A Comprehensive Examination of the Compass Rose Pattern in Futures Markets

CHUN I. LEE
KIMBERLY C. GLEASON
IKE MATHUR*

This article provides a comprehensive examination of the existence, or the lack thereof, of the compass rose pattern in futures markets. The results from 118 futures contracts traded on 31 futures exchanges in 15 countries show that the compass rose pattern exists only in some futures contracts, in contrast to the robust existence among stocks documented by Crack and Ledoit (1996) and Chen (1997). Not all contracts on the same exchange exhibit this pattern. However, the pattern appears to be concentrated in some sectors. Although this evidence suggests that effective tick sizes that are different among contracts may be the determining factor for the existence of the pattern, contradicting evidence also suggests that there are other yet-to-be-identified determinants at work. Furthermore, whereas the pattern is absent in the daily returns of primary stock index futures contracts such as the Major Market Index (MMI), it is

*Correspondence author, Department of Finance, Southern Illinois University, Carbondale, IL 62901-4626.

- *Chun I. Lee is an Assistant Professor in the Department of Business Administration at Texas Southern University in Houston, Texas.*
- *Kimberly C. Gleason is an Assistant Professor in the Department of Finance at Bentley College in Waltham, Massachusetts.*
- *Ike Mathur is a Professor in the Department of Finance at Southern Illinois University in Carbondale, Illinois.*

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very easily observable in the intraday returns of the same futures contract. The elusiveness of the pattern is further demonstrated in the returns on the cash S&P 500 Index, which does not exhibit the pattern until the focus is on returns that are within a 1% boundary.

INTRODUCTION

Recent literature suggests that technical analysis may have more predictive ability than previously thought (Taylor, 1994; Chang & Osler, 1995), as sophisticated forecasting algorithms continue to evolve. Consequently, the discovery of some previously unknown patterns should be viewed as welcome news. Exploring the correlation dimension of the time series of prices may reveal that they are driven by nonlinear dynamics rather than deterministic chaos. In that case, the power of technical analysis may be better understood in light of nonlinear patterns, as indicated by Clyde and Osler (1997).

Examining the scatter diagram of daily stock returns plotted against themselves with one day's lag, Crack and Ledoit (1996) find that a geometrical structure emerges. The structure takes the form of evenly spaced rays radiating from the origin with the thickest rays pointing in the major directions of the compass, hence the term "Compass Rose pattern," and is caused by discrete jumps in stock prices. The pattern was discovered by Crack and Ledoit when they used dots (.) rather than the plus symbol (+) in plotting scatter diagrams. The compass rose may have also been masked in previous research due to the use of an excessively large frame size in plots (Kramer & Runde, 1997).

Crack and Ledoit report that the pattern is "indisputably present in every stock," and Chen (1997) finds evidence of a compass rose pattern in the Taiwanese stock market. Given that these studies examine only stocks, they leave unanswered the question related to the existence and pervasiveness of this pattern in non-equity assets such as futures contracts.

Patterns are more sought after in futures markets where technical analysis has long been used in short-term oriented trading. The compass rose pattern in stock markets documented by Crack and Ledoit (1996) may turn out to be a manifestation of the nonlinear dynamics driving stock and futures prices and, thus, may have implications for the predictability of returns. Or it may be only a consequence of price discreteness, as argued by Crack and Ledoit (1996), and as empirically demonstrated by Szpiro (1998). As stated by Harris (1991), neither the

discreteness of futures prices, nor its potential consequences, have been examined in detail, despite their persistence across stock prices.

Irrespective of whether the search for structure in the time series of returns can provide new mechanisms by which supernormal returns can be made, it is important to recognize that microstructure effects may be relevant in light of the biases that they may create even in relatively low frequency data with commonly used estimation procedures. For example, Crack and Ledoit (1996) show that chaos tests for low dimensional structure in *n*-histories—such as the BDS test of Brock et al. (1987)—are affected to the extent that evidence to support the existence of chaos may

TABLE I

Contracts Examined[a]

Abbreviation	*Name of Exchange*	*Contracts Examined*
CBOT	Chicago Board of Trade	FV, US
CSCE	Coffee, Sugar & Cocoa Exchange	SB, SE
DTB	Deutsche Terminborse	BF, EF, NB
EOE	European Options Exchange	AX, FT
FOX	London Futures & Options Exchange	BB, FH, FP, FW, LD, LW
HKFE	Hong Kong Futures Exchange	GK, HB, HC, HN, HP, HS, HT
IOM	Index & Options Market, CME	SP, BC (daily and intraday)
IPE	International Petroleum Exchange	CB, LF, GS
KLCE	Kuala Lumpur Commodity Exchange	KK, KP
KRE	Kobe Rubber Exchange	YU
KRSE	Kobe Raw Silk Exchange	YQ
LCE	London Commodity Exchange	FB, LS
LIFFE	London International Financial Futures	A-, E-, F-, G-, I-, J-, L-, U-, V-, X-, Y-, Z-
MATIF	Marche ag Terme International DeFrance	ME, MJ, MQ, MN, MP, MU, MX, MZ
MDCE	Maebashi Dried Cocoon Exchange	YB
MEFF	Mercade De Opciones Y Futuros Financieros	HM, IX, JM, KM, LM, MM, OM, QM
ME	Montreal Exchange	BA, CA, CE, CG
MIF	Mercade Italiano Futures	MF, MH
NTE	Nagoya Textile Exchange	YO
NZFOE	New Zealand Futures & Options Exchange	BZ, IZ, UZ, ZZ
OSE	Osaka Securities Exchange	NO
OTE	Osaka Textile Exchange	YP, YV, YY
SIMEX	Singapore International Monetary Exchange	CX, DS, DY, FS, GX, JX, MS, NX, PX, SG, SY, UR
SFE	Sydney Futures Exchange	BS, IS
SOFFEX	Swiss Options & Financials Futures Exchange	SW, SZ
TOCOM	Tokyo Commodity Exchange	YA, YC, YG, YI, YR, YW
TGE	Tokyo Grain Exchange	CV, TG, YM, YZ
TIFFE	Tokyo International Financial Futures Exchange	DT, ET, IT
TSE	Tokyo Stock Exchange	BT, GT, JT, TT
TOR	Toronto Stock Exchange	TV, TX
WCE	Winnipeg Commodity Exchange	WA, WC, WF, WR, WW

[a]This table lists the contracts examined in this paper. The full names for the contracts examined are provided in Table 2.

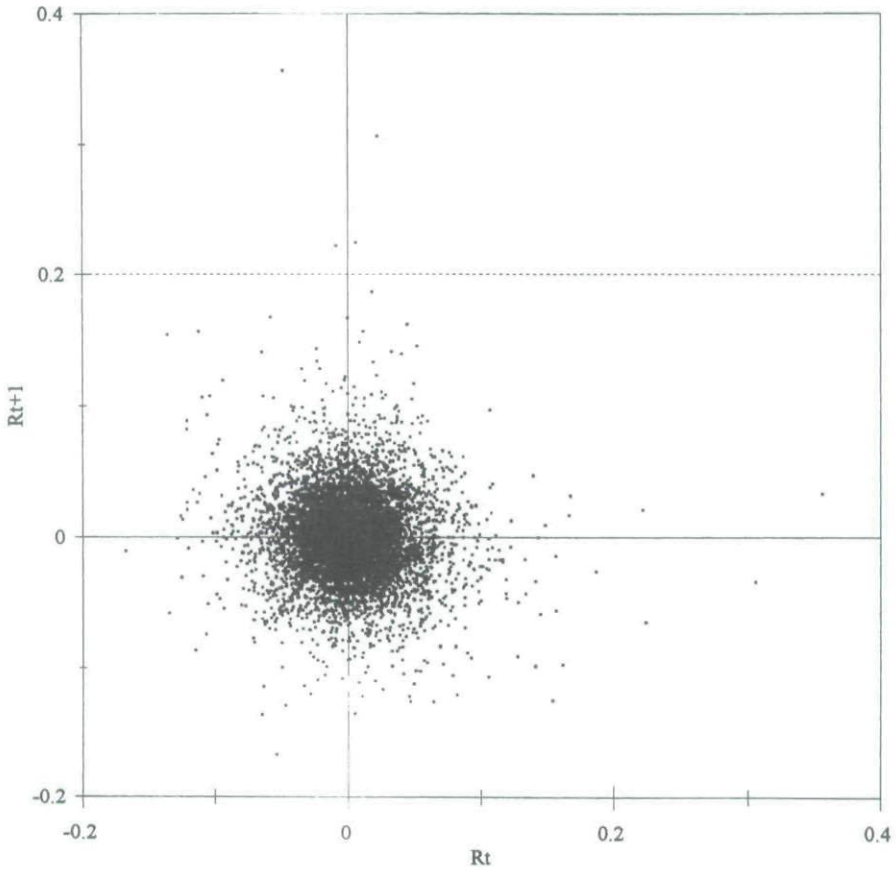

FIGURE 1A
Sugar #11 (world) contract (SB). Coffee, Sugar & Cocoa Exchange. Pattern for total sample.

have been completely driven by stock price discreteness. The existence of the compass rose pattern in futures prices may translate into problems with inferences made from the results of procedures such as ARCH and GARCH models. Thus the compass rose pattern deserves investigation.

The results from 118 contracts traded on 31 futures exchanges in 15 countries show that the compass rose pattern exists only in 43 futures contracts. Not all contracts on the same exchange show the pattern, which suggests that effective price limits that are different among contracts may be the determining factor for the existence of the pattern. The elusiveness of the pattern is further illustrated in the returns on the cash S&P 500 Index, which does not exhibit the pattern until a 1% limit restriction is imposed on the returns. Finally, whereas the compass rose pattern is missing in the S&P 500 Index futures contracts, the intraday

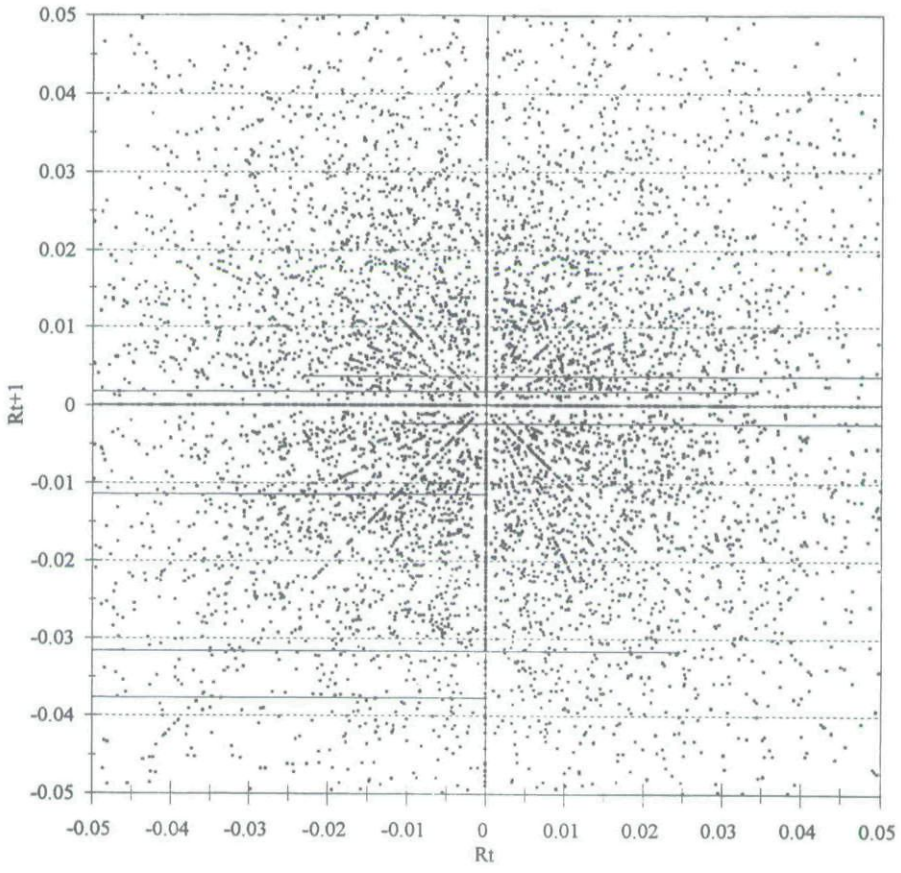

FIGURE 1B (Continued)
Sugar #11 (world) contract (SB). Coffee, Sugar & Cocoa Exchange. Pattern screened at 5%.

5-minute Major Market Index contract exhibits the strikingly strong pattern.

DATA AND METHODOLOGY

Data

Given the ever-increasing number of futures contracts, it is a daunting task to attempt to examine all of them in a study such as the present one. Nonetheless, to be as comprehensive as possible to increase the extent to which the conclusions can be generalized, this study examines most of the futures contracts traded outside the United States. This choice is made mainly because these non-U.S. instruments have not been exten-

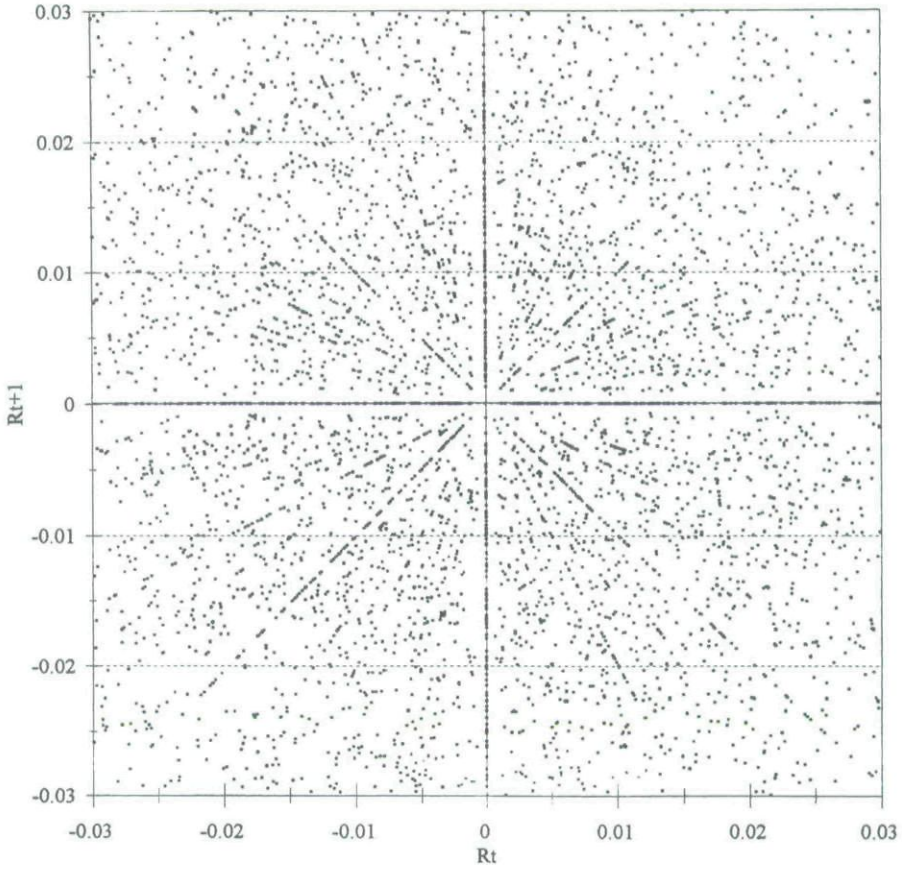

FIGURE 1C (Continued)
Sugar #11 (world) contract (SB). Coffee, Sugar & Cocoa Exchange. Pattern screened at 3%.

sively examined, yet they play an important role in risk management in today's environment of global investments. For the U.S. futures, only the S&P 500 Index futures and the Major Market Index (MMI) futures contracts traded on the Chicago Mercantile Exchange (CME), the 30-year U.S. Treasury Bonds and the 5-year U.S. Treasury Notes futures contracts traded on the Chicago Board of Trade (CBOT), and two sugar contracts traded on the Coffee, Sugar & Cocoa Exchange (CSCE) are examined.

Daily price series of the nearby contracts of 118 futures contracts traded on 31 exchanges in 15 countries are obtained from the Knight-Ridder Database. The intraday 5-minute price series of the MMI and the S&P Index futures contract traded on the CME are also examined. The underlying assets these contracts represent include currencies, energy, financial instruments, foodstuffs, grains/oilseeds, industrials, metals, and

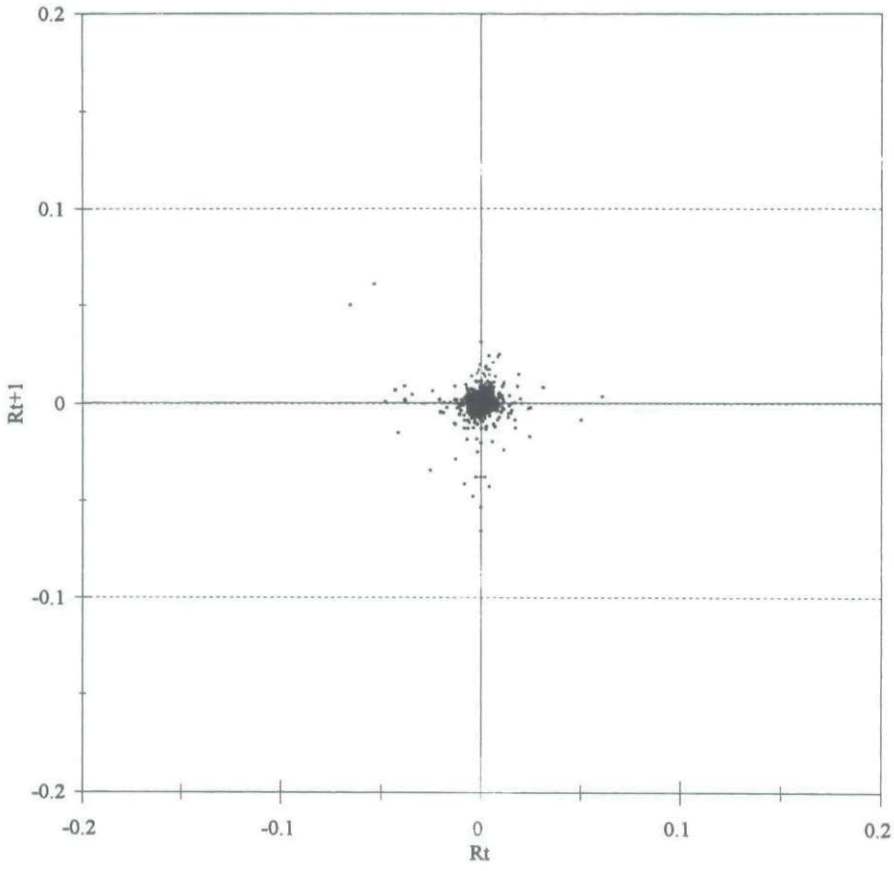

FIGURE 2A
Sugar #14 (domestic) contract (SE). Coffee, Sugar & Cocoa Exchange. Pattern for total sample.

stock indices. Table I lists these contracts along with the exchanges on which they are traded.

Methodology

The return for period t, R_t, is calculated as the change of the closing price of period t, $P_t - P_{t-1}$, over the closing price of period P_{t-1}, that is,

$$R_t = (P_t - P_{t-1})/P_{t-1} \tag{1}$$

Equivalently, considering that prices move only in discrete jumps (h), the ratio of next to current period returns can be expressed as

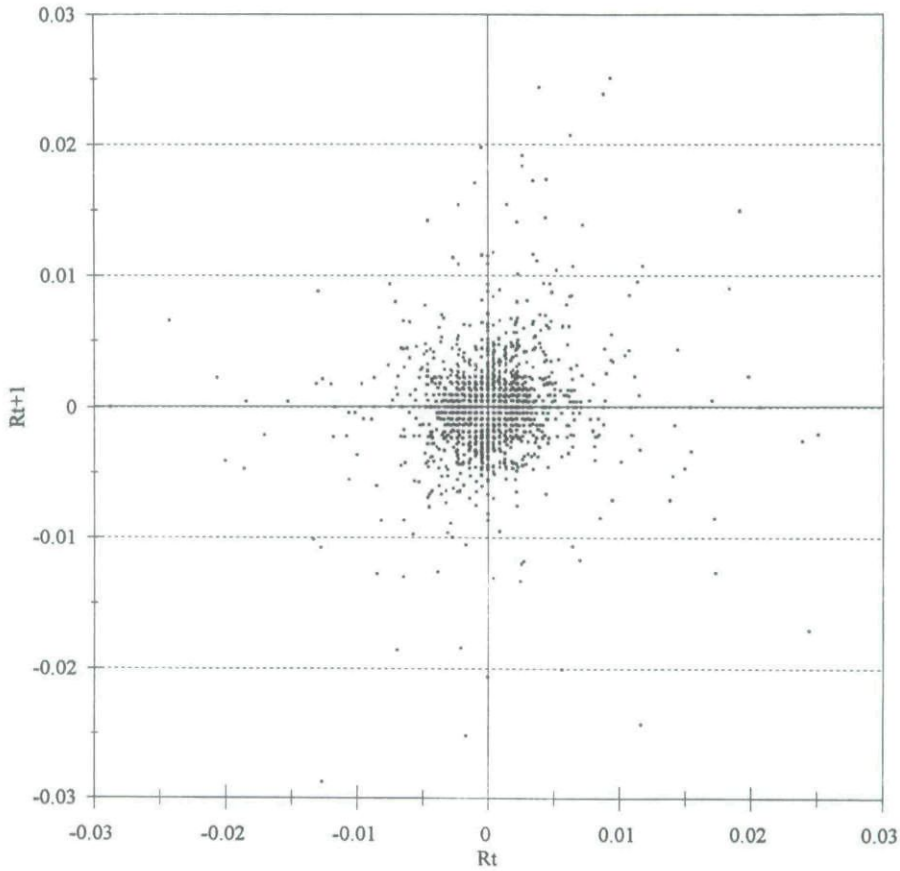

FIGURE 2B (Continued)
Sugar #11 (domestic) contract (SE). Coffee, Sugar & Cocoa Exchange. Pattern screened at 3%.

$$R_{t+1}/R_t = [(P_{t+1} - P_t)/P_t]/[(P_t - P_{t-1})/P_{t-1}] \quad (2)$$

which can be simplified to $n_{t+1}h/n_th = n_{t+1}/n_t$, where n_t is the number of ticks that the price change represents.

Crack and Ledoit (1996) argue that the source of the compass rose pattern in common stock returns is explained through the existence of three necessary and sufficient conditions: (i) First, the price level has to be large relative to the price change from the last to the current period. This condition reflects the intensity or volatility of price movements over the short term. (ii) Second, the price changes occur in small discrete jumps. This condition requires that the asset is liquid and trades under orderly market conditions. (iii) Third, the price of the asset must vary over a relatively wide range. This condition reflects the volatility or intensity

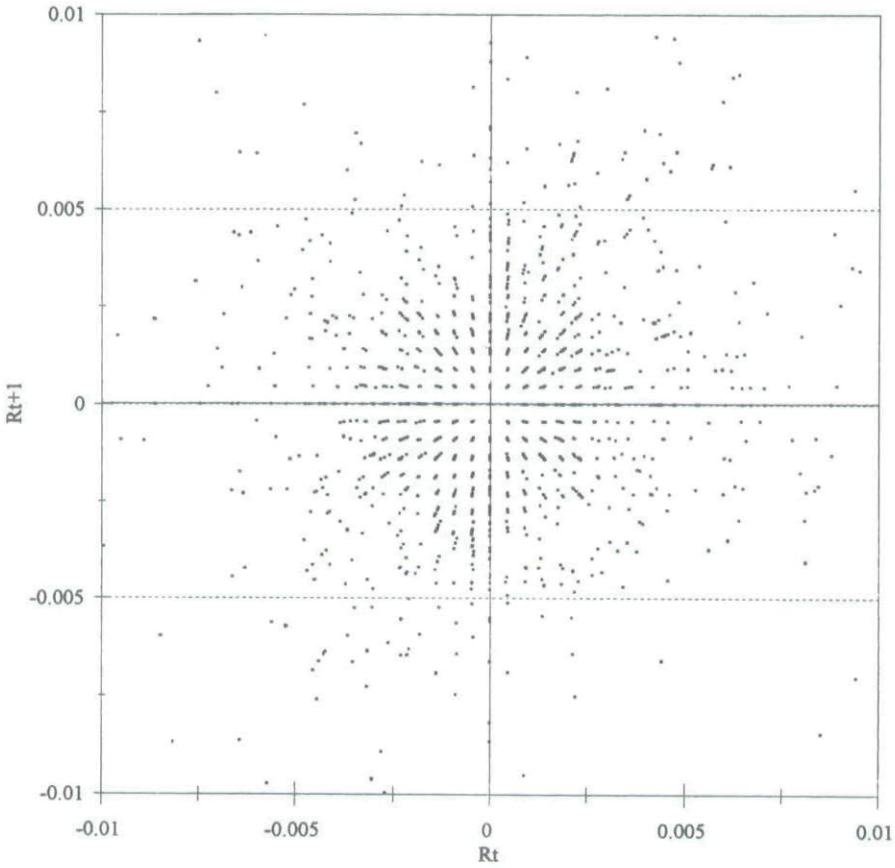

FIGURE 2C (Continued)
Sugar #14 (domestic) contract (SE). Coffee, Sugar & Cocoa Exchange.
Pattern screened at 1%.

of the asset's price movements over the long term. However, in a subsequent article, Szpiro (1998) demonstrates that the only condition necessary for the pattern to exist is that price changes should occur in discrete jumps.

After computing returns, a scatterplot is generated of R_{t+1} against R_t. In the case that returns remain relatively stable over time, the plot will indicate that returns tend to cluster on lines radiating from the origin, with the thickest rays emanating in the major directions (north, south, east, and west), resembling a compass. Under the condition identified by Crack and Ledoit (1996) that the price exhibits a relatively large variance over the time period examined, and the use of a small frame and dots rather than + typographical symbols in the plot, the data points will be "smudged" across the grid, creating the appearance of the compass rose.

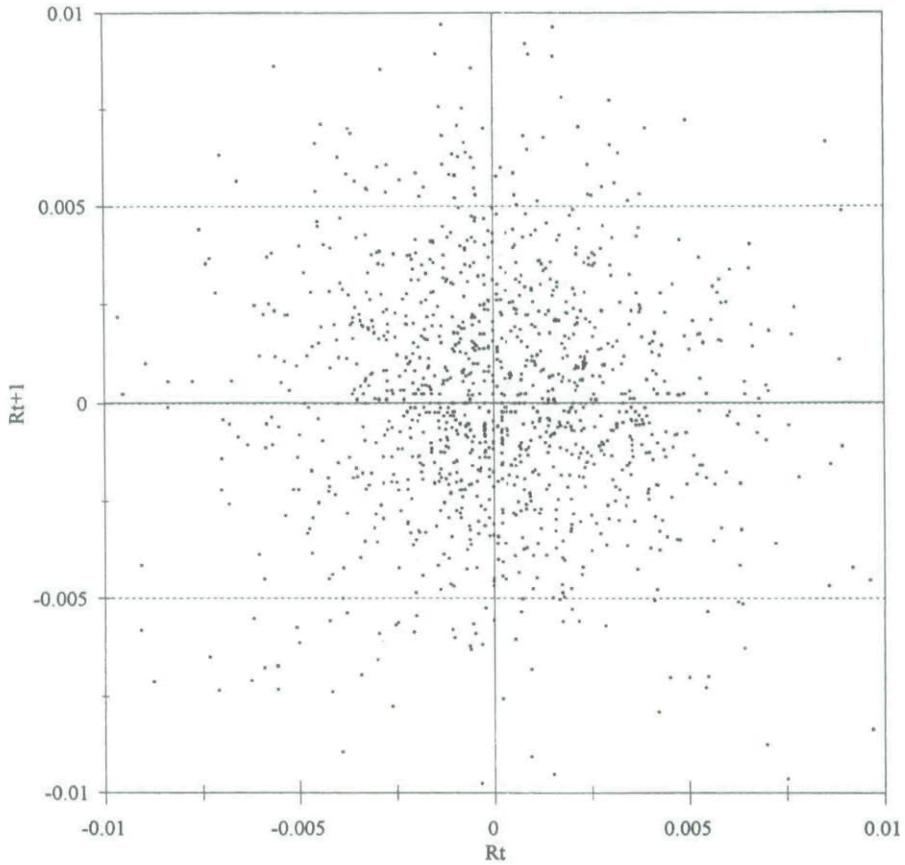

FIGURE 3A
German bond (bund) (BF). Deutsche Terminborse. Pattern screened at 1%.

RESULTS

Figure 1 reports the return patterns of the two sugar contracts traded in the CSCE. Figures 1A, 1B, and 1C show the patterns for the Sugar #11/ World Raw contract (symbol SB). When all the available 8192 observations are used in the plot of the diagram, the resulting graph, shown in Figure 1A, does not resemble the compass rose pattern. By eliminating 1287 observations that are greater than 5% in magnitude in either R_t or R_{t+1}, the pattern starts to emerge in Figure 1B, although it is not that obvious. Only after eliminating 3390 observations with R_t or R_{t+1} exceeding 3% in magnitude is the pattern clearly present in Figure 1C. The notable rays in the figure are those pointing to the east, west, north, south, northeast, east northeast, north northeast, northwest, north northwest, west northwest, southwest, west southwest, south southwest, south southeast, and east southeast.

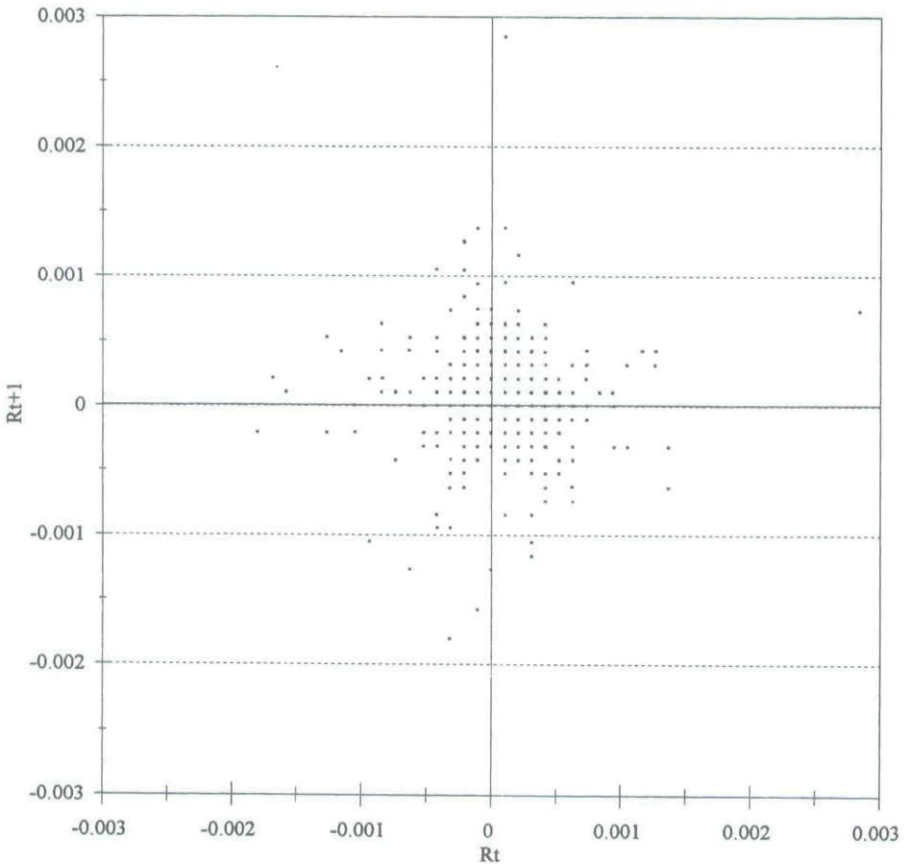

FIGURE 3B (Continued)
FIBOR, 3-month (EF). Deutsche Terminborse. Pattern screened at 1%.

Figures 2A, 2B, and 2C show the patterns for the other sugar contract of CSCE, the Sugar #14/Domestic Raw (symbol SE). Again, using all of the 2157 available observations obscures the pattern, as shown in Figure 2A. After zooming in and removing returns that are greater than 3% in magnitude, one observes, in Figure 2B, a pattern resembling the compass rose—yet it is not quite the same. The compass rose pattern is unmistakably observed in Figure 2C only after further restricting the returns to a 1% limit. Notice that, for this contract, returns are so uniformly small, compared with those on the SB contract, that only 122 of the original 2157 observations have to be truncated to fit within the 1% limit. Because it is reasonable to question whether the pattern observed in Figure 2C is a compass rose pattern, we arbitrarily classify this contract as one without a compass rose pattern. However, one must keep in mind that there are only 2152 observations available for analysis and that it is

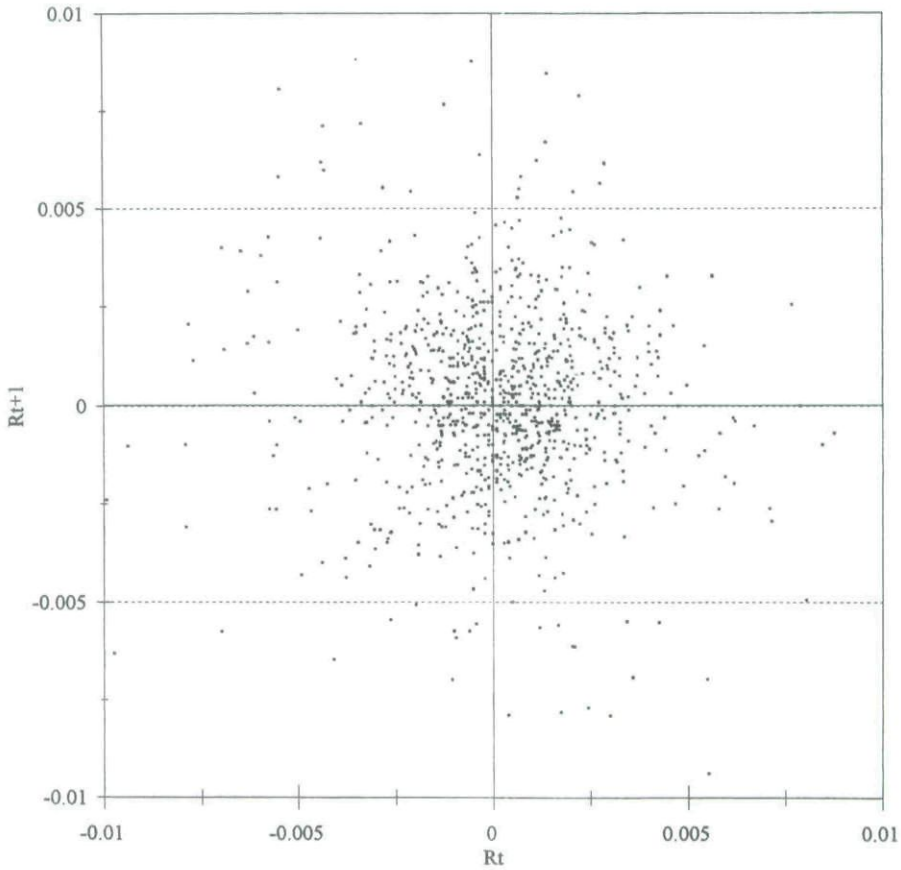

FIGURE 3C (Continued)
German bond, medium term (NB). Deutsche Terminborse. Pattern screened at 1%.

very likely, as more observations become available, the pattern may become more like the compass rose pattern.

One might get the impression from Figures 1 and 2 that, despite the several steps of screening that may be necessary to generate the pattern in a clear form, the compass rose pattern is present in most futures contracts. Figure 3 shows this is not the case. Figure 3A reports the return pattern of the German Bond contract (symbol BF) of the Deutsche Terminborse (DTB). Even after restricting returns to a 1% limit, with resulting observations of 1197 (from the original 1264), the compass rose pattern is noticeably absent. On the other hand, with only 425 observation in the whole sample and 418 observations within the 1% limit, a grid pattern emerges in Figure 3B for the 3-Month FIBOR contract (symbol EF). It appears that the number of observations, though important, is not the sole factor determining whether one can observe the compass rose

TABLE II

Summary of Futures Contracts With/Without the "Compass Rose" Pattern[a]

Exchange	*Contracts with Pattern*	*Tick*	*Effective Tick*	*Exchange*	*Contracts without Pattern*	*Tick*	*Effective Tick*
	Industrials: 0 (0%)				Industrials: 10 (100%)		
				KRE	YU: Rubber RSS #3	¥0.1	¥0.1
				KRSE	YQ: Silk, Raw	¥1.0	¥1.0
				MATIF	YB: Cocoons, Macbashi Dried	¥1.0	¥1.0
				NTE	YO: Cotton Yarn #20, Osaka	¥0.10	¥0.10
				OTE	YP: Wool Yarn, Osaka	¥1.0	¥1.0
				OTE	YV: Cotton Yarn #40, Osaka	¥0.1	¥0.1
				OTE	YY: Cotton Yarn #20, Osaka	¥0.1	¥0.1
				TOCOM	YC: Cotton Yarn #40	¥0.10	¥0.10
				TOCOM	YR: Rubber #3	¥0.10	¥0.10
				TOCOM	YW: Wool #48	¥1.0	¥1.0
	Currencies: 0 (0%)				Currencies: 7 (100%)		
				MEFF	MM: Deutsche Mark/Spanish Peseta	0.01	0.01
				SIMEX	DY: U.S. Dollar/Japanese Yen, Deferred Spot	¥0.01	¥0.01
				SIMEX	GX: Deutsche Mark/U.S. Dollar	$0.0001	$0.0001
				SIMEX	JX: Japanese Yen/U.S. Dollar	$0.000001	$0.0001
				SIMEX	PX: British Pound/U.S. Dollar	$0.0002	0.0002
				SIMEX	UR: U.S. Dollar/Deutsche Mark, Deferred Spot	DM0.0001	DM0.01
				TIFFE	DT: U.S. Dollar/Japanese Yen	¥0.05	¥0.05
	Indices: 2 (10%)				Indices: 20 (90%)		
IOM	BC: Major Market Index (intraday)	0.05	0.05	EOE	AX: Amsterdam EOE Index	0.05	0.05
LCE	FB: Freight Index	1	1	HKFE	HC: Hong Seng, Commerce & Industry	1	1
				HKFE	HN: Hong Seng, Financial Sub-Index	1	1
				HKFE	HP: Hong Seng, Property Sub-Index	1	1
				HKFE	HS: Hong Seng Index	1	1
				HKFE	HT: Hong Seng, Utility Sub-Index	1	1
				IOM	BC: Major Market Index (daily)	0.05	0.05
				IOM	SP: S&P 500 Index (daily)	0.05	0.05
				LIFFE	X-: FT-SE 100 Index	0.5	0.5
				LIFFE	Y-: FT-SE MID 250 Index	0.5	0.5
				MATIF	MX: CAC-40 Index	0.5	0.5
				MEFF	IX: IBEX 35 Index	0.50	0.50
				NZFOE	IZ: Capital Share Price Index	1.00	1.00

TABLE II (Continued)

Summary of Futures Contracts With/Without the "Compass Rose" Pattern[a]

Exchange	*Contracts with Pattern*	*Tick*	*Effective Tick*	*Exchange*	*Contracts without Pattern*	*Tick*	*Effective Tick*
				OSE	NO: Nikkei 225 Index	¥10	¥10
				SIMEX	NX: MCSI Hong Kong Stock Index	0.5	0.5
				SFE	IS: All Ordinaries Share Price Index	0.1	0.1
				SOFFEX	SZ: Swiss Market Index	0.10	0.10
				TSE	TT: TOPIX Index	1.00	1.00
				TOR	TV: Toronto 100 Index	0.05	0.05
				TOR	TX: Toronto 35 Index	.02	0.02
	Foodstuffs: 10 (42%)				Foodstuffs: 14 (58%)		
CSCE	SB: Sugar #11 (World)	$0.0001	$0.01	CSCE	SE: Sugar #14 (Domestic)	$0.0001	$0.01
FOX	BB: Barley, EEC	£0.05	£0.05	FOX	FP: Potatoes	£0.10	£0.10
FOX	FH: Live Pigs	£0.10	£0.10	FOX	LD: Coffee, Robusta Dollar	$1.00	$1.00
FOX	FW: Wheat EEC	£0.05	£0.05	FOX	LW: Sugar $5, White	$0.10	$0.10
KLCE	KK: Palm Kernel Oil, Crude	RM 1.0	RM 1.0	KLCE	KP: Palm Oil	RM 1.00	RM 1.00
MATIF	ME: Rapeseed, Deutsche Mark	DM1	DM1	MATIF	MJ: Rapeseed, French Franc	FF 0.01	>FF 0.01
TGE	TF: Sugar, Raw	¥10	¥10	LCE	LS: Sugar, #6 Raw	$0.01	$0.01
WCE	WA: Barley, Western/No. 1	$0.10	$$0.10	MATIF	MQ: Potatoes	FF 0.25	FF0.25
WCE	WR: Rye/No. 1	$0.10	$0.10	MATIF	MZ: Rapeseed, U.S. Dollar	$0.01	>$0.01
WCE	WW: Wheat, Domestic Feed/No.	$0.10	$0.10	TGE	CV: Corn, #3	$0.00125	$0.10
				TGE	YM: Soybeans	¥10	¥10
				TGE	YZ: Azuki Beans	¥10	¥10
				WCE	WC: Canola/No. 1	$0.10	$0.10
				WCE	WF: Flaxseed/No. 1	$0.10	$0.10
	Financials: 25 (56%)				Financials: 20 (44%)		
CBOT	FV: Treasury Note, U.S., 5-year	1/64	1/64	CBOT	US: Treasury Bonds, U.S., 30-year	1/32	1/32
DTB	EF: FIBOR, 3-Month	0.00005	0.0001	DTB	BF: German Bond (Bund)	0.0001	0.0001
HKFE	HB: HIBOR, 3-Month	0.0001	0.0001	DTB	NB: German Bond, Medium-Term (BOBL)	0.0001	0.0001
LIFFE	E-: Eurodollar, 3-Month	0.0001	0.0001	EOE	FT: Guilder Bond	0.0001	0.0001
LIFFE	F-: Euroswiss, 3-Month	0.0001	0.0001	LIFFE	A-: German Bond (Bund)	0.0001	0.0001
LIFFE	G-: Gilt, Long	1/32	1/32	LIFFE	I-: Italian Government Bond (BTP), 10-Year	0.0001	0.0001
LIFFE	L-: Short Sterling, 3-Month	0.01	0.01	LIFFE	J-: Yen Bond, Japan, 20-Year	0.0001	0.0001
LIFFE	U-: Euromark, 3-Month	0.00005	0.0001	LIFFE	V-: Eurolira, 3-Month	0.0001	0.0001
LIFFE	Z-: ECU, 3-Month	0.0001	0.0001	MATIF	MN: Notional Bond, 10-Year	0.0002	0.0002

TABLE II (Continued)

Summary of Futures Contracts With/Without the "Compass Rose" Pattern[a]

Exchange	*Contracts with Pattern*	*Tick*	*Effective Tick*	*Exchange*	*Contracts without Pattern*	*Tick*	*Effective Tick*
MATIF	MP: PIBOR, 3-Month	0.0001	0.0001	MATIF	MU: ECU Long-Bond	0.0002	0.0002
MEFF	HM: MIBOR, 90-D., PLUS	0.0001	0.0001	MEFF	KM: Notional Bond, 10-Year	0.0001	0.0001
MEFF	JM: MIBOR, 90-Day	0.0001	0.0001	MEFF	QM: MIBOR, 360-Day, Plus	0.0001	0.0001
MEFF	LM: Notional Bond, 3-Year	0.0001	0.0001	ME	CE: Canadian Government Bond, 5-Year	0.0001	0.0001
MEFF	OM: MIBOR, 360-Day	0.0001	0.0001	ME	CG: Canadian government Bond, 10-Year	0.0001	0.0001
ME	BA: Canadian Bankers Acceptance, 1-Month	0.0001	0.0001	MIF	MF: Italian Long Bond	0.0litl	0.0001
ME	CA: Canadi Bankers Acceptance, 3-Month	0.0001	0.0001	MIF	MH: Libor, 1-Month	0.0litl	0.0001
SIMEX	MS: Euromark, 3-Month	0.0001	0.0002	NZFOE	ZZ Treasury Bonds, New-Zealand, 3-Year	0.01	0.01
NZFOE	BZ: Bank Accepted Bill	0.0001	0.0001	SOFFEX	SW: Swiss Bonds	0.001	0.001
NZFOE	UZ: Treasury Bonds, New-Zealand, 10-Year	0.0001	0.0001	SIMEX	DS: Eurodollar	0.001	$0.0001
SIMEX	SY: Euroyen, 3-Month	0.0001	0.0001	TSE	BT: Yen-Bond, Japan, 10-Year	0.0001	0.0001
SFE	BS: Bank Accepted Bill	0.0001	0.0001				
TIFFE	ET: Euroyen, 1-Year	0.0001	0.0001				
TIFFE	IT: Euroyen 3-Month	0.0001	0.0001				
TSE	GT: Treasury Bonds, U.S., 30-Year	1/32	1/32				
TSE	JT: Treasury Bonds: Japan, 20-Year	0.0001	0.0005				
	Metals: 3 (60%)				Metals: 2 (40%)		
HKFE	GK: Gold	$0.10	$0.50	SIMEX	SG: Gold	$0.05	$5
TOCOM	YA: Palladium	¥1.0	¥1.0	TOCOM	YI: Silver	¥0.01	¥0.01
TOCOM	YG: Gold	¥1.0	¥1.0				
	Energy: 3 (60%)				Energy: 2 (42%)		
IPE	GS: Gasoline, Unleaded	£0.25	£0.25	IPE	CB: Crude Oil, Brent Global Spot	$0.01	0.01
IPE	LF: Gas-Oil-Petroleum	$0.25	$0.25	SIMEX	CX: Crude Oil, Brent	$0.01	$0.01
SIMEX	FS: High Sulphur Fuel Oil	$0.10	$0.10				
	Total: 43 (36%)				Total: 75 (64%)		

[a]The exchange name, the contract name, tick size, and effective tick size are provided for contracts with and without the pattern.

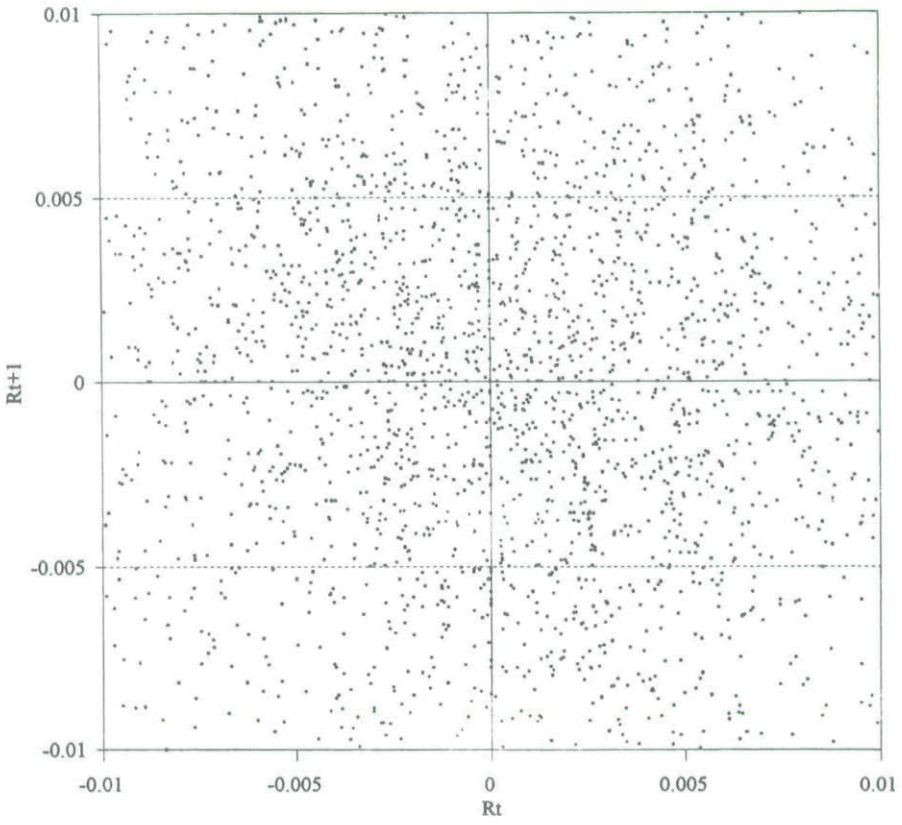

FIGURE 4A
S&P 500 Index (daily (SP). Index & Options Market (CME). Pattern screened at 1%.

pattern. Further evidence to support this argument is provided in Figure 3C for the Medium-Term German Bond contract (symbol NB), which has 927 observations (from the whole sample of 950) within the 1% limit. Despite about twice the number of observations, compared with the 418 for the EF, the compass rose pattern is not observed in the NB.

In discussing the exception to the robust existence of the compass rose pattern, Crack and Ledoit (1996) specifically mention market indices. This comment prompts us to examine a number of futures contracts on stock indices, including all five contracts on the Hong Kong Futures Exchange, the CAC-40 index of MATIF, the IBEX Index of MEFF, the All Ordinary Share Price Index of the Sydney Futures Exchange, and the Toronto-100 and -35 Indices of the Toronto Stock Exchange. For the U.S. stock index futures contracts, we examine the S&P 500 Index contract (symbol SP) and the MMI contract (symbol BC) of the Index and Options Market of the CME. None of these index futures contracts exhibit the

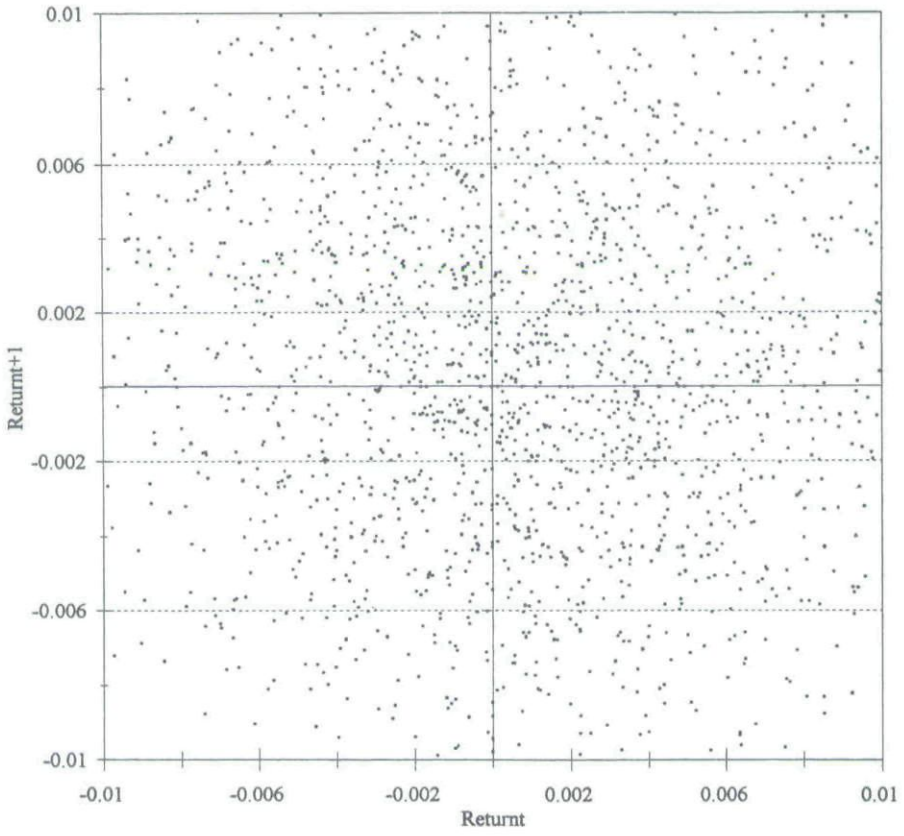

FIGURE 4B (Continued)
Major Market Index (daily) (BC). Index & Options Market (CME). Pattern screened at 1%.

compass rose pattern. To conserve space, only the results for SP and BC are reported in Figures 4A and 4B.

Figures 4A and 4B show that the daily returns for these two indices do not exhibit the compass rose pattern. However, for many traders, the intraday price series are of more interest than the daily price series. Thus an analysis of intraday returns is warranted. The intraday 5-minute returns for BC are reported in Figure 4C. In sharp contrast to the lack of the pattern for the daily return series, the intraday returns for the same BC contract clearly show a pattern that resembles the compass rose pattern. The qualifying word *resembling* is used because one might question whether the pattern is strictly a compass rose pattern, because it shows a more apparent horizontal and vertical grid-type pattern. However, as one considers the much smaller returns associated with the 5-minute

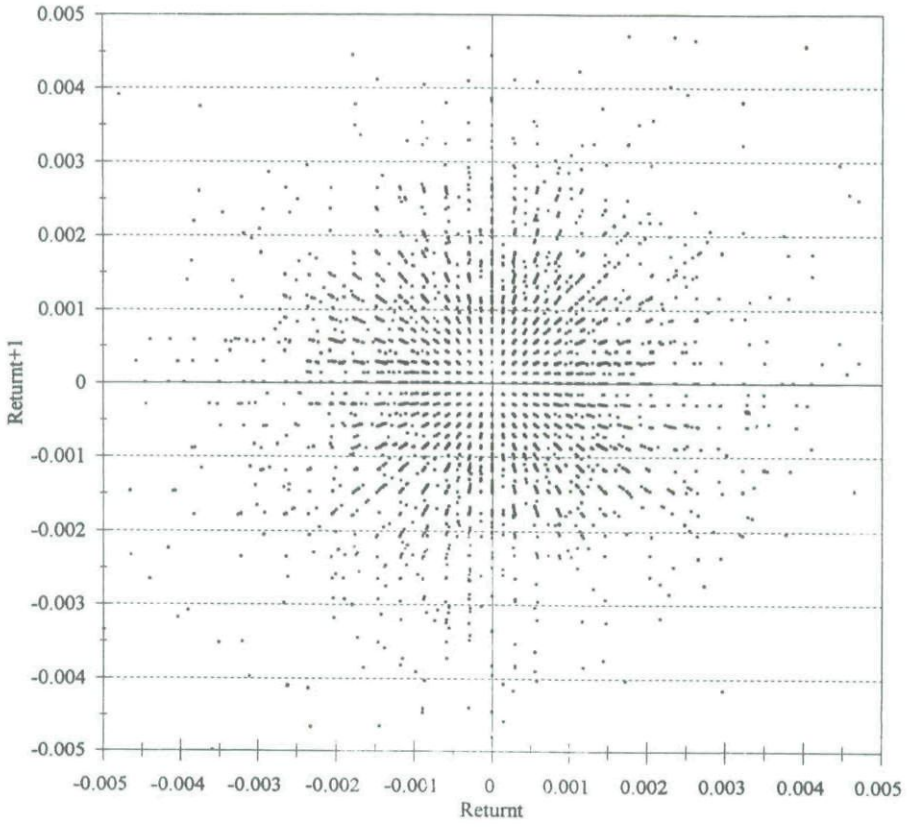

FIGURE 4C (Continued)
Pattern for Major Market Index (intradaily) (BC). Index & Options Market (CME).

time interval, the labeling of the pattern becomes less relevant for practical purposes. It remains that the intraday BC contract exhibits a pattern.

On a related issue of whether the compass rose pattern can be observed for a portfolio of two futures contracts, we also examine a portfolio composed of the futures contracts on the U.S. Treasury 30-year bonds (US) and the U.S. Treasury 5-year notes (FV), traded on the CBOT. We construct a note-over-bond (NOB) contract by going long on one notes contract and going short on one bonds contract. As shown in Figures 5A–5C, the pattern is present in the notes contract and is not present in the bonds contract or the NOB portfolio. It appears that in forming the NOB contract, the effective tick becomes half of the average effective ticks for the US and the FV contracts, thereby violating Crack and Ledoit's second condition that daily price changes are in discrete jumps of a small number of ticks.

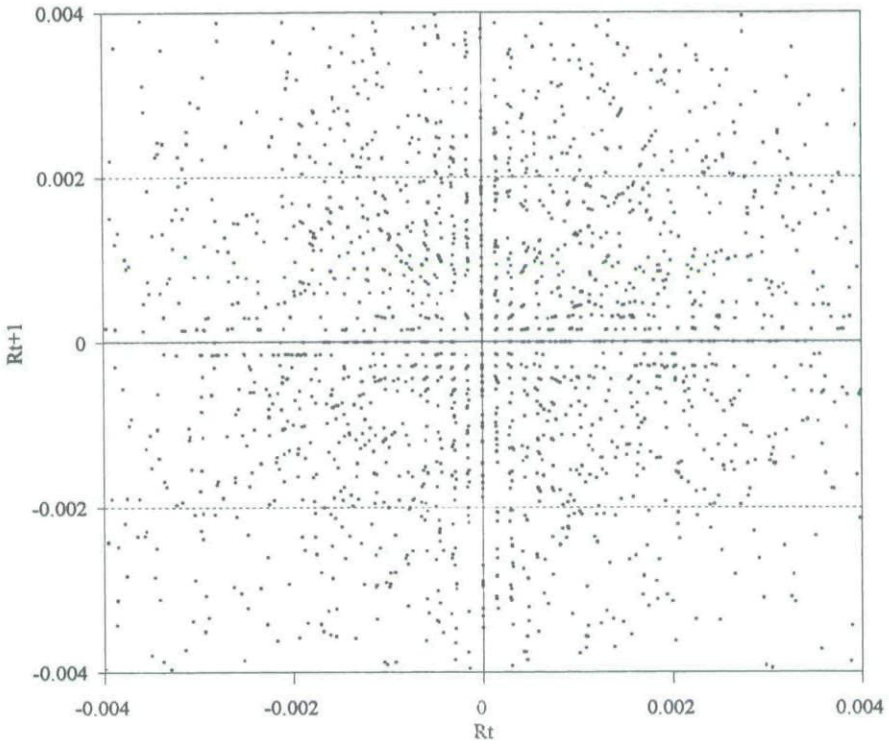

FIGURE 5A
Pattern for U.S. treasury note (5-year) (FV) contract. Chicago Board of Trade.

Table II summarizes the results for all contracts, arranged into seven sectors. For industrials, the pattern is not observable for any of the 10 contracts. The same result is also observed for the seven currency contracts. Two of the twenty-two indices contracts, or 10%, exhibit the pattern. Ten, or 42%, of the foodstuff contracts show the pattern, whereas 25, or 56%, of the financial futures exhibit the pattern. A majority of the metals and energy contracts show the pattern. The results suggest that the pattern may be more prevalent in some sectors, when compared with others. Sectors in which the percentage of contracts with the pattern deviates substantially from the overall average of 36% appear promising for further research.

We also examine both the official tick size and the effective tick size—defined as the typical actual price change for each contract—and conclude that it is not evident at all that the effective tick size, relative to the official tick size, matters in determining the existence of the compass rose pattern. This is because for most contracts the effective and official tick sizes are identical, and some contracts exhibit the pattern

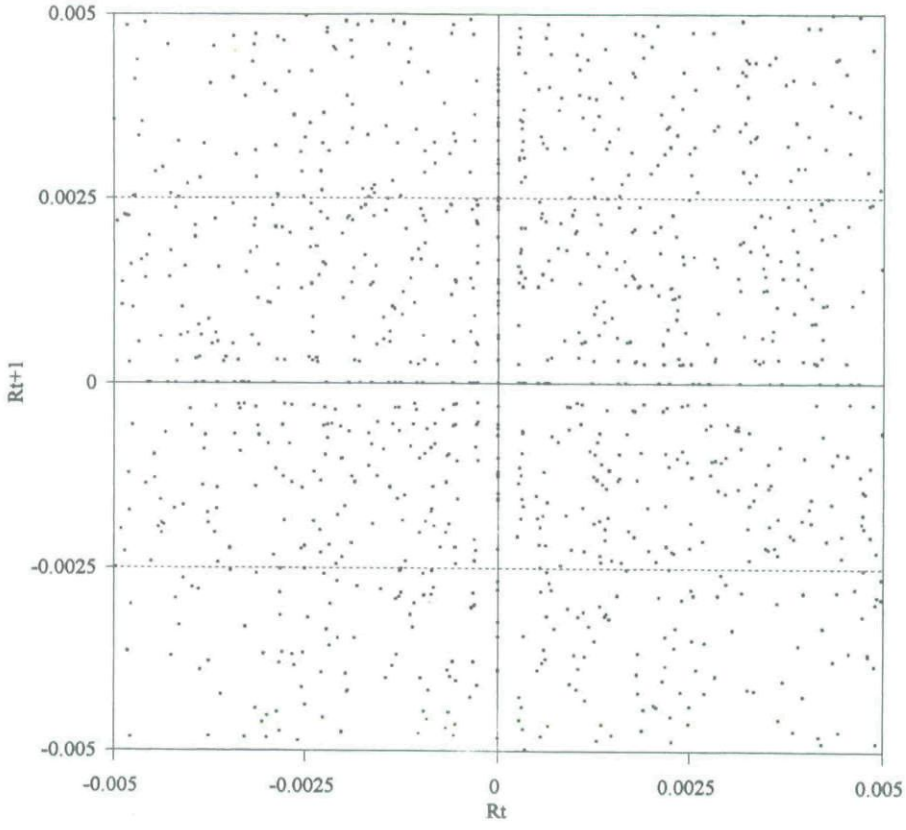

FIGURE 5B (Continued)
Pattern for U.S. treasury note (30-year) (US) contract. Chicago Board of Trade.

whereas others do not. For contracts with effective tick size greater than the official tick size, some (for example, SB, Sugar #11 (world) of CSCE and HB, the 3-month HIBOR of HKFE) exhibit the pattern whereas others (for example, MJ, the rapeseed of MATIF and SB, Sugar #14 (domestic) of CSCE) do not.

An interesting issue to consider is whether price limits have an impact on the existence of the compass rose pattern. Our sample includes contracts with varying levels of limits relative to the tick size, as well as contracts without limits. We are not able to discern any pattern that would suggest that either the presence or the lack of limits has any influence on the existence of the pattern. Chen (1997) reports similar results.

The elusiveness of the compass rose pattern is further demonstrated by the examination of the cash S&P Index returns. Crack and Ledoit (1996) state that the pattern is altogether absent in market indices. A look at Figure 5D, produced with the same bounds used by Crack and

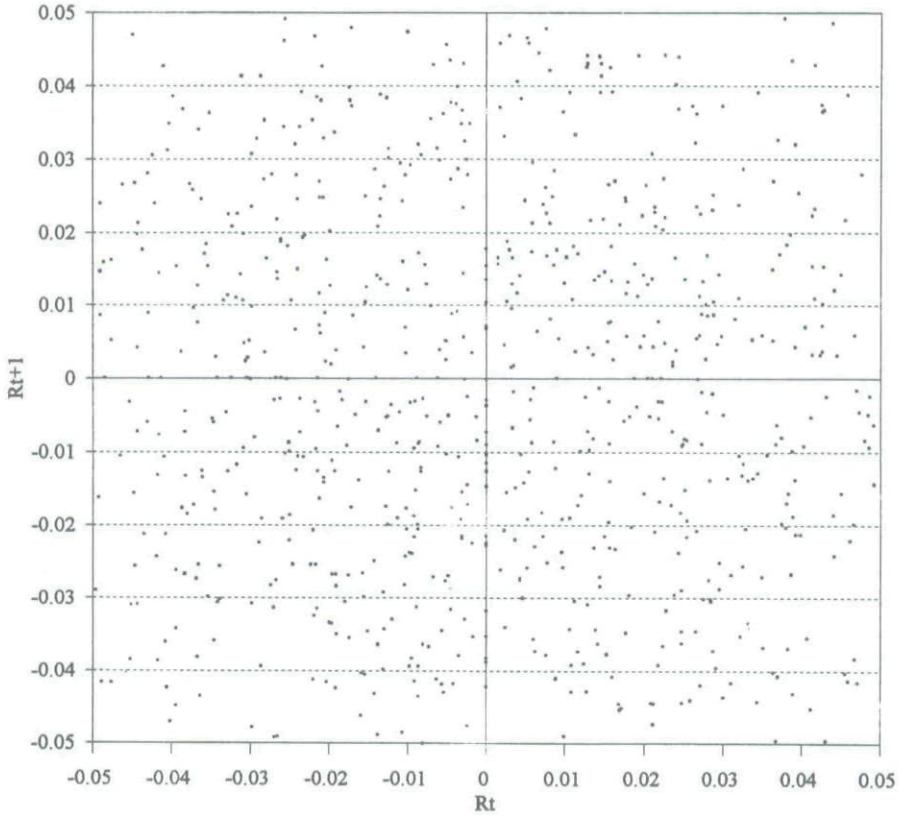

FIGURE 5C (Continued)
Pattern for synthetic (NOB) portfolio.

Ledoit (1996), show the correctness of their statement. However, after zooming in to within the 1% bound, the pattern emerges, as shown in Figure 5E.

CONCLUSIONS

Overall, the results from this study show that the compass rose pattern exists only in some futures contracts, unlike the robust existence among stocks documented in Crack and Ledoit (1996). Not all contracts traded on the same exchange show the pattern, which suggests that microstructure, other than the effective price limits of the contracts in any particular exchange, may not be the factor responsible for the presence of the pattern. That the effective price limit of each contract is the one determinant of the pattern is based on the observation that the pattern emerges for some contracts at higher limits of screening, say 3%, whereas other con-

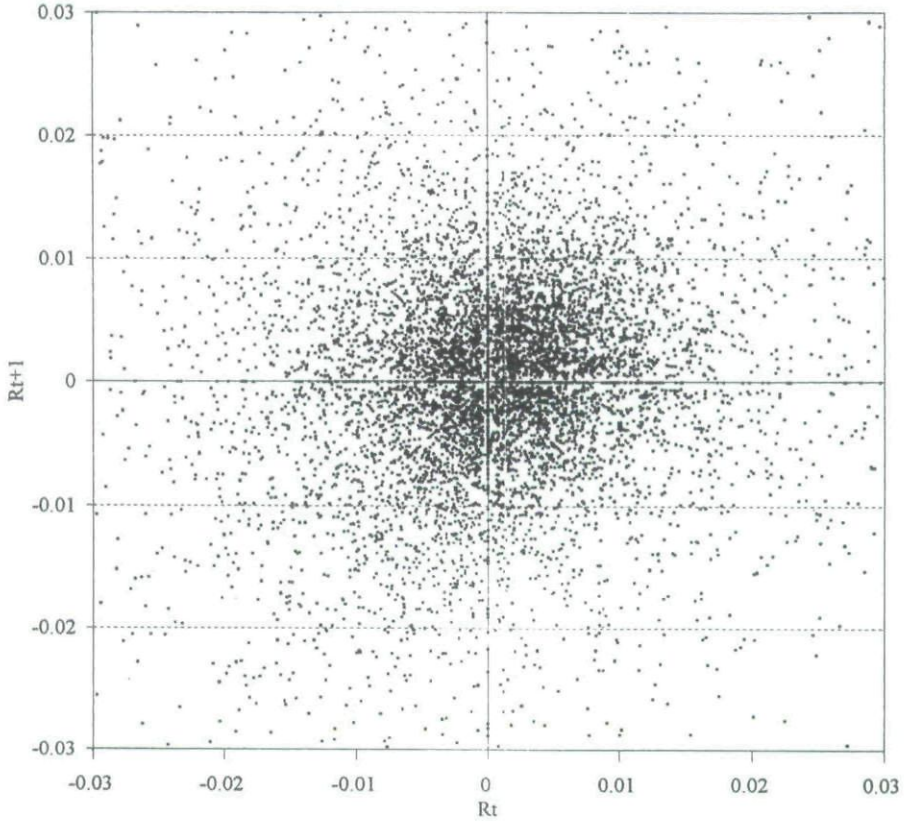

FIGURE 5D (Continued)
Cash S&P 500 Index daily returns. Pattern screened at 3%.

tracts require further screening at a tighter range, that is, within 1%. Even for contracts in which the pattern finally emerges after repeated screening of returns, the pattern can be elusive. For contracts in which the pattern is nonexistent, large numbers of observations do help in generating the pattern. However, the pattern is evident for some contracts even if the number of observations is small.

An interesting finding is that the presence of the pattern is not consistent across different categories of contracts. For example, the pattern is totally absent in industrial and currency contracts, and is more prevalent in metals and energy contracts. Further, research is indicated on a possible relationship between contract sector and the possibility of observing the pattern.

The finding that the pattern exists for intraday returns but not for daily returns on the MMI futures contract is unique and suggests that for futures contracts, where short-term trading is more prevalent, the

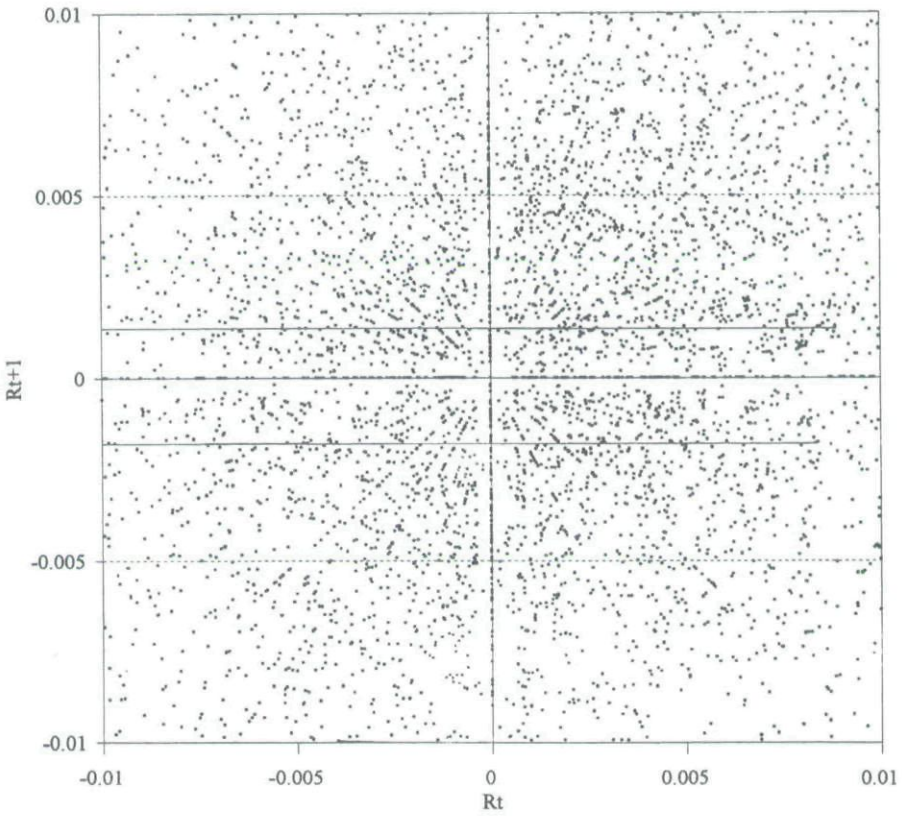

FIGURE 5E (Continued)
Cash S&P 500 Index daily returns. Pattern screened at 1%.

pattern may be more visible for the intraday returns series rather than daily returns series. Further study is needed to test this conjecture. The elusiveness of the compass rose pattern is further illustrated by the examinations involving the S&P 500 Index. The finding of the existence of the pattern in intraday returns but not in daily returns on the S&P 500 Index futures contracts is unique. The presence of the pattern in the cash S&P 500 Index is in contrast to the statement by Crack and Ledoit (1996) that stock indices do not exhibit the pattern.

Finally, it is possible that the compass rose pattern may hold the potential for improved forecasts with ARMA-GARCH procedures for those futures contracts in which the pattern is evident. Bollerslev, Chou, and Kroner (1992) show that low-order ARMA-GARCH procedures adequately model conditional heteroskedasticity. An out of sample forecast from an ARMA-GARCH model could be compared with the points on a compass rose, and the forecast could be adjusted to the closest point on

the pattern, with the forecast assuming the value of the second coordinate. However, this is an area that merits further research.

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