : F_j^A(x_i) \neq G_j^A(x_i) \text{ for some } x_i\ ;$$
$$H_{A1} : F_j^A\left(x_i\right) \leq G_j^A\left(x_i\right) \text{ for all } x_i, F_j^A\left(x_i\right) < G_j^A\left(x_i\right) \text{ for some } x_i; \text{ and}$$
$$H_{A2} : F_j^A\left(x_i\right) \geq G_j^A\left(x_i\right) \text{ for all } x_i, F_j^A\left(x_i\right) > G_j^A\left(x_i\right) \text{ for some } x_i.$$

We follow the approach recommended by Bai et al (2011, 2015) to simulate the critical values for the test. A significantly positive T_j^A implies that risk averters prefer spots over futures, and vice versa.

For risk seekers, the following descending DD test, T_j^D ($j = 1, 2, 3$) is used to compare DCDFs integrated:

$$T_j^D(x) = \frac{\hat{F}_j^D(x) - \hat{G}_j^D(x)}{\sqrt{\hat{V}_j^D(x)}} \qquad (3)$$

where $\hat{V}_j^D(x) = \hat{V}_{F_j}^D(x) + \hat{V}_{G_j}^D(x) - 2\hat{V}_{FG_j}^D(x)$,

$$\hat{F}_j^D(x) = \frac{1}{N(j-1)!}\sum_{i=1}^{N}(f_i - x)_+^{j-1}, \quad \hat{G}_j^D(x) = \frac{1}{N(j-1)!}\sum_{i=1}^{N}(s_i - x)_+^{j-1},$$

$$\hat{V}_{H_j}^D(x) = \frac{1}{N}\left[\frac{1}{N((j-1)!)^2}\sum_{i=1}^{N}(z_i - x)_+^{2(j-1)} - \hat{H}_j^D(x)^2\right], H = F, G; z = f, s; \text{ and}$$

$$\hat{V}_{FG_j}^D(x) = \frac{1}{N}\left[\frac{1}{N((j-1)!)^2}\sum_{i=1}^{N}(f_i - x)_+^{j-1}\left(s_i - x\right)_+^{j-1} - \hat{F}_j^D(x)\hat{G}_j^D(x)\right];$$

in which the integrals $F_j^D\left(x\right)$ and $G_j^D\left(x\right)$ are defined in (1) for $j = 1, 2, 3$. A significantly positive T_j^D statistic implies that risk seekers prefer futures over spots, and vice versa.

We test the following hypotheses:

$H_0 : F_j^D(x_i) = G_j^D(x_i)$, for all x_i; $H_D : F_j^D(x_i) \neq G_j^D(x_i)$ for some x_i ;
$H_{D1} : F_j^D\left(x_i\right) \geq G_j^D\left(x_i\right)$ for all $x_i, F_j^D\left(x_i\right) > G_j^D\left(x_i\right)$ for some x_i; and
$H_{D2} : F_j^D\left(x_i\right) \leq G_j^D\left(x_i\right)$ for all $x_i, F_j^D\left(x_i\right) < G_j^D\left(x_i\right)$ for some x_i;

The DD test compares the distributions at a finite number of grid points. We follow Fong et al. (2005), Lean et al. (2007), and Gasbarro et al. (2007) to make 10 major partitions with 10 minor partitions within any two consecutive major partitions in each comparison and use the statistical inference based on the simulated critical values. We also follow Bai et al (2011, 2015) to employ $\max_x \left|T_j^A(x)\right|$ to test for the preferences of risk averters and modify their statistic to be $\max_x \left|T_j^D(x)\right|$ to test for the preferences of risk seekers. As the conclusion drawn by applying these statistics are the same as T_j^A $\left(T_j^D\right)$, we only report results based on test on T_j^A $\left(T_j^D\right)$ in this paper.

Combining the DD test for risk averters and risk seekers allows an identification of preferences for investors with convex, concave, S-shaped, and reverse S-shaped utility functions. In this paper, we examine T_j^A $\left(T_j^D\right)$ over the entire range as well as both positive and negative domains of the empirical return distributions to reveal risk averters' (seekers') preferences. Examining T_j^A (T_j^D) on the entire distribution enables us to reveal the risk preferences of risk averters (seekers). On the other hand, examining T_j^A over the positive domain and T_j^D over the negative domain enables us to identify the risk preferences of investors with j^{th} order S-shaped utility functions. These investors exhibit j^{th} order risk aversion over the positive domain and risk seeking over the negative domain. At last, examining T_j^D over the positive domain and T_j^A over the negative domain enables us to identify preferences of investors with j^{th} order reverse S-shaped utility functions. These investors exhibit j^{th} order risk seeking over the positive domain and risk aversion over the negative domain.

Table 1 here

4. Empirical Results

Table 1 provides descriptive statistics for the daily returns of spot and futures indices for the entire sample period. The mean return and the standard deviation of futures are slightly higher (but not significant) than those of spot. The daily returns of both indices are positively skewed. Both indices have higher kurtosis than normality, and futures have much higher kurtosis than spot. In addition, the highly significant Jarque-Bera statistics show that both returns in this study are non-normal.

We turn to reveal the MV analysis for the sub-periods. The descriptive statistics for sub-periods are summarized in Table 1. From the table, we find that spot market has higher mean returns than futures market in both AFC and internet crash sub-periods while the reverse happens in both pre-AFC and bull-market sub-periods. The mean of daily returns for both spot and futures are negative in the internet crash sub-period but increase dramatically and become significantly positive in the bull-market sub-period. The standard deviations are higher for futures than spot in all sub-periods. The skewness is all negative except in the AFC sub-period. The kurtosis for both indices is small in both internet and bull-market sub-periods. In addition, the highly significant Jarque-Bera statistics show that both returns of each sub-period are non-normal. Consistent with the suggestion made by Bookstaber and Clark (1985) and others, our findings reveal that the MV rules are not applicable in our study. We turn to use SD rules for our analysis.

Figure 2 here

Figure 2 exhibits the ACDFs of the returns for both spot and futures and their corresponding DD statistics, T_j^A, for the risk averters. The ACDF plots show that there is no FASD between spot and futures because their ACDFs cross. It shows that T_1^A moves from positive in the negative domain to negative in the positive domain of the returns distribution, inferring that spot dominates futures in the lower range (negative returns), while futures dominates spot in the upper range of returns (positive returns).

To verify this more formally, we apply the DD test for the risk averters to the two series and display the results in Table 2. To minimize a Type II error and to avoid almost SD (Leshno and Levy 2002), we use a 5% cut-off point[7] for the proportion of the test statistic in our statistical inference. Using the 5% cut-off point, if futures dominate spot, we should find at least 5% of T_j^A to be significantly negative and no portion of T_j^A to be significantly positive. The reverse holds if spot dominates futures. From the table, we find that 10% (11%) of T_1^A is significantly negative (positive).[8] Thus, the results invalidate the hypothesis that futures stochastically dominate spot or vice versa at the first order. These results reflect an inference that spot is preferred to futures on the downside risk and futures is preferred on the upside profits. If the HSIF dominates the HSI at the first-order, then all investors (who prefer more to less) would prefer futures to spots. This implies that no asset pricing models would be able to rationalize the exceptionally high

[7] We note that Leshno and Levy (2002) use an example of 1% to state the problem of almost SD. We choose a more conservative 5% cut-off point to avoid the problem of almost SD. The conclusion drawn in our paper holds if one uses any less conservative cut-off point, say 1%.

[8] In this paper, for convenience, we follow Fong et al. (2005), Gasbarro et al. (2007), and Wong et al. (2008) to use the 5% critical value for the SD test. We note that the conclusion in our paper still holds using the 1% critical value, since, referring to the values in all the plots, the absolute values of most of the test statistics are still bigger than the 1% critical value.

returns of futures in terms of risk compensation. Our results do not justify such a conclusion.

Table 2 here

The absence of FASD leads us to focus the analysis on higher orders to compel utility interpretations in terms of investors' risk aversion and decreasing absolute risk aversion (DARA), respectively. The plots of T_2^A and T_3^A, depicted in Figure 2 as being positive along the entire distribution of the returns. In addition, Table 2 displays that 17% (32%) of the second-order (third-order) DD statistic is significantly positive and no T_2^A (T_3^A) DD statistic is significantly negative at the 5% level, revealing that spot is preferred by the risk averters. Hence, we conclude that there is a dominance of spot over futures in terms of both SASD and TASD at the 5% level.

Investors in the stock and futures markets could be risk-seeking (see, for example, Anderson, 2004; Post and Levy, 2005). The exhibiting of SD between the spot and futures from a risk-averse perspective provides limited information, if there is any, of its relation in a risk-seeking context. Therefore, both risk-averse and risk-seeking analyses must be undertaken to empirically determine the nature of their relationships. To study risk seekers' behaviors, we rely on the DSD theory (Sriboonchita et al., 2009) and employ the corresponding DD statistics for risk seekers, T_j^D.

Figure 3 here

Figure 3 shows the DCDF of the returns for both spot and futures and the corresponding T_j^D over the entire distribution of returns. The figure concludes that there is no FDSD between the futures and spot. But futures are preferred to spot in the positive domain of returns, and the reverse preference is happened in the negative domain under FDSD. In addition, both T_2^D and T_3^D are positive along the entire distributions of returns, from which we can infer that futures is preferred to spot for the risk seekers.

Table 3 here

Table 3 shows the DD statistics for risk-seekers, T_j^D, for the entire sample period and all the sub-periods. The table displays that 11% (11%) of T_1^D is significantly positive (negative), from which we can infer no dominance in FDSD. However, 19% (33%) of T_2^D (T_3^D) is significantly positive and no T_2^D (T_3^D) is significantly negative at the 5% level. This implies that risk-seekers prefer futures to spot in SDSD and TDSD. Different from the ASD test, the evidence from the DSD test shows that the risk seekers are attracted to the futures index to maximize their utilities. Although some of the DSD comparisons mirror the ASD, both tests must be performed because the preferences of the risk averters are neither the complement nor the mirror image for the preferences of the risk seekers.

Levy and Wiener (1998) and Levy and Levy (2002, 2004) use SD to differentiate between S-shaped and reverse S-shaped utility functions. They introduce prospect stochastic dominance (PSD) to determine the dominance of one asset alternative over another for prospect theory with S-shaped utility functions, and introduce Markowitz stochastic dominance (MSD) to determine the dominance of one asset alternative over another for all reverse S-shaped functions. Later, Wong and Chan (2008) extend the theory to the third order and link the extended PSD and MSD to the corresponding S-shaped and reverse S-shaped utility functions to the first three orders.

To further study the preferences for prospect investors or investors with the S-shaped utility functions in Hong Kong markets, we examine the significance of T_j^D in the negative domain as shown in Table 3 and the significance of T_j^A in the positive domain as shown in Table 2. On the other hand, to further study the preferences for Markowitz investors or investors with the reverse S-shaped utility functions in Hong Kong markets, we examine the significance of T_j^A in the negative domain as shown in Table 2 and the significance of T_j^D in the positive domains as shown in Table 3. From Tables 2 and 3, we find that all significant portion (11%, see Table 2) of T_1^A in negative domain are positive whereas all significance (10%, see table 3) of T_1^D in positive domain are also positive, inferring that Markowitz investors prefer spot in the negative domain and prefer futures in the positive domain. All significant portion (11%, see Table 2) of T_1^A in positive domain are negative whereas all significance (11%, see table 3) of T_1^D in negative domain are also negative, inferring that prospect investors prefer spot in the negative domain and prefer futures in the positive domain.

For the whole sample period, we find 6% of significant T_2^A in positive domain and 7% of significant T_2^D in negative domain are positive. This implies that the prospect investors prefer spot in the positive domain and prefer futures in the negative domain in the sense of second-order SD. On the other hand, we find 11% of significant T_2^A in negative domain and 12% of significant T_2^D in positive domain are positive. This implies that the Markowitz investors prefer spot in the negative domain and prefer futures in the positive domain in the sense of second-order SD. The same implication applies to the third-order SD.

Considering futures are riskier than spot, we conclude that the prospect investors are risk seeking over losses and risk averse over gains while the Markowitz investors are risk averse over losses and risk seeking over gains. Our empirical findings are robust to the entire period as well as any sub-period, no matter whether they are up, down, and mixed markets (see Table 2 and 3).

Table 4 here

Another way to examine the robustness of our findings is to check whether our results hold for different diversified portfolios (Wong and Li, 1999; Bai et al, 2009a,b; Egozcue and Wong, 2010; Lam et al 2008, 2010) consisting of both spot and futures. Table 4 shows the results of this test by comparing the spot or futures with different portfolios combining the spot and futures, respectively. Consistent with earlier results, risk averters do not prefer futures whereas risk seekers show a consistent preference for futures. In addition, without reporting the results, we find that our findings are consistent with preferences for Markowitz investors as well as prospect investors for different diversified portfolios. In summary, the results of Table 4 are consistent with our previous results without diversification.

5. Conclusion

This paper first applies DD tests to examine the behaviors of risk averters and risk seekers towards stocks and futures investment in Hong Kong. Our study bears out that the risk-averse (risk-seeking) investors will increase their expected utilities by switching from the futures (spot) to the spot (futures). Thus, we conclude that although the spot index does not outperform the futures index or vice-versa from a wealth perspective, risk-averse (risk-seeking) investors prefer the spot (futures) market, since they will increase their expected utilities by switching from the futures (spot) to the spot (futures) through any trading mechanism.

We further the analysis by looking into the positive and negative domains of the investment returns. Our findings conclude that prospect investors prefer spot in the positive domain and prefer futures in the negative domain while the Markowitz investors prefer spot in the negative domain and prefer futures in the positive domain in the sense of second and third orders SD.

References

Anderson, G. (2004). Toward an empirical analysis of polarization. Journal of Econometrics, 122, 1-26.

Bai, Z.D., Liu, H.X., & Wong, W.K.(2009a). On the Markowitz mean-variance analysis of self-financing portfolios. Risk and Decision Analysis 1(1), 35-42.

Bai, Z.D., Liu, H.X., & Wong, W.K. (2009b). Enhancement of the applicability of Markowitz's portfolio optimization by utilizing random matrix theory. Mathematical Finance 19(4), 639-667.

Bai, Z.D., Li, H., Liu, H.X., & Wong, W.K., (2011). Test statistics for prospect and Markowitz stochastic dominances with applications. Econometrics Journal, 122, 1-26.

Bai, Z.D., Li, H., McAleer, M., & Wong, W.K., (2015). Stochastic dominance statistics for risk averters and risk seekers: An analysis of stock preferences for USA and China. Quantitative Finance, 15(5), 889-900.

Bae, S.C., Kwon, T.H., & Park, J.W. (2004). Futures trading, spot market volatility, and market efficiency: The case of the Korean Index Futures Markets. Journal of Futures Markets, 24 (12), 1195–1228.

Barberis, N., Huang, M., & Santos, T., (2001). Prospect theory and asset prices. Quarterly Journal of Economics, 116, 1-54.

Barrett, G.F., & Donald, S.G. (2003). Consistent tests for stochastic dominance. Econometrica, 71(1), 71-104.

Bhargava, V., & Brooks, R. (2002). Exploration of the role of expectations in foreign exchange risk management. Journal of Multinational Finance Management, 12(2), 171-189.

Bookstaber, R.M., & Clark, R. (1985). Problems in evaluating performance of portfolios with options. Financial Analysts Journal, 41, 48–62.

Booth, J.R., Tehranian, H., & Trennepohl, G.H. (1985). Efficiency analysis and option portfolio selection. Journal of Financial and Quantitative Analysis, 20 (4), 411–440.

Brooks, R. (1989). Investment decision making with derivative securities. Financial Review, 24, 511–527.

Brooks, R. (1991). Analyzing portfolios with derivative assets: a stochastic dominance approach using numerical integration. Journal of Futures Markets, 11, 411–440.

Brooks, R., & Levy, H. (1993). Portfolio insurance: does it pay? Advances in Futures and Options Research, 6, 329–353.

Brooks, R., Levy, H., & Yoder, J. (1987). Using stochastic dominance in evaluating the performance of portfolios with options. Financial Analysts Journal, 43, 79–82.

Chan, C.-Y., de Peretti, C., Qiao, Z. & Wong, W.K., (2012). Empirical test of the efficiency of the UK covered warrants market: Stochastic dominance and likelihood ratio test approach,

Journal of Empirical Finance, 19(1), 162-174.
Cheng, L.T.W., Fung, J.K.W., & Chan, K.C. (2000). Pricing dynamics of index options and index futures in Hong Kong before and during the Asian financial crisis. Journal of Futures Markets, 20, 145–166.
Clark, E.A., Qiao, Z., & Wong, W.K., (2016). Theories of risk: testing investor behaviour on the Taiwan stock and stock index futures markets. Forthcoming in Economic Inquiry.
Conover, J.A., & Dubofsky, D.A., (1995). Efficiency selection of insured currency positions: protective puts vs. fiduciary calls. Journal of Financial and Quantitative Analysis, 30(2), 295–312.
Davidson, R., & Duclos, J-Y. (2000). Statistical inference for stochastic dominance and for the measurement of poverty and inequality. Econometrica, 68, 1435-1464.
Dillinger, A. M., Stein, W.E., & Mizzi, P.J., (1992). Risk-averse decisions in business planning. Decision Sciences, 23, 1003-1008.
Egozcue, M., & Wong, W.K. (2010). Gains from diversification on convex combinations: A majorization and stochastic dominance approach. European Journal of Operational Research, 200, 893–900.
Fong, W.M., Wong, W.K., & Lean, H.H. (2005). International momentum strategies: A stochastic dominance approach. Journal of Financial Markets, 8, 89–109.
Fong, W.M., Lean, H.H. & Wong, W.K. (2008). Stochastic dominance and behavior towards risk: The market for Internet stocks. Journal of Economic Behavior and Organization, 68(1), 194-208.
Fung, J.K.W., Cheng, L.T.W., & Chan, K.C. (1997). The intraday pricing efficiency of Hong Kong Hang Seng Index Options and Futures Markets. Journal of Futures Markets, 17, 797–815.
Fung, J.K.W., & Draper, P. (1999). Mispricing of index futures contracts and short sales constraints. Journal of Futures Markets, 19, 695–715.
Fung, J.K.W. (2007). The information content of option implied volatility surrounding the 1997 Hong Kong stock market crash. Journal of Futures Markets, 27(6), 555 – 574.
Fung J.K.W., & Yu, P.L.H. (2007). Order imbalance and the dynamics of index and futures prices. Journal of Futures Markets, 27(12), 1129–1157.
Gasbarro, D., Wong, W.K., & Zumwalt, J.K. (2007). Stochastic dominance analysis of ishares, European Journal of Finance, 13, 89-101.
Guo, X., & Wong, W.K., (2016). Multivariate stochastic dominance for risk averters and risk seekers. Forthcoming in RAIRO - Operations Research 50(3), 575-586.
Hadar, J., & Russell, W. (1969). Rules for ordering uncertain prospects. American Economic Review, 59(1), 25-34.
Hammond, J.S. (1974). Simplifying the choice between uncertain prospects where preference is nonlinear. Management Science, 20(7), 1047-1072.

Hartley, R., & Farrell, L. (2002). Can expected utility theory explain gambling? American Economic Review, 92, 613-624.

Ho, R. Y. K., Fang, J. Z., & Woo, C. K. (1992). Intraday arbitrage opportunities and price behavior of the Hang Seng Index Futures. Review of Futures Markets, 11, 413–430.

Kahneman, D., & Tversky, A. (1979). Prospect theory of decisions under risk. Econometrica, 47(2), 263–291.

Kyriacou, K., & Sarno, L. (1999). The temporal relationship between derivatives trading and spot market volatility in the UK: Empirical analysis and Monte Carlo evidence. Journal of Futures Markets, 19, 245–270.

Lam, K., Liu, T.S., & Wong, W.K. (2008). The Magnitude effect in the over-and-underreaction in international markets, International Journal of Finance, 20(3), 4833 - 4862.

Lam, K., Liu, T.S., & Wong, W.K. (2010), A pseudo-Bayesian model in financial decision making with implications to market volatility, under- and overreaction, European Journal of Operational Research 203(1), 166-175.

Lean, H.H., Smyth, R. & Wong, W.K. (2007). Revisiting calendar anomalies in Asian stock markets using a stochastic dominance approach. Journal of Multinational Financial Management, 17, 125–141.

Lean, H.H., Wong, W.K., & Zhang, X. (2008). The Sizes and Powers of Some Stochastic Dominance Tests: A Monte Carlo Study for Correlated and Heteroskedastic Distributions. Mathematics and Computers in Simulation, 79(1), 30-48.

Leshno, M., & Levy, H. (2002). Preferred by “all” and preferred by “most” decision makers: Almost stochastic dominance. Management Science, 48, 1074-1085.

Leung, P.L., & Wong, W.K. (2008). On testing the equality of the multiple Sharpe ratios, with application on the evaluation of IShares. Journal of Risk 10(3), 1-16.

Levy, M., & Levy, H. (2002). Prospect theory: much ado about nothing? Management Science 48(10), 1334-1349.

Levy, H., & Levy, M. (2004). Prospect theory and mean-variance analysis, Review of Financial Studies, 17(4), 1015-1041.

Levy, H., & Wiener, Z. (1998). Stochastic Dominance and Prospect Dominance with Subjective Weighting Functions. Journal of Risk and Uncertainty, 16(2), 147-163.

Li, C.K., & Wong, W.K. (1999). A note on stochastic dominance for risk averters and risk takers. RAIRO Recherche Operationnelle, 33, 509-524.

Linton, O., Maasoumi, E., & Whang, Y-J. (2005). Consistent testing for stochastic dominance under general sampling schemes. Review of Economic Studies, 72, 735-765.

Pok, W.C., & Poshakwale, S. (2004). The impact of the introduction of futures contracts on the spot market volatility: the case of Kuala Lumpur Stock Exchange. Applied Financial Economics, 14, 143–154.

Porter, R.B. (1973). An empirical comparison of stochastic dominance and mean-variance portfolio choice criteria. Journal of Financial and Quantitative Analysis, 8, 587-608.

Porter, R.B., & Gaumnitz, J.E. (1972). Stochastic dominance vs. mean-variance portfolio analysis: an empirical evaluation. American Economic Review, 62, 438-446.

Post, T., & Levy, H. (2005). Does risk seeking drive asset prices? A stochastic dominance analysis of aggregate investor preferences and beliefs. Review of Financial Studies, 18(3), 925-953.

Qiao, Z., Clark, E., & Wong, W.K., (2012). Investors' preference towards risk: Evidence from the Taiwan stock and stock index futures markets. Accounting Finance, 54(1), 251-274.

Qiao, Z., Wong, W.K., & Fung, J.K.W., (2013). Stochastic dominance relationships between stock and stock index futures markets: International evidence. Economic Modelling, 33, 552–559.

Quirk J.P., & Saposnik, R. (1962). Admissibility and measurable utility functions. Review of Economic Studies, 29, 140-146.

So, R.W., & Tse, Y. (2004). Price discovery in the Hang Seng Index markets: index, futures, and the tracker fund. Journal of Futures Markets, 24(9), 887 – 907.

Sriboonchita, S., Wong, W.K., Dhompongsa, S., & Nguyen, H.T. (2009). Stochastic dominance and applications to finance, risk and economics. Chapman and Hall/CRC, Taylor and Francis Group, Boca Raton, Florida, USA.

Stoll, H. R., & Whaley, R. E. (1990). The dynamics of stock index and stock index futures returns. Journal of Financial and Quantitative Analysis, 25, 441–68.

Thaler, R.H., & Johnson, E.J. (1990). Gambling with the house money and trying to break even: the effects of prior outcomes on risky choice. Management Science 36, 643-660.

Trennepohl, G.L., Booth, J., & Tehranian, H. (1988). An empirical analysis of insured portfolio strategies using listed options. Journal of Financial Research 11 (1), 1–12.

Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty. Journal of Risk and Uncertainty, 5, 297-323.

Wong, W.K. (2007). Stochastic dominance and mean-variance measures of profit and loss for business planning and investment. European Journal of Operational Research, 182, 829-843.

Wong, W.K., & Chan, R. (2008). Markowitz and prospect stochastic dominances. Annals of Finance, 4(1), 105-129.

Wong, W.K., & Li, C.K. (1999). A note on convex stochastic dominance theory. Economics Letters, 62, 293-300.

Wong, W.K., & Ma, C. (2008). Preferences over Meyer's location-scale family. Economic Theory, 37(1), 119-146.

Wong, W.K., Phoon, K.F., & Lean, H.H. (2008). Stochastic dominance analysis of Asian hedge funds. Pacific-Basin Finance Journal, 16(3), 204-223.

Table 1: Descriptive Statistics for the Returns of the Spot Index and Futures Index

	Full Sample		Pre-AFC		AFC		Internet Bubble		Bull Market	
Variable	Spot	Futures	Spot	Futures	Spot	Futures	Spot	Futures	Spot	Futures
Mean $x10^{-4}$)	3.925	3.969	5.701	5.934	6.654	6.617	-9.135	-9.228	9.908*	9.971*
Std Dev	0.01623	0.01836	0.01326	0.01512	0.02554	0.02937	0.01571	0.01711	0.01113	0.01256
Skewness	0.09054	0.28797	-0.5391	-0.5035	0.3188	0.5063	-0.2420	-0.1103	-0.18095	-0.14238
Kurtosis	10.79	12.10	4.60	4.49	6.95	7.68	2.89	1.89	2.73	2.70
Jarque-Bera	8158.85*	11165.93*	107*	93*	404*	577*	7.8**	40.12*	9.96*	8.30**
N	3225	3225	692	692	605	605	757	757	1171	1171

* $p < 1\%$, ** $p < 5\%$, *** $p < 10\%$. F Statistic is for testing the equality of variances.

Table 2: Results of DD Test for the Risk Averters

	FASD		SASD		TASD	
	$\%T_1^A > 0$	$\%T_1^A < 0$	$\%T_2^A > 0$	$\%T_2^A < 0$	$\%T_3^A > 0$	$\%T_3^A < 0$
Whole Period: Jan 3, 1995 – Dec 31, 2007						
Total	11	11	17	0	32	0
Positive Domain	0	11	6	0	26	0
Negative Domain	11	0	11	0	6	0
Pre-AFC: Jan 3, 1995 – Oct 22, 1997						
Total	7	6	15	0	0	0
Positive Domain	0	6	5	0	0	0
Negative Domain	7	0	10	0	0	0
AFC: Oct 23, 1997 –Mar 28, 2000						
Total	7	3	14	0	20	0
Positive Domain	0	3	4	0	16	0
Negative Domain	7	0	10	0	4	0
Internet Crash: Apr 3, 2000 – Apr 30, 2003						
Total	2	2	23	0	32	0
Positive Domain	0	2	6	0	23	0
Negative Domain	2	0	17	0	9	0
Bull Market: May 2, 2003 – Dec 31, 2007						
Total	8	9	36	0	55	0
Positive Domain	0	9	10	0	34	0
Negative Domain	8	0	26	0	21	0

Note: DD test statistics, T_j^A (j = 1, 2, 3), for the risk averters and T_j^D (j = 1, 2, 3), for risk seekers are computed over a grid of 100 on the range of the empirical distributions of spot and futures returns. Refer to (2) and (3) for the definitions of T_j^A and T_j^D, respectively, with F as futures and G as spot. The table reports the percentage of DD statistics that are significantly negative or positive at the 5% significance level, based on the simulated critical values suggested by Bai et al (2011, 2015).

Table 3: Results of DD Test for the Risk Seekers

	FDSD		SDSD		TDSD	
	$\% T_1^D > 0$	$\% T_1^D < 0$	$\% T_2^D > 0$	$\% T_2^D < 0$	$\% T_3^D > 0$	$\% T_3^D < 0$
Whole Period: Jan 3, 1995 – Dec 31, 2007						
Total	11	11	19	0	33	0
Positive Domain	11	0	12	0	4	0
Negative Domain	0	11	7	0	29	0
Pre-AFC: Jan 3, 1995 – Oct 22, 1997						
Total	6	7	26	0	38	0
Positive Domain	6	0	19	0	13	0
Negative Domain	0	7	7	0	25	0
AFC: Oct 23, 1997 –Mar 28, 2000						
Total	3	7	17	0	17	0
Positive Domain	3	0	11	0	0	0
Negative Domain	0	7	6	0	17	0
Internet Crash: Apr 3, 2000 – Apr 30, 2003						
Total	2	2	27	0	40	0
Positive Domain	2	0	19	0	14	0
Negative Domain	0	2	8	0	26	0
Bull Market: May 2, 2003 – Dec 31, 2007						
Total	9	8	30	0	48	0
Positive Domain	9	0	22	0	15	0
Negative Domain	0	8	8	0	33	0

Note: DD test statistics, T_j^A (j = 1, 2, 3), for the risk averters and T_j^D (j = 1, 2, 3), for risk seekers are computed over a grid of 100 on the range of the empirical distributions of spot and futures returns. Refer to (2) and (3) for the definitions of T_j^A and T_j^D, respectively, with F as futures and G as spot. The table reports the percentage of DD statistics that are significantly negative or positive at the 5% significance level, based on the simulated critical values.

Table 4: Results of DD Test for the Portfolios of Spot and Futures

	100% futures		100% spot	
Percentage of spot	$\% T_2^A \left(T_3^A\right) > 0$	$\% T_2^D \left(T_3^D\right) > 0$	$\% T_2^A \left(T_3^A\right) > 0$	$\% T_2^D \left(T_3^D\right) > 0$
10	20 (46)	21 (46)	17 (31)	18 (31)
20	20 (44)	21 (44)	16 (30)	19 (30)
30	19 (43)	21 (43)	16 (28)	18 (30)
40	19 (42)	20 (42)	15 (27)	19 (28)
50	18 (40)	20 (39)	16 (26)	18 (27)
60	18 (38)	19 (38)	15 (24)	18 (26)
70	18 (37)	19 (37)	14 (23)	18 (25)
80	18 (36)	19 (35)	13 (21)	18 (23)
90	17 (34)	19 (34)	14 (19)	18 (22)

Notes: Results of the DD test for second (third)-order SD of the futures and spot against the portfolios. The weight of spot in the portfolios is shown in the first column. The body of the table shows the percentage of ASD and DSD statistics, which are significantly positive at the 5% level based on the simulated critical values suggested by Bai et al (2011, 2015).

Figure 1: Time Series Plots of Hang Seng Index (HIS) and Hang Seng Index Futures (HSIF)

Figure 2: ACDFs of Returns for Spot and Futures and their Corresponding DD Statistics for the Risk Averters

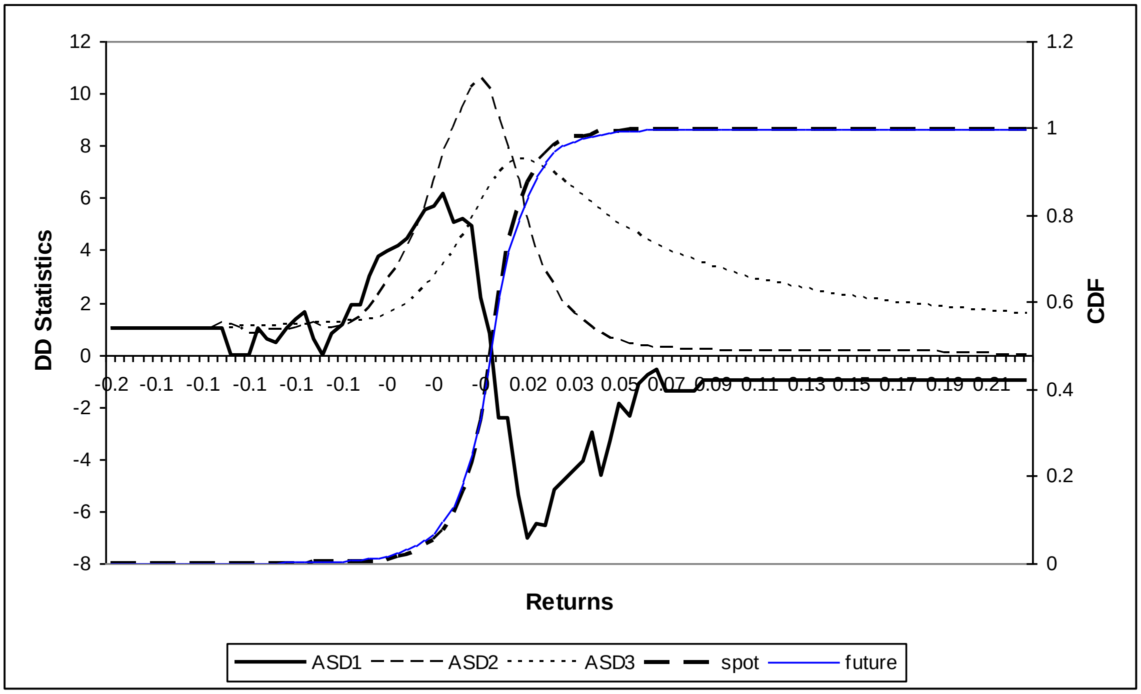

Figure 3: DCDFs of Returns for Spot and Futures and their Corresponding and DD Statistics for Risk Seekers