



Stochastic dominance relationships between stock and stock index futures markets: International evidence



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ABSTRACT

In this paper, we first modify the stochastic dominance (SD) test for risk averters proposed by Davidson and Duclos (2000) to be the SD test for risk seekers. We then adopt both tests to examine the SD relationships between stock indices and their corresponding index futures for 10 countries. The sample contains data from 6 developed countries and 4 developing countries. The study proposes that there should be no SD relationship between spot and futures markets in developed financial markets in which arbitrage opportunities (both pure and quasi) are rare and short-lived. However, we expect that SD relationships could be found in emerging financial markets that have more impediments to arbitrage. Consistent with this conjecture, our study finds that there are no SD relationships between spot and futures markets in the mature market sample, implying that these markets could be efficient. However, for the emerging markets, spot dominates futures for risk averters, while futures dominate spot for risk seekers in the second- and third-order SD. These results indicate that there are potential gains in expected utilities for risk averters (seekers) if they switch their investment from futures (spot) to spot (futures) in the emerging markets.

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1. Introduction

In an efficient market, the force of arbitrage ensures that a futures contract and the price of its underlying cash asset move in lock-step and a movement in either asset, say, the futures, will trigger spontaneous movement in the corresponding spot market. As a result, there should be no arbitrage opportunity between futures and the underlying cash asset and they should be perfect substitutes for investors. However, real market factors, such as execution risk, market liquidity, participation of astute and highly capitalized arbitrageurs, transaction costs, and institutional constraints like restrictions on short-selling cash assets, impede arbitrage and de-couple the two assets.

Arbitrage inefficiency between futures and spot has been revealed in different forms and by many studies. Previous studies have examined the efficiency issue by testing the existence of pure arbitrage opportunities and a lead–lag relationship between the two markets.¹ However,

these two approaches are highly related because imperfect correlation between the two markets is necessary for the existence of pure arbitrage opportunities. The tests on pure arbitrage opportunities are considered to be “weak” form tests.

This study proposes a “strong” form test of market efficiency via stochastic dominance (SD) under both risk aversion and risk seeking assumptions. The complete set of SD tests allows the study to detect the existence of “quasi” arbitrage possibilities even in the absence of pure arbitrage opportunities. Therefore, the SD tests are better in the sense that they can pick up a less apparent form of inefficiency between the two markets.

Due to reasons such as a lower degree of institutional participation, less efficient trading systems that prevent efficient trade execution, less informed investors, and less arbitrage capital in emerging financial markets, we would expect that it is more likely to discover a dominance relationship between the two assets in emerging markets than in mature markets. The study tests the above proposition by examining a group of 6 developed markets and another group of 4 emerging markets. Consistent with our conjecture, the study finds that there are significant SD relationships in the 4 emerging markets, indicating the existence of at least quasi arbitrage opportunities in these countries. On the other hand, no SD relationship is found in the developed market sample.

The rest of this paper is organized as follows. We will briefly discuss the theory of SD for risk averters and risk seekers in Section 2. Section 3 introduces the Davidson and Duclos test (hereafter DD

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¹ Many studies have investigated the lead–lag relationship between the two markets by applying various parametric econometric models; see, for example, Kawaller et al. (1987), Stoll and Whaley (1990), Chan (1992), Zhong et al. (2004), and many others. However, their analyses are usually conducted under certain assumptions about market return distributions, which are well-known to be violated in reality.

Table 1
Descriptive statistics for daily returns.

Variable	USA		Canada		UK		Germany		France	
	Spot	Futures	Spot	Futures	Spot	Futures	Spot	Futures	Spot	Futures
Mean	0.0000	0.0000	0.0002	0.0002	-0.0001	-0.0001	0.0001	0.0001	-0.0001	0.0000
Median	0.0005	0.0006	0.0007	0.0007	0.0004	0.0002	0.0009	0.0007	0.0003	0.0006
Maximum	0.0557	0.0575	0.0451	0.0576	0.0590	0.0595	0.0755	0.0729	0.0700	0.0710
Minimum	-0.0601	-0.0627	-0.1011	-0.0727	-0.0589	-0.0606	-0.0887	-0.1482	-0.0768	-0.0831
Std. Dev.	0.0112	0.0114	0.0112	0.0113	0.0114	0.0115	0.0156	0.0155	0.0140	0.0141
Skewness	0.0473	-0.0093	-0.5986	-0.3272	-0.2316	-0.1824	-0.1021	-0.3903	-0.0995	-0.1145
Kurtosis	5.4884	5.6367	9.1763	6.1460	6.0696	6.1562	5.9994	9.1508	5.9583	6.0101
Jarque–Bera	512.8823***	575.0418***	3266.9790***	852.2822***	797.4604***	835.3334***	761.8219***	3240.315***	742.5077***	769.6899***

Note: These are descriptive statistics for the daily returns of the spot and futures. The sample covers January 3, 2000–December 31, 2007.
***Indicates significance at 1% level.

test, 2000) for SD and discusses test implementation issues. Section 4 describes the data set and presents descriptive statistics. The SD empirical results are presented and analyzed in Section 5. Section 6 contains some concluding remarks.

2. SD theory

SD theory, initially developed by Hadar and Russell (1969), Hanoch and Levy (1969), and many others is one of the most useful tools for ranking investment prospects in investment decision-making under uncertainty. Let F and G be the cumulative distribution functions (CDFs), and f and g be the corresponding probability density functions (PDFs) of two investments, X and Y , respectively, with common support $[a,b]$ where $a < b$. Define

$$H_0^A = H_0^D = h, H_j^A(x) = \int_a^x H_{j-1}^A(t) dt \text{ and } H_j^D(x) = \int_x^b H_{j-1}^D(t) dt \quad (1)$$

for $h = f$, and g ; $H = F$, and G ; and $j = 1, 2$, and 3 . We call the integral H_j^A the j^{th} order ascending cumulative distribution function (ACDF) and the integral H_j^D the j^{th} order descending cumulative distribution function (DCDF) for $H = F$ and G and for $j = 1, 2$ and 3 .

We first state definition the first-, second- and third-order ascending SD (ASD)² for risk averters, denoted as FASD, SASD, and TASD, respectively in the following (see, for example, Fishburn, 1964; Quirk and Saposnik, 1962):

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

Wong and Li (1999), Li and Wong (1999), and others show that SD rules apply to risk seekers, with the preferences reversed to those of risk averters under certain conditions.³ Whereas SD for risk averters works with the ACDF, which counts from the worst return to the best return, SD for risk seekers works with the DCDF, which counts from the best return descending to the worst return (Post and Levy, 2005; Stoyan, 1983; Wong, 2007). Hence, SD for risk seekers could be called descending SD (DSD). We have the following definition for DSD (see, for example, Meyer, 1977; Stoyan, 1983).

² We call it ascending SD, since its integrals count from the worst return ascending to the best return.

³ Readers may refer to Lemma 3 and Theorems 7, 10, and 12 in Li and Wong (1999) and Theorem 1 and Corollary 1 in Wong and Li (1999) for more information on the relationship of preferences between risk averters and risk seekers.

Definition 2. X dominates Y by FSDS ($SDSD, TDSD$) denoted by $X \succ^1 Y$ ($X \succ^2 Y, X \succ^3 Y$) if and only 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 returns x , the strict inequality holds for at least one value of x ; where FSDS ($SDSD, TDSD$) stands for first-order (second-order, third-order) descending SD.

We note that in Definitions 1 and 2, the condition " $\mu_x \geq \mu_y$ " needs to be included for the third-order ASD and DSD (R.H. Chan et al., 2012). We define utility functions for risk averters, U_j^A , and risk seekers, U_j^D , as shown in the following:

Definition 3. For $j = 1, 2$, and 3 , $u \in U_j^A$ or U_j^D is a utility function such that

$$U_j^A = \{u : (-1)^i u^i \leq 0, i = 1, \dots, j\} \text{ and } U_j^D = \{u : (-1)^i u^i \geq 0, i = 1, \dots, j\}.$$

Investors with utility u in U_1^A or U_1^D are nonsatiated (prefer more to less); those with utility u in U_2^A are nonsatiated and risk-averse; and those with utility u in U_3^A are nonsatiated and risk-averse and have decreasing absolute risk aversion (DARA). On the other hand, investors with utility u in U_2^D are nonsatiated and risk-seeking, while those with utility u in U_3^D are non-satiated and risk-seeking and have increasing absolute risk-seeking. Thus, we call investors with utility u in U_j^A the j th order of risk averters and investors with utility u in U_j^D the j th order of risk seekers. SD analysis is important because investigating the SD relationship across different financial assets is equivalent to examining the choice of assets by utility maximization under SD theory. To be precise, if $X \succ_j Y$, then $E[u(X)] - E[u(Y)] > 0$ for any risk averter with utility u in U_j^A and if $X \succ^j Y$, then $E[u(X)] - E[u(Y)] > 0$ for any risk seeker with utility u in U_j^D for any $j = 1, 2$, and 3 . See Li and Wong (1999) for more information. The SD theory could be extended to a range of non-expected utility. See Wong and Ma (2008) and the references therein for more information.

We also note that a hierarchical relationship exists (C.Y. Chan et al., 2012; Levy, 1992) in ASD (DSD): FASD (FDSD) implies SASD (SDSD), which in turn implies TASD (TDSD). However, the converse is not true: the existence of SASD (SDSD) does not imply the existence of FASD (FDSD). Likewise, the existence of TASD (TDSD) does not imply the existence of SASD (SDSD) or FASD (FDSD).

An individual chooses between F and G in accordance with a consistent set of preferences satisfying the von Neumann and Morgenstern (1944) consistency properties. Accordingly, F is (strictly) preferred to G , or equivalently, X is (strictly) preferred to Y if

$$\Delta E_u \equiv E[u(X)] - E[u(Y)] \geq 0 (> 0)$$

$$\text{where } E[u(X)] \equiv \int_a^b u(x) dF(x) \text{ and } E[u(Y)] \equiv \int_a^b u(x) dG(x).$$

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