Bad Days and Good Nights:
A re-examination of Non-Traded and Traded Period Returns

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Abstract

We find an anomaly for traded and non-traded period returns for major non-US stock markets. Returns were significantly negative over trading periods and positive over non-traded periods, while for US stock markets, both non-traded and traded period returns were positive. This anomaly appears to be due to differences in regulatory risk management requirements for equity derivative market-makers. The introduction of Basle I based capital requirements appears to have amplified the anomaly.

Keywords: Stock Market Anomalies, Return Decomposition, Close to Open, Open to Close, Skewness, Kurtosis, Basle I, Capital Requirements, Risk Management

JEL classification:

1. INTRODUCTION

According to the weak form of the efficient markets hypothesis, the stock market is efficient with respect to all past price and trading volume information and investors should not be able to use this information to exploit abnormal returns. However, researchers have identified many different anomalous patterns, including a number of calendar based patterns such as the January effect, the turn-of-the-month effect, and the weekend (or Blue Monday) effect. Furthermore, several studies have concluded that these market inefficiencies would enable investors to earn superior returns.[1] Although for many of these strategies, the returns are often eliminated when transaction and impact costs are considered.

In this research, we return to a previously considered problem – the non-trading versus trading period effect – and do so in a new light with a new data set. We find a new anomaly for non-US stock markets, which is simple and yields significant positive returns relative to the standard buy and hold strategy. As this strategy is implemented using stock index futures, the transaction and impact costs are sufficiently small to remain even after such costs are considered. We show that for the Japanese stock market from 1988 to 2008 (which experienced an average loss of 3.3% per year) the anomaly trading strategy yielded an average positive return over the same period of 11.24% (6.5% after costs).

The anomaly is based upon the difference between stock market returns realised during trading periods versus non-traded periods. For the US Market, we find that the mean and variance of returns for non-traded periods are significantly less that those of the traded period returns. Hong and Wang (1995) also report lower returns, while Fama (1965), French (1980) and French and Roll (1986) all found that the variance of returns are significantly lower when the US stock market is closed compared to opened. For the higher moments of both return distributions, we find that non-traded period returns display much greater non-normality compared to the trading period returns. This result is also consistent with the concept of "business time" [Geman, Madan & Yor, (2001)], which indicate that during trading time (markets are open), the process approaches a normal diffusion and that non-trading time (markets are closed) introduces non-normality in the return distribution.

For three European stock markets and for Japan, we find non-traded period returns also have significantly lower variance with more significant higher moments but the mean returns are significantly higher than traded period returns. Furthermore, for all four non-US markets considered, the return during trading periods is significantly negative. These results have also been presented in the literature (see Compton and Kunkel (2003) for evidence on European stock markets and Comolli and Ziemba (2000) for the Japanese stock market). However, we are unaware of any research which implements this anomaly using stock index futures and considers the change in this anomaly since these earlier papers.

In this research, we consider this puzzling result. Why do non-US stock markets generate losses during the trading day with positive returns realised solely in non-traded periods? We show that this difference cannot be explained by preferences for higher moments, arrival of private or macroeconomic information or investment restrictions. It appears that differences in risk management approaches associated with different regulatory environments between the US and the other markets are the most likely reason. Finally, we consider the implications that the distribution of non-trading period returns display more non-normality relative to trading day returns. We conclude that trading day returns follow some diffusion and that non-trading day returns follow a jump process. This is relevant to risk management, portfolio optimisation and investment.

Given our work is intimately related to the trading/non-trading period effect literature, we will review the major work in this area and indicate where our research extends and contributes to this literature. When estimating stock market returns, it is common practice to consider daily observations and use closing prices as the input variable. Clearly, this will lead to errors if the returns over subsequent closing prices display some dependence. Given that such closing prices do not always follow on consecutive days (due to weekends and holidays), daily returns have been decomposed into returns for particular days of the week (month or year) and over weekends and holiday periods. The evidence that that daily returns do not display the same characteristics for different days. This has led to a number of anomalies being identified. Such sub periods have identified the Weekend Effect[2], Day of the Week Effects[3] and

Holiday Effects[4]. These studies have generally estimated returns using the closing prices from one day to the next.

French (1980) first identified the weekend effect while studying daily stock returns from 1953 to 1977. French finds a "weekend effect" where Monday's mean return is significantly less that zero, while the other weekday returns are significantly greater than zero. Lakonishok and Smidt (1989) test the weekend effect using ninety years of data from 1897 to 1987. Like French, they find a strong weekend effect where Monday's mean return is significantly negative. French's weekend effect has also been found in many other asset groups including futures, Treasury securities, investment grade corporate bonds, and junk bonds.

Several intraday studies have found that most of Monday's negative return occurs over the weekend, from Friday's close to Monday's open. Rogalski (1984) examines the U.S. stock market from 1974 to 1984 to see whether the weekend effect is a closed market effect by decomposing daily close-to-close returns into: (i) a non-trading (or close-to-open) return and (ii) a trading (or open-to-close) return. Rogalski finds a unique twist to the weekend effect where the Monday non-trading return (Friday close-to-Monday open) is negative while the Monday trading return (Monday open-to-Monday close) is similar to the trading returns of other weekdays. Rogalski concludes that the weekend effect is generated over the weekend when the stock market is closed. Researchers have also identified a weekend effect in international markets. Jaffe, Westerfield, and Ma (1989) find a weekend effect in the stock markets of Australia, Canada, Japan, and the United Kingdom. While Agrawal and Tandon (1994) examine stock data from eighteen countries and find that nine countries have their lowest, and negative, returns on Monday.

Of additional interest is the behavior of stock market returns within a day. Many stock markets are open for only a subset of the day (typically approximately 1/3 of the 24 hours in a day) and are closed for the remainder. Research has considered the differences between returns estimated using the closing prices and returns from the previous day's closing price to the opening price of the following trading day. Bessembinder and Hertzel (1993), Blandon (2007) are representative of such work. Probably the most important early work in this area is by Fama (1965), French (1980), French and Roll (1993) who identified that the variance of the non-traded period is significantly less that the variance of the trading period. These papers concentrated on the US stock market and tended to find that the non-traded mean return was less than returned earned during the trading day. Hong and Wang (1995) are only one representative paper which indicates returns for the non-traded period are lower. Much of the emphasis of this line of research has been to point out that the variance for non-traded periods is significantly lower than during the traded period. Fama (1965), French (1980) and French and Roll (1986) all found that the variance of returns are significantly lower when the US stock market is closed compared to open.

In research on the weekend effect for Europe, Compton and Kunkel (2003) also examine returns for European stock markets over non-traded versus traded periods and find that the return during non-traded periods is positive for almost all European stock markets and negative for almost all traded periods. Apart from rejecting the existence of a weekend effect for Europe, it is curious that Compton and Kunkel (2003) failed to expand this result. They hypothesize that the reason for greater closed market returns was that their data set was chosen during a bear market period. They suggest that future research should test this hypothesis to "determine whether this pattern reverses during bull markets and whether is persists in European and other markets". This is accomplished with this research. We will show that this non-trading period higher return is realized both in bull and bear markets. In fact, we find that when the overall stock market falls, the strategy still makes a positive return and has an even greater positive return when the stock market rises.

This paper is organized as follows. The following chapter discusses the data sources and time periods of analysis for five major stock index futures markets. These are the most actively traded futures contracts on broad based stock market indices for the United States (S&P 500), Britain (FTSE 100), Germany (DAX), France (CAC) and Japan (Nikkei 225). Futures markets are selected as the appropriate markets to examine due to the transparency of futures prices and that both the opening and closing futures prices represent actual transactions by market participants. Subsequently, when we consider trading strategies associated with the "statistical" anomaly, we are confident that such trading strategies would have been possible over the alternative time periods (with minimal transaction and impact costs). This will be followed by an examination of the distributional properties of stock index futures returns over the alternative time periods, close to close, close to open and open to close. By using a kernel estimation method, we will determine the density of the alternative returns and show that there are considerable differences between them. Rather than restrict our analysis to the variance (as has been previously done), we will consider all the moments of the density including the mean, skewness and kurtosis. We find that there are significant differences between the trading period returns (opening price to closing price O/C) and non-traded period returns (closing price to opening price C/O). As the close to close returns (C/C) is simply a combination of the two, we report that for all the stock markets considered, the distribution is non-normal. However, the vast majority of the positive return (mean) is achieved when the market is closed. In addition, almost all non-normality (i.e. non-zero skewness and excess kurtosis) also occurs overnight. During the trading day, the distribution is symmetrical and only slightly leptokurtic.

Using stochastic dominance arguments, we show that for three of the five stock index futures markets, the non-trading period density display second and third order stochastic dominance over the trading period density. This is found for the FTSE, DAX and Nikkei markets.

The next section considers a trading strategy based upon these results. We implement a stock index futures strategy of buying the futures at the close and selling at the opening (C/O) and compare this with buying the futures at the opening and selling at the close (O/C) and the usual buy and hold strategy (C/C). Using the usual wealth relative approach, we compare how such strategies would have performed (with and without transaction costs) over the period from the early 1990s to 2007. We find that for the S&P 500, trading overnight is not profitable. However, for all other four stock markets, the overnight strategy is profitable with the lowest variance of the three alternative strategies. Apart from the CAC, the non-traded period strategy is the top performing strategy for all non-US stock markets.

The next section considers why this anomaly may exist. Why do non-US stock markets generate losses during the trading day with positive returns realised solely in non-traded periods? We show that this difference cannot be explained by preferences for higher moments, arrival of private or macroeconomic information or investment restrictions. It appears that differences in risk management approaches associated with alternative regulatory environments between the US and the other markets are the most likely reason. In the previous section, we observed that the pattern of gains for the non-trading period strategy tended to increase for all four non-US stock markets after the middle of 1998. This corresponds to the point when the Basle I accord was implemented by European banks (and a similar approach implemented by banks in Japan). We find evidence that the change in the non-trading period anomaly occurs concurrently with the implementation of the VaR approach to the management of market risk brought about by Basle I.

Next, we consider the implications that the distribution of non-trading period returns display more non-normality relative to trading day returns. We conclude that trading day returns follow some diffusion and that non-trading day returns follow a jump process. This is relevant to risk management, portfolio optimization and investment. Finally, we summarize and suggest areas for future research.

1. DATA SOURCES

The markets considered for this research include five of the largest stock markets traded worldwide. These include the S&P 500 (US), FTSE 100 (UK), Germany (DAX), France (CAC) and Nikkei (Japan). As of the end of 2007, these 5 markets represent 75% of the overall global equity market. While the previous empirical research (referenced above) tended to examine cash stock market prices (or spot stock index values), we will examine stock index futures prices in this research. The primary reason for this is that opening and closing prices for stock market (indices) may not reflect simultaneous actual trading opportunities (see Stoll and Whaley (1990)).[5] Given that stock index futures prices reflect actual transactions and that the transaction costs when dealing in stock index futures is a small fraction of the cost of dealing in the stock market index itself, we will restrict our analysis to stock index futures on these five markets. The markets considered and the time period of the analysis can be found in Table 1.

Market	Stock Index Futures	
	Beginning	End
S&P 500	4/21/1982	11/16/2007
FTSE 100	3/1/1988	11/16/2007
DAX	1/21/1991	11/16/2007
CAC 40	1/3/1990	11/16/2007
Nikkei 225	9/5/1988	11/16/2007

Table 1, Stock Index Futures Markets Examined

The futures prices were obtained from the CME for the futures on the S&P 500, the LIFFE for the futures on the FTSE 100 and from the Deutsche Börse for the futures on the DAX. For the CAC 40 and the Nikkei 225, the futures prices were obtained from Bloomberg. The data included the opening price, high, low, and closing prices. For the futures contracts, only the nearest to expiration contracts were considered on the quarterly cycle (March, June, September and December) and the rollover to the next contract was assumed to be done at the expiration of the respective futures.[6]

2. EVALUATION OF STOCK INDEX FUTURES RETURNS

Having obtained the data, returns were determined for close to close prices (C/C), close to open prices (C/O) and open to close prices (O/C). Returns were determined using the natural logarithm of the ratio of the appropriate prices. The returns for the entire data period were determined and the summary statistics were estimated. This can be seen in Table 2. In this table, the first four moments of the daily returns for the nearest to expiration futures contracts appear. For convenience, the first two moments were annualized and the second moment was expressed as the standard deviation (multiplied by 252 or $\sqrt{252}$, respectively).

In the top panel of Table 2, the moments of the C/C return process for the five stock index futures markets appear. For four of the markets, the mean return was positive and, when annualized, ranged between 5.77% and 10% per year. For the Nikkei futures, the average return over the period from 1988 to 2007 was -3.33% per year. The annualized standard deviations (a.k.a. volatility) were all approximately equal to 20% per year. As has been pointed out extensively in the literature, the third and fourth moments reject the assumption that the return process is normally distributed.[7] For all stock index futures markets, except the Nikkei futures, the skewness statistic is significantly negative and for all markets the kurtosis measure is significantly higher than the normality assumption. This result has motivated a literature which considers alternatives to the usual Geometric Brownian Motion assumption when modeling stock market returns. However, we will not consider this problem here but simply point out that our results are consistent with the literature.[8]

Close to Close				
Markets	Mean (annualised)	Std Dev (annualised)	Skew	Kurtosis
S&P 500	10.00%	18.69%	-3.412	120.432
FTSE 100	6.38%	17.23%	-0.109	5.819
DAX	9.88%	22.50%	-0.142	8.753
CAC	5.77%	21.48%	-0.124	6.074
Nikkei	-3.33%	22.79%	-0.008	5.677
Open to Close				
Markets	Mean (annualised)	Std Dev (annualised)	Skew	Kurtosis
S&P 500	7.72%	**17.43%**	**-1.705**	**77.376**
FTSE 100	**-7.07%**	**14.69%**	**-0.026**	**6.683**
DAX	**-4.78%**	**19.32%**	**-0.368**	**7.753**
CAC	**-3.03%**	**18.30%**	**0.043**	**6.432**
Nikkei	**-14.60%**	**17.81%**	0.054	5.711
Close to Open				
Markets	Mean (annualised)	Std Dev (annualised)	Skew	Kurtosis
S&P 500	**2.30%**	**8.22%**	**-13.938**	**877.284**
FTSE 100	**13.45%**	**9.97%**	**-0.300**	**25.404**
DAX	14.66%	**12.29%**	-0.071	**15.699**
CAC	8.78%	**11.47%**	**-0.651**	**14.514**
Nikkei	**11.24%**	**13.78%**	-0.060	**13.020**

Table 2, Summary Statistics of Returns for Close/Close, Open/Close and Close/Open for 5 Stock Index markets.

In the middle panel of Table 2, the moments of the return process for the traded period appear i.e. from the opening of the futures market to the close. As can be seen, all four moments are different from those for the close to close returns. To assess statistical significance, tests of the moments of the distribution were conducted relative to the sample moments of the close to close period. If significant differences were observed at the 95% level (one tailed test) or above, the mean, standard deviation, skewness and kurtosis appear in bolded text in the table.[9] In all cases, the mean return is reduced relative to the close to close mean return. However, for the S&P 500, the mean remains positive (at 7.72%) and this is insignificantly different from the close to close mean. For the remaining 4 stock index futures markets, not only is the mean return significantly reduced relative to the close to close mean, but also are significantly negative relative to a null hypothesis of a zero return. For all five markets, the variances are significantly lower compared to the close to close variance. The degree of negative skewness is significantly reduced relative to the close to close return process for the S&P 500, FTSE 100 and the CAC. For DAX, the skewness is significantly more negative during the trading period and for the Nikkei, the skewness in the trading period is not significantly different from that of the close to close period. For all stock markets (except the Nikkei), the excess kurtosis is significantly reduced for the traded period returns versus the close to close returns.

In the bottom panel of Table 2, we find the summary statistics for the returns over non-traded periods (measured by the $Ln(O_t/C_{t-1})$). We observe substantive differences relative to the returns of both close to close and trading periods. Firstly, we observe that all five markets have average positive returns over the period. However, while the return for the S&P 500 is significantly reduced (relative to the close to close return), the FTSE 100 and Nikkei non-traded period mean returns are significantly higher (FTSE at a 90% significance level). For all five markets, the variances are significantly reduced relative to either the close to close or trading period returns. This is consistent with previously discussed research (Fama (1965), French (1980) and French and Roll (1986)) that found that the variance of the non-traded period is significantly less than either the close to close or trading period returns. However, we find that the skewness statistic is now significantly more negative for non-traded periods relative to close to close periods (with the exceptions of the Nikkei and DAX). Finally, for all five markets, the excess kurtosis is significantly higher, both relative to the close to close and trading period returns.

Given that in Table 2 not all the moments are significantly different between the alternative periods and the close to close returns (although all the variances are significantly lower), it would be helpful to compare the overall densities of the alternative periods with a single test. This can be easily accomplished by the use of stochastic dominance tests. Following the approach of Bawa (1975), we determined by standard kernel estimation methods the cumulative densities of the returns over the alternative periods.[10] Using the standard tests, we found that the non-traded period returns displayed second and third order stochastic dominance for the Nikkei, DAX and FTSE markets relative to the traded period returns.[11] Therefore, this provides evidence that for risk adverse agents, strict preferences exist with non-trading period returns dominating trading period returns.

It is important to understand what is driving these positive returns during the non-traded periods. The usual hypothesis made in finance is that returns are a monotonically increasing function of the risk and this risk is captured as variance. Clearly, for the S&P 500, we find that returns appear to map monotonically to variance (for the three periods, the highest return is associated with the highest standard deviation). However, for all other four markets, return is not monotonically increasing with variance. While the highest returns (non-traded periods) are associated with the lowest variances, the lowest returns (traded periods) are associated with the highest variances. Therefore, the definition of risk may be different for these markets. To better assess the relationship between return and variance over the alternative periods, we have decomposed the close to close mean and variance by the non-traded and traded periods. In addition, we have estimated Sharpe Ratios. These can be seen in Table 3.

Markets	Close to Close Mean (annualised)	% of To	Open to Close Mean (annualised)	% of Total	Close to Open Mean (annualised)	% of Total
S&P 500	10.00%	100%	7.72%	77.2%	2.30%	23.0%
FTSE 100	6.38%	100%	-7.07%	-110.8%	13.45%	210.8%
DAX	9.88%	100%	-4.78%	-48.4%	14.65%	148.4%
CAC	5.77%	100%	-3.03%	-52.4%	8.78%	152.1%
Nikkei	-3.33%	100%	-14.60%	438.7%	11.24%	-337.7%

Markets	Close to Close Variance (annualised)	% of Total	Open to Close Variance	% of Total	Close to Open Variance	% of Total
S&P 500	3.49%	100%	3.04%	87.0%	0.68%	19.4%
FTSE 100	2.97%	100%	2.16%	72.6%	0.99%	33.5%
DAX	5.06%	100%	3.73%	73.7%	1.51%	29.8%
CAC	4.61%	100%	3.35%	72.6%	1.32%	28.5%
Nikkei	5.20%	100%	3.17%	61.1%	1.90%	36.5%

Markets	Close to Close Sharpe Ratio	Open to Close Sharpe Ratio	Close to Open Sharpe Ratio
S&P 500	**0.535**	**0.443**	**0.279**
FTSE 100	**0.370**	**-0.482**	**1.349**
DAX	**0.439**	**-0.248**	**1.193**
CAC	**0.269**	**-0.165**	**0.765**
Nikkei	**-0.146**	**-0.820**	**0.816**

Markets	Close to Close Sharpe Ratio	Open to Close Sharpe Ratio	Close to Open Sharpe Ratio
S&P 500	**0.535**	**0.443**	**0.279**
FTSE 100	**0.370**	**-0.482**	**0.103**
DAX	**0.439**	**-0.248**	**0.126**
CAC	**0.269**	**-0.165**	**0.081**
Nikkei	**-0.146**	**-0.820**	**0.086**

Table 3, Decomposition of Close to Close return and variance across the alternative non-traded / traded periods and Sharpe Ratios for five major global stock index futures.

In Table 3, we decompose the close to close return mean and variances by the two sub periods. We can see that for the S&P 500, 77.2% of the overall stock market return and 87% of the variance is generated during the trading day. For the other four markets, the mean return was negative over the period. Thus, the mean decomposition will not have the same meaning as for the S&P 500. For the variance decomposition, we find that the trading day variance is lower than the S&P 500 (with the highest being the DAX with 73.7% and the Nikkei 61.1% of the close to close variance). However, we can still reject the null hypothesis that the trading day variance proportion is equal to the proportion that the trading day makes up of the actual 24 hour period ($H_0 : \sigma^2_{O/C} = \frac{1}{3}\sigma^2_{C/C}$, when assuming the trading period represents 1/3 of the 24 hour period). Of particular interest is the first panel which presents Sharpe Ratios.[12]

We find that the optimal trading strategy for the S&P 500 futures is the close to close strategy (which represents a standard buy and hold strategy, rolling to the next futures contract at the expiration of each futures contract). However, for all the other four stock index futures markets, the optimal strategy would have been to invest solely in the overnight period. Given this opportunity, it is puzzling why investors did not exploit this and therefore eliminate the anomaly. One alternative explanation is that investors are not measuring risk in terms of variance but have an alternative risk measure.

Suppose we consider preference for positive skewness in returns as proposed by Harvey & Siddique (2000). For the S&P 500, the trading period return would be preferred to either the close to close or non-trading period return (depending on the market price of skewness risk). As the close to close, displays the highest return, we can reject that investors would prefer close/close returns to trading period returns, if risk preferences are ranked by the degree of positive skewness. Again, perhaps for the S&P 500, risk preferences are ranked in mean/variance space. For the DAX, we find that highest return period (non-traded period) has the most positive skewness (lowest negative skewness) and the average return is monotonic in the level of skewness. However, for all other stock markets, the average return is an inverse function of the skewness: the highest average return is for the non-traded period where the degree of negative skewness is the highest.

From a standpoint of rational agents risk preferences, these results introduce a puzzle. Given that investors face few if any restrictions when investing in stock index futures internationally, rationality would imply investing in those securities that provide the highest return for a given risk. If the investor defined risk as variance risk, the optimal choices would be to invest for the non-traded periods for all non-US stock markets and initiate a buy and hold strategy for the S&P 500. However, in terms of ranking, all four non-US markets would be preferred to buying and holding the S&P 500 (in terms of a Sharpe Ratio).

Another explanation, is that all agents may measure risk in some consistent manner (for example, variance) but have an alternative measure of risk imposed upon them. Suppose that agents are required to measure risk by some regulatory agency and this approach diverges with their personal measure of risk. As a concrete example, suppose an agent measures risk by the daily standard deviation while regulators require such agents to measure risk by the daily standard deviation multiplied by $\sqrt{10} * 3$.[13] While normal risk preferences should be unchanged by a multiplicative transformation of variance, this will change preferences when not all investment alternatives experience the same transformation of variance. In the bottom panel of Table 3, adjusted Sharpe Ratios are presented. These assume that for the S&P 500, the unadjusted standard deviation is used to determine the Sharpe Ratio, while for the four other markets the standard deviation is multiplied by the factor proposed above.

We now find that for all stock markets (apart from the Nikkei) the highest Sharpe Ratio strategy is the standard buy and hold strategy (C/C) as was the case with the S&P 500. Furthermore, all of the non-US markets buy and hold strategies have lower Sharpe Ratios compared to the S&P 500 buy and hold strategy. Mean /Variance agents would not be able to exploit the overnight anomaly due the high charge imposed on variance, while such a charge would not necessarily apply to buying and holding the stocks themselves. We will consider this explanation in more detail later in this paper.

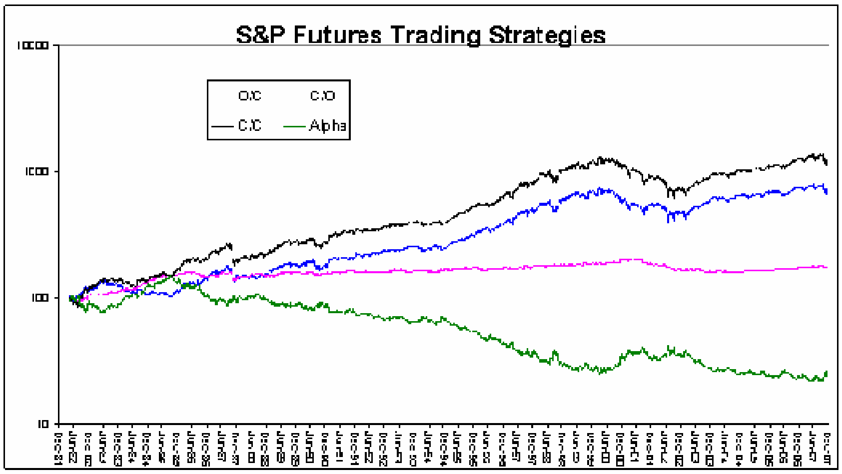
Of course, the simplest explanation for these results is that they only arise from statistical "data mining" and do not represent actual trading opportunities. If this is the case, then the results simply indicate that these "statistical" opportunities can not be profitably exploited. To assess this explanation first, we will now consider how alternative trading strategies based upon these anomalies would have performed over the period of analysis (for each market). This will allow us to assess if actual trading profits would have been realized and how robust these profits are to the inclusion of transaction costs.

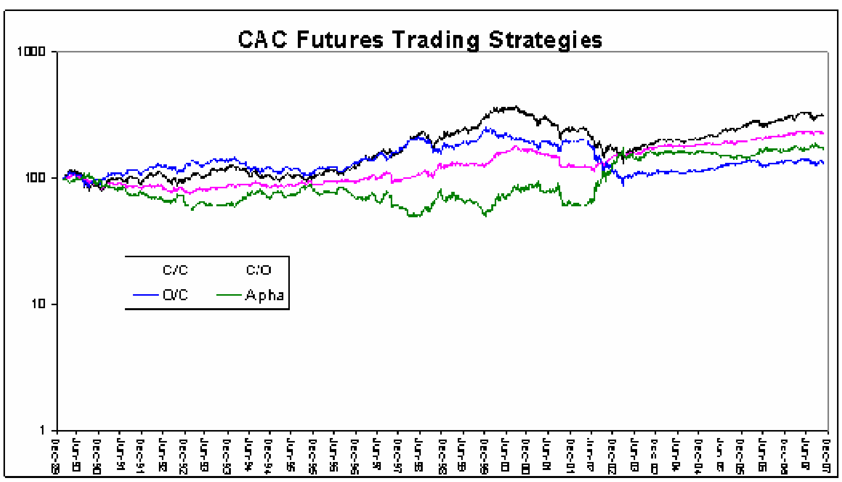
3. TRADING STRATEGIES

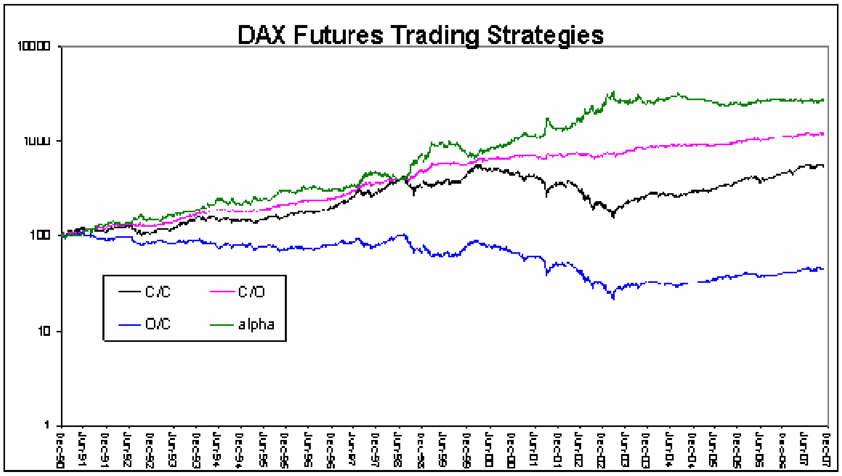
We consider four trading strategies for the five markets. For each trading strategy we assumed that the investor started with a notional investment of 100 units. We do not assume any particular base currency (which implies the funds are in local currency) to keep comparisons simple.[14] These four strategies are:

1. Buying the futures at the close of the first day of the period and holding the futures contract until expiration. Then a new futures contract is purchased for the nearest to deliver and held until that expiration. This is repeated until the end of the sample period. This will be referred to as the C/C strategy (close to close)
2. Buying the nearby futures contract at the opening price each day and selling the futures contract at the closing price of that same day. This will be referred to as the O/C strategy (open to close or the trading period strategy).
3. Buying the nearby futures contract at the closing price of each day and selling the futures contract at the opening price of the next trading day. At the expiration date of the futures, it was assumed that this strategy employed the next to delivery futures contract rather than the futures contract expiring. This will be referred to as the C/O strategy (close to open or the non-traded period strategy).
4. Buying the futures contract at the closing price of each day and selling two futures contracts at the opening price of the next trading day. Then at the end of the trading day, buying one futures contract back. This strategy is a combination of strategies 2 and 3. This will be referred to as the "alpha" strategy.

For each of these strategies, we used the same data set used in section 2 to estimate the returns. Instead of simply estimating wealth relatives, $W_t = W_{t-1} * e^{\ln\left(P_t / P_{t-1} \right)}$, and cumulating these to determine strategy performance, we defined strategy performance by $W_t = W_{t-1} * e^{r\Delta t + \ln(P_t^* / P_{t-1}^*)}$ where W_t is the wealth relative at time point, t, P_t^* is the futures price at which we sold the futures contract at that same time point, P_{t-1}^* is the futures price where we purchased the futures contract, r is the overnight interest rate (using the one LIBID rate as a surrogate) and Δt is the time increment from when we purchased the futures and when we sold the futures. The stars associated with the futures prices, P_t^* and P_{t-1}^* represent bid and offer prices, respectively. Thus, we will impose a bid/offer spread by defining $P_t^* = P_t$ -½s and $P_t^* = P_t$ +½s, where s is some bid/offer spread. Initially, we will assume that s=0, however subsequently we will include a positive s representative of the spread during the opening and close for each of the five markets. Finally, we will consider the quantity s*, where profits are eliminated. The cumulative (logarithmic) wealth of the four alternative strategies appears in Figure 1.[15]






DAX Futures Trading Strategies
10000
1000
100
10
1
C/C
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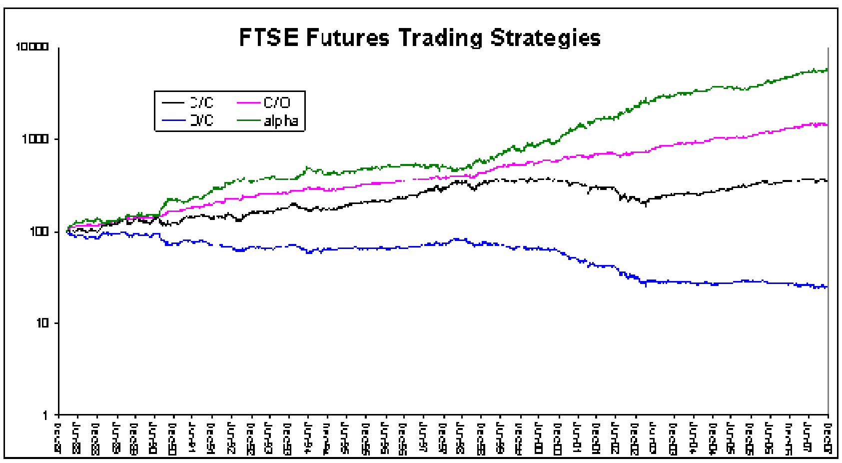
FTSE Futures Trading Strategies
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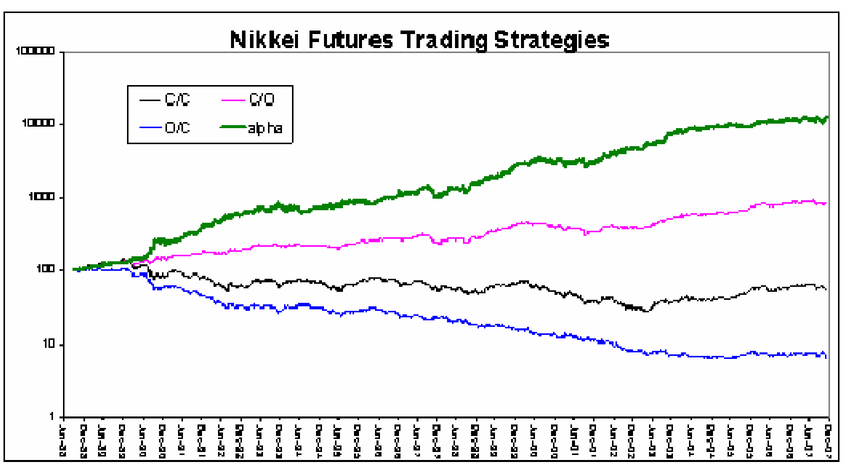
Nikkei Futures Trading Strategies
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O/C
alpha

Figure 1, Logarithmic Wealth Relatives of four alternative stock index futures strategies for five major global stock index futures markets.

As can be seen from the five panels in Figure 1, the four alternative strategies yield considerably different wealth profiles over time. For the S&P 500 futures (in the top panel in Figure 1), the best performing strategy is the simple close to close strategy. The second best performing strategy prior to the 1987 stock market crash is the C/O strategy, however, after 1987, the O/C strategy is consistently better than either the C/O or the alpha strategy. The worst performing strategy for almost the entire period of analysis is the alpha strategy (this strategy performs slightly better than the O/C strategy during a short period from 1984 to 1986). Thus, these results are consistent with the means for the alternative period returns found in Table 2.

In the panel immediately below that of the S&P 500 displays the performance of the alternative stock index futures strategies for the CAC 40. In some ways, the ranking of the relative wealth generated appears similar to that of the S&P 500. The close to close and O/C (trading period) strategies dominate the C/O (non-traded period) strategy and the alpha strategy. However, this changes dramatically in 2002. After that point, both the C/O and alpha strategies dominate the O/C strategy and approach the performance of the close to close strategy. One explanation for this effect is that there was a structural change in the French stock market in 2002, where the opening/ closing prices of stocks traded in the market were changed to an auction system. Prior to this, the stock prices were determined by a small pool of market makers, which could have introduced biases into these prices that in turn fed through to the futures prices.

For the remaining three stock index futures markets, the non-traded period strategy (C/O) and the alpha strategies provide considerable profits, while the trading period returns lead to substantial losses. For the DAX, FTSE 100 and Nikkei, the best performing strategy over all time periods is the alpha strategy followed by the non-trading period strategy, the close to close strategy and finally the trading period strategy. These results are consistent both with the returns over the alternative periods found in Table 2 and with the tests of stochastic dominance discussed in section 2.

For these three markets, one can see that the performance of the non-traded period strategy (C/O) is remarkably stable. Although not reported here, a simple exponential function of the wealth relative to time explains between 95% and 99% of the variance of the growth of wealth for these three markets.

Clearly, for the four non-US stock index futures markets, returns generated in non-traded period can be translated into viable trading strategies that either match the performance of a simple buy and hold strategy or exceed it (for the entire period for the FTSE, DAX and Nikkei and for the CAC since 2002). However, this type of analysis provides little information about strategy performance for sub-periods. To assess the viability of the alternative strategies, an alternative examination of strategy performance was considered. It was found that when the strategy was evaluated solely on a quarterly basis, similar relative performances (as were for the cumulative strategy) were found. This analysis can be found in Appendix A. For the best performing "alpha" strategy, the returns were significantly positive with relatively low variance and modest draw downs. Thus, the strategies do not appear to be sensitive to the time period of analysis. We can proceed with the knowledge that the cumulative wealth relative analysis will be robust to the period of analysis.

4. EXPLANATIONS & IMPLICATIONS OF THE ANOMALY

Before proceeding to consider why these anomalies exist, it is helpful to summarise our main findings. We find significant differences between the return processes for traded and non-traded periods for Stock Index Futures across five major markets.

For the US Market, we find that the mean and variance of returns for non-traded periods are significantly less that those of the traded period returns. For the higher moments of both return distributions, we find that non-traded period returns display much greater non-normality compared to the trading period returns. These results are similar to those that have previously appeared in the trading/non-trading period literature. For European and Japanese markets, we find non-traded period returns also have significantly lower variance with more significant higher moments but the mean returns are significantly **higher** than traded period returns. Furthermore, for all four non-US markets considered, the return during trading periods is significantly negative. We have constructed trading strategies to show how the anomaly can generate profitable trading strategies for European and Japanese stock market (even after transaction costs have been considered). This is the anomaly we seek to explain: Why do non-US stock markets generate losses during the trading day with positive returns realised solely in non-traded periods?

The most obvious possible reason for alternative means during the two periods is that the two periods have alternative distributions. The statistical moments of the returns in Table 2 suggest that overall returns for stock index futures markets are a mixture of alternative processes. During the trading day for four of the five markets, the trading period returns display less of degree of non-normality than during non-traded periods. The only exception was for the DAX futures, where the trading period skewness statistic was significantly more negative than during non-traded periods (and relative to the close to close period). For all five markets, the kurtosis statistic was smaller during the trading period compared to either the non-traded period returns or the close to close returns.

While the trading day returns remain non-normal, they are much closer to normality compared to either close to close returns or non-traded day returns. Of particular interest is the skewness statistic, which is insignificantly different than zero for three of the markets (FTSE 100, Nikkei and CAC). However, all the kurtosis statistics reject the assumption that traded period returns for all five markets are normally distributed. Such results are consistent with diffusion models where the volatility is stochastic. Tompkins (2001) tested alternative models to explain the unconditional return process for stock index futures and reported that using close to close returns, stochastic volatility models were unable to capture the high degree of negative skewness and excess kurtosis. Similar results were found by Bates (2000) among others. However, for the trading period returns of stock index futures, a model such as Heston (1993) would be able to generate a distribution with similar higher moments.

Given that trading occurs continuously during the trading day would suggest that market participants would be able to hedge the risks of derivatives by simultaneous trading in the cash, futures and options markets. Such hedging would reduce the risks of stock index derivatives to movements in the overall stock market and under the usual perfect market assumptions, result in a return equal to the risk free rate. This would imply a lower return compared to that of an unhedged stock index positions (whose return includes the equity risk premium). However, in the presence of volatility risks that are not spanned in the state space, we would expect an increase in the expected return to reflect the market price of volatility risk. Therefore, we would expect (for reasonable levels of the market price of volatility risk) that the trading day returns will lie between the risk free rate and below the expected return of the stock market. For the S&P 500, we find that the trading period return is indeed below that of the close to close returns. In any case, we would not expect that daily returns empirically would be significantly negative, which we observe for the other four stock index futures markets.

For the non-traded period, the statistical moments suggest that a Jump Process is more likely than some diffusion process. Firstly, we observe extremely low variances in the non-traded period with much more non-normality. Models such as those suggested by Merton (1976) and Cox & Ross (1976) could generate such results. Bell (1996) showed for the FTSE 100 cash index that close to close returns could be decomposed into a diffusion during trading periods and jump processes during non-traded periods. As jump risk is also not spanned by the state space, this will introduce a market price of jump risk. In the empirical options literature, Pan (2002) showed that a substantial market price of jump risk exists and she hypothesizes this is crucial for the pricing of options on stock indices. Therefore, given this risk, we would expect the returns for the non-traded period to include this jump risk and be positive.

It would appear that both volatility risks and jump risks contribute to the returns we observe for stock index derivatives (options). However, it appears that the market price of volatility risk is non-existent for the traded period returns for four of the five markets. For the S&P 500, the return is extremely low for the non-traded period which would suggest a relatively low market price of jump risk. For the four other non-US markets, the non-traded period return would have an extremely high market price of jump risk. Given that all five stock index futures markets display similar distributional characteristics for the close to close returns, it is unlikely that for some markets volatility risk is priced and in others it is not. Furthermore, given the inter-relationship between global equity markets, it is unlikely that one market would have a low market price of jump risk, while the others have significantly higher market prices of jump risk.

In conclusion, it is unlikely that the return puzzle we have identified would be due solely to different means associated with different processes for the traded and non-traded period returns. However, the fact that overall stock market returns can be decomposed into diffusions during trading time and jump processes for non-traded time has important implications, which we will consider later in this section.

An alternative explanation could lie in the behavioral finance literature. During the trading day with continuous trading, derivative risks can be hedged away. However, as was pointed out by Kahneman & Tversky (1971, 1973) a common heuristic bias is the Over Confidence bias. It could be that traders trade for some pleasure inherent in the activity rather than to maximize profits and/or minimize risks. Such over trading is consistent with the claim that French and Roll (1986) make that trading itself causes volatility. During the non-traded period, by definition, investors are unable to trade and thus face the risk of extreme events occurring which cannot be covered. Such extreme liquidity risk would require such investors to demand a liquidity premium to hold such positions overnight. This could explain both the relatively low returns during the trading day and higher returns overnight. Unfortunately, this does not explain our puzzle. For surely, if traders reduce trading period returns by overtrading this would occur in all markets. Given that the S&P 500 index futures traded period returns are only slightly less than the overall close to close returns and all the non-US stock index futures markets have significantly negative returns, this would be unlikely unless traders in non-US markets display a significantly higher degree of overconfidence than US traders. Likewise, if a liquidity risk premium did exist, why would it affect only non-US markets?[16]

Previously we considered preference for positive skewness in returns as proposed by Harvey & Siddique (2000). However, we discussed previously that for all five stock markets, the average return is an inverse function of the skewness: the highest average return is for the non-traded period where the degree of negative skewness is the highest.

Maybe there is a market micro-structure explanation for the negative returns during the trading period and positive returns during the non-traded period. It has been proposed [reference to follow] that individual firms tend to release positive news about the firm's prospects during the trading period and release negative news when markets are closed. However, while this could be consistent with the results of the S&P 500, it is divergent with the results for the other four markets. For these markets, if news tends to be positive during the trading day, why are the returns negative? And similarly, if the news overnight tends to be negative, why are returns positive for these non-traded periods?

Our final explanation of the mean return puzzle could be related to differences in the market micro structure of US and non-US markets. Specifically, differences in how risk is measured and capital set aside to support trading activities.

In Europe and Japan, most equity derivatives market making is dominated by banks, which are regulated by banking supervisory agencies adhering to accords proposed by the Bank for International Settlement. For the supervision of market risk, these banks must adhere to the Basle I internal market risk model (1995), which requires capital charges associated with market risk to be estimated using a Value at Risk approach. For European financial institutions, the EU adopted a Europe-wide capital requirement known as the Capital Adequacy Directive (CAD), first published in March 1993. It defined minimum levels of capital to be adopted for EU banks and securities houses by January 1996. According to Jorion (1997), CAD requirements are similar and in some cases identical to those of the Basle proposal. While Basle guidelines are aimed solely at Banks, CAD regulated both European banks and security houses. CAD was put into effect in 1996 but Basle I rules only started applying in 1998. For the Japanese markets, the Bank of Japan followed the lead of Basle I and the CAD directive, requiring Japanese financial institutions to implement an identical VaR approach to risk management also during 1998.

In the US markets, banks were restricted from market making in equity and equity derivative markets by the Glass-Stegall act (prior to 2002). Due to this exclusion, US equity derivative market makers have not been under the jurisdiction of bank regulators but have been self-regulated or regulated by the CFTC. The risk measurement approach differs significantly from that of Basle I or the CAD. For the S&P 500 stock index futures and options market makers trading at the CME, the risk is assessed for 1 trading day (see SPAN margining system) while Basle I /CAD has a 10 day trading horizon plus the additional charge of 3 times the VaR.

Assume that stock index (futures) option market makers tend to be sellers of OTM puts and buyers of OTM calls. This would lead to an overnight risk position similar to what would appear in Figure 2. At the current price of the underlying futures, the current position would be delta neutral and would realize losses from an extreme fall in the market and gains from a rise in the market.

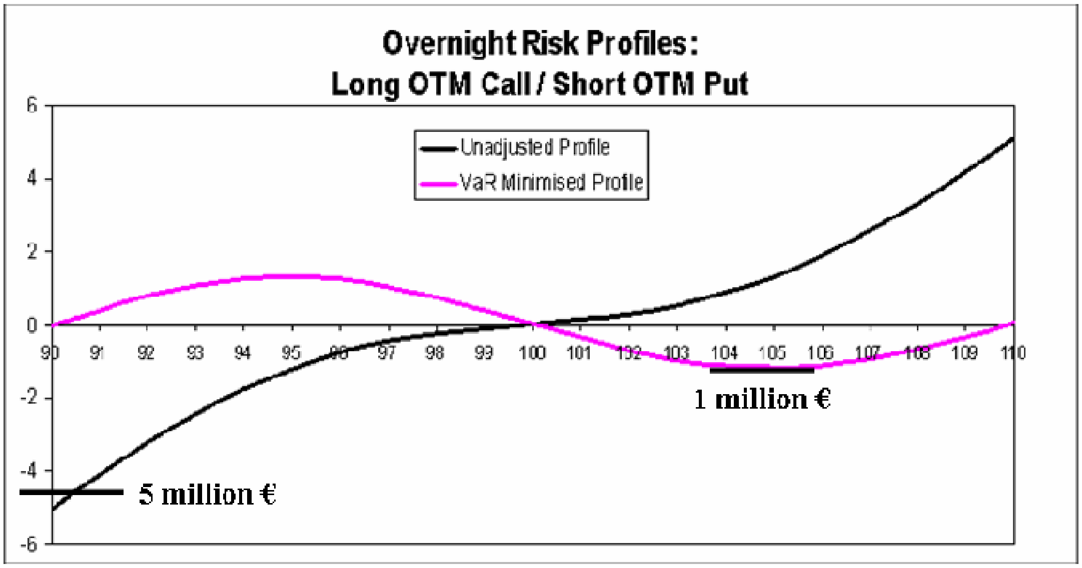

Figure 2, Overnight Profit and Loss Profit of a Stock Index Options position selling OTM puts and buying OTM calls.

In this figure, we have a constructed a hypothetical portfolio where a trader has sold OTM puts and bought OTM calls. Taleb (1998) suggests that this tends to resemble the usual portfolio holding of stock index option market-makers. In this figure, the black curved line indicates the hedging portfolio which is delta neutral at the current level of the underlying futures. For US based market makers on options on the S&P 500 futures, the risks have been measured by the so called "greek" derivatives and the Chicago Mercantile Exchange requires capital to be set aside (margin) to support possible losses that could occur from the close of trading to the opening of trading the next day. Now suppose that the period of exposure is not one trading day 10. This would consider a much wider possible range of futures prices that could be realized relative to the single day (a multiple of the daily standard deviation multiplied by $\sqrt{10}$). When such an extreme range is spanned, some confidence level (for example 99%) is assessed to determine the capital charge (margin) to support the non-traded period risk. In this hypothetical example, the capital charge would be 5 million. Given that capital set aside to support risky market positions is a cost and given that market makers wish to minimize this cost, consider the alternative hedging strategy. If the market maker sells some quantity of futures contracts at the close of trading, the profit loss profit of the portfolio starts to resemble a (inverse) sine curve (represented by the grey line). For the same extreme span of possible future underlying prices, the capital charge has been substantially reduced (in this hypothetical example to 1 million). Then at the opening of the next trading day, the market maker would purchase back the same number of futures contracts to return to delta neutrality.

However, this is not simply a hypothetical trading strategy. This approach has been proposed by Taleb (1998) and discussed extensively by Hua & Wilmott (1997) and Hua (1997). All these papers discuss modifications to the normal delta neutral hedge in the presence of jumps and/or overnight discrete hedging. Wilmott (1999) discusses the modification of an options hedging strategy when the optimal static hedge is to minimize VaR costs. In all four papers, the recommended strategy would entail selling the underling stock index (or stock index futures) at the closing of the market and purchasing back the stock index (or futures) when the market reopens. If, on the margin, enough equity option market makers following this approach, the price of the underlying stock index will fall at the close and rise at the open.

Clearly for all market makers of stock index options, such minimization of overnight risks would be sensible and given [as Taleb (2003) claims] most market makers hold a similar portfolio, we would expect a modified delta hedging strategy as suggested above. However, the difference is that US stock index option market makers have an imposed time horizon of risk of one trading day, while market makers under the Basle I /CAD regime have a 10 day time horizon. Suppose that non-US equity derivatives market makers minimise their VaR risk (and associated capital charge), this leads to trading strategy which would explain why returns for the overnight period are positive for non-US stock index futures markets. If an equity derivatives market maker instead minimises the overnight loss, as is done in the US, there is no incentive to follow the same trading strategy and thus the overnight returns remain lower than trading period returns.

To test this hypothesis, we first assume that the majority of non-US institutions had previously managed risks using the “greek” hedging approach prior to 1998 with a one day horizon. With the implementation of the CAD directive in 1996 and the Basle I internal market risk model during 1998, non-US institutions revised the risk evaluation to adapt to the new regime. For European Securities houses, this occurred in 1996 and for both European banks and Japanese financial institutions this occurred during 1998. Given that Basle I was phased in during 1998 (with the requirement that full implementation was to be completed by the end of the year), we selected June 30, 1998 as the midpoint of the year to evaluate whether the anomaly differed before and after this date.

We considered the performance of the non-traded period strategy prior to June 30, 1998 and after that date to the end of 2007. Using the quarterly trading strategy discussed in section 3, we determined the mean return, the standard deviation and the standard error of the mean. Then, we conduct a t-test to assess if the mean return had changed from the pre Basel I period to the post Basle I period. This can be seen in Table 4.

	S&P 500		CAC 40		Nikkei 225		FTSE 100		DAX	
	Prior 1998	Post 1998	Prior 1998	Post 1998	Prior 1998	Post 1998	Prior 1998	Post 1998	Prior 1998	Post 1998
Mean	**-1.13%**	**0.17%**	**2.46%**	**0.42%**	**2.41%**	**4.07%**	**1.38%**	**2.81%**	**1.19%**	**1.76%**
Std Dev	3.64%	3.34%	3.66%	4.89%	5.75%	4.93%	4.74%	4.28%	4.81%	8.33%
Std Error	0.46%	0.42%	0.61%	0.79%	0.96%	0.80%	0.79%	0.70%	0.91%	1.35%
T-test	**-2.85**	**3.10**	**3.35**	-2.58	**-1.73**	**2.08**	**-1.81**	**2.06**	-0.63	0.42
Null	**(2.47)**	**0.41**	**4.04**	0.53	**2.51**	**5.09**	**1.75**	**4.05**	1.31	1.30

Table 4, Comparison of Quarterly Returns for the non-traded period strategy prior to and post the introduction of the Basle I internal market risk model (1995).

In Table 4, we find that for four of the five markets, the mean return increased in the period after 30th June 1998. To assess if the change was significant we conducted a standard t-test of means for the pre and post Basle I period and a t-test of the null hypothesis (0% return). For the S&P 500, prior to 30th June 1998, the mean return of the non-traded period strategy was significantly negative. The return after this time was significantly more positive at 0.17%. However, this does not reject the null hypothesis, i.e. the return differs from 0.0%. For the CAC 40, we find that the return after 30th June 1998 is positive (at 0.42%) but this is significantly below that of the period prior to this date (and does not reject the null hypothesis of a 0.0% return). For the DAX, the return for the post Basle I period is positive and higher than the non-traded strategy return for the pre Basle I period. However, due to the high variance of the returns over the period, we are unable to confirm that this increase is statistically significant. Likewise, we cannot reject the null hypothesis of a 0.0% return for either period (again due to the relatively high variance of the strategy). Thus, for the CAC and DAX, the evidence does not support our hypothesis that the introduction of Basle I changed the mean return (and thus the anomaly).

For the FTSE and Nikkei, we find confirming evidence of our hypothesis. In both markets, the mean return after 30th June 1998 is significantly more positive than for the prior period. For the Nikkei, we can reject the null hypothesis for both periods and for the FTSE only in the post Basle I period can the null hypothesis be rejected (at a 95% level). Therefore, we can show that for these two stock index futures markets, not only did the anomaly exist throughout the period; it became more extreme after 1998.

These results suggest that an alternative hypothesis may be more appropriate. Given that the non-traded period positive return anomaly existed for the DAX, Nikkei and FTSE for the entire period of analysis, it is possible that the shift to a VaR type risk management approach occurred earlier for German financial institutions compared to English or Japanese institutions. The CAC remains a puzzle. Table 2 clearly indicates that the overall returns for the non-traded period significantly exceed that of the trading period returns. Furthermore, from Figure 1, we can see that the cumulative returns of the alternative strategies vary across time. For the period from 1988 to 2002, the trading period strategy performs better than the non-traded period return (and approaches the cumulative return of the close to close strategy). After 2002, the non-traded period return for the CAC dominates the traded period return. This is clearly unrelated to the introduction of either Basle I or CAD. What caused this change in the anomaly remains for future research and may be due to market microstructure issues in the French market.

5. SUMMARY AND SUGGESTIONS FOR FUTURE RESEARCH

In this research, we consider returns for five global stock index futures markets over traded and non-traded periods. We find considerable differences between traded and non-traded period returns. For the US stock market (S&P 500 futures), we find that the mean return is higher for the trading period compared to the non-traded period with the non-traded period return having significantly lower variance. For four non-US stock markets (UK, Germany, France and Japan) the non-traded period return is significantly higher than the trading period return, again with a lower variance. For all five stock markets, the higher moments of the non-traded period return displays more non-normality compared to the trading period.

Based upon this analysis, we construct trading strategies which compare a buy and hold strategy (based on close to close futures returns), a trading period strategy (based on buying at the opening futures price and selling at that day's closing futures price), a non-traded period strategy (buying at the closing futures price and selling at the next available opening futures price) and a hybrid strategy (which entails running a short position in futures during the trading period and a long position in futures during the non-traded period). Even after reasonable levels of transaction costs are considered, the non-trading period and hybrid strategy generate significant positive returns over the period. Thus, an anomaly appears to exist.

We consider possible explanations for this anomaly. It is clear from the statistical analysis that traded and non-traded period returns are drawn from different distributions. It appears that trading period returns are best described by some sort of diffusion process which includes stochastic volatility, while non-traded period returns are better described by some sort of jump process. Given that two alternative processes describe returns, it is possible that each would have a different mean. As both processes include non-traded sources of risk (stochastic volatility for traded periods and jumps for non-traded periods), we would expect that returns would include some risk premium for the particular risk assumed. However, we find that a positive risk premium for volatility risk appears to exist solely for S&P 500 futures. While a positive risk premium for jump risk appears to exist for all five stock index futures markets (although extremely low for the S&P 500 futures). Therefore, we cannot explain the mean differences by some coherent and consistent market-wide perception of reasonable market risk premia.

We consider behavioral finance explanations (references to follow) and while there may be a trader overconfidence bias leading to lower returns during the trading period, this seems to only apply to non-US markets. Likewise, we can reject that hypothesis that investor preference for positive skewness can explain the anomaly. Finally, we consider that US and non-US investors in stock index derivatives have alternative regimes for the measurement of market risks. If we assume that traders of S&P 500 futures and options measure risk by the SPAN margin system at the CME, then the time horizon for estimation of risk is one trading day. If we assume that traders of all non-US futures and options markets measure risk by the Basle I / CAD directive, the time horizon for the estimation of risk is ten trading days (as associated with how VaR is required to be implemented). The fact that the increase in the time horizon leads to more extreme changes in the possible future prices leads to a substantial increase in the capital charge required to maintain a typical option portfolio of a stock index options market maker. If such market makers seek to minimize VaR costs when constructing their portfolios, this would lead to a trading strategy consistent with the anomaly we report.

To test the hypothesis that the alternative regulatory risk requirements explain the anomaly, we examined the non-traded period returns prior to and post the imposition of the Basle I accord in 1998. We find that for the Japanese and British stock markets, the introduction of Basle I significantly increased the mean of the non-traded period returns (and thus the anomaly), while it remained unchanged for the German and was reduced for the French market. For the US market, the non-period return changed from a negative return prior to 1998 to a zero return thereafter.

This research provides a number of contributions to the literature. Firstly, we point out that an economically relevant anomaly in non-US stock markets exists. Secondly, we provide evidence that for some of these markets, the anomaly could be due to alternative regulatory regimes for the measurement of market risk.

Suggestions for future research could include examination of international overlaps in returns using contemporaneous data.[17] Preliminary examination of other equity markets has found similar results to the non-US return anomaly found here, and research could consider these in more depth. Future research could also examine other asset markets such as commodities, bonds and foreign exchange. This would consider the implications when market closures are reduced.

Finally, we have not considered the implications of those results implying that non-traded period returns appear to be better described by a jump process instead of diffusion. Given that overall return processes can be decomposed into alternative processes, option valuation (and risk management) may wish to incorporate different processes for traded periods and non-traded periods. This might provide insights into the decomposition of option risk premium for jump and stochastic volatility risks and provide insights into the contribution of each to the option pricing biases associated with implied volatility smiles. Additional research could consider the implications of current risk measurement approaches (like VaR) which assume diffusion for non-traded periods. If non-traded period returns are better described by a jump process, these approaches will incorrectly assess risks. For Monte Carlo based risk measurement approaches, our research indicates that jump processes should be simulated for non-traded periods, while a diffusion with stochastic volatility should be simulated for traded periods. Research could consider whether an improvement in risk measurement would result.

APPENDIX A

At the beginning of the each quarter corresponding to the day following the expiration of the stock index futures, each strategy was assumed to begin with a monetary value of F_t units of the local currency. F_t reflects the nominal value of one futures contract for the market in question at the beginning of the period when the strategy was initiated. This amount will be referred to as the cash account and served as the cash amount required for margining purposes.

For the trading period strategy, on each trading day it was assumed that 1 futures contract was bought at the opening price and sold at the closing price of that day. For the non-traded period strategy, it was assumed that 1 futures contract was sold at the closing price and bought at the opening price of the next trading day. Finally, for the "alpha" strategy, it was assumed that the investor sold 1 futures contract on the first day of the trading period (the day following the expiration of the previous futures contract), bought 2 futures contracts at the closing price of that day and sold 2 futures contracts at the beginning of the next trading day. This strategy was repeated each day for the entire quarter with 1 futures contract bought at the close on the expiration day of that futures contract. This strategy can be seen as a combination of (selling) the trading period strategy and the non-traded period strategy.

Any daily gain or loss (determined at the close of each days futures trading) was added or subtracted from the cash account and the net amount was placed on overnight deposit. Then, the strategy was repeated every trading day until the expiration of that futures contract. At this point, the value of the cash account was determined. This was assumed to be liquidated at that point and a new cash account of F_t units of the local currency (reflecting the then current futures contract nominal value for the nearest to delivery 3 month futures contract) and the strategy was repeated. In this way, we can assess how this strategy would have performed quarter by quarter over the entire period of analysis. Summary statistics of the final cash account levels, along with the returns earned over the quarter appear in Table A.1 (for ease of comparison, each initial cash account level was set to 100 units).

FTSE	Quarterly Yield	Quarterly Profit	DAX	Quarterly Yield	Quarterly Profit
Average	**101.96**	1.96	Average	**101.52**	1.52
MAX	115.22	15.22	MAX	120.91	20.91
MIN	92.77	-7.23	MIN	81.61	-18.39
STDEV	4.59	4.59	STDEV	7.01	7.01
MEAN	**101.60**	1.60	MEAN	**100.63**	0.63
CAC	**Quarterly Yield**	**Quarterly Profit**	**NIKKEI**	**Quarterly Yield**	**Quarterly Profit**
Average	**101.37**	1.37	Average	**103.26**	3.26
MAX	112.18	12.18	MAX	119.30	19.30
MIN	90.37	-9.63	MIN	82.44	-17.56
STDEV	4.45	4.45	STDEV	5.37	5.37
MEAN	**101.67**	1.67	MEAN	**103.15**	3.15

Table A.1, Quarterly results of the "alpha" strategy for four non-US stock index futures markets.

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[1] See Kim (1988), Henzel and Ziemba (1996), and Chow, Hsiao, and Solt (1997).

[2] See Cross (1973), French (1980), Gibbons and Hess (1981), and Lakonishok and Levi (1982) for the US stock market, and Jaffe and Westerfield (1985), Jaffe, Westerfield, and Ma (1989), Agrawal and Tandon (1994) for non-US Markets.

[3] See Rogalski (1984), Smirlock and Starks (1986), and Harris (1986) for early work in this area.

[4] See Cross (1973), French (1980), Gibbons and Hess (1981), and Lakonishok and Levi (1982)

[5] We also found apart from the "noise" or transitory volatility that Stoll and Whaley (1990) indicate, the approach for the determining of opening prices of two of the stock markets appeared to have changed over time. For the S&P 500, the opening price of the index was set equal to the closing price for the entire period of analysis. However, for the Dow Jones 30 (over the same period), the opening price differed from the previous day's closing price. Given the high correlation between these alternative measures of the US stock market and given that they are simultaneously recorded, this suggests the opening price of the S&P 500 stock index does not reflect actual transactions at the opening of the trading day. Likewise, for the FTSE 100 stock index, there were systematic differences between the closing price and next day's opening price of the index until January 2000, when the opening price was set exactly equal to the previous day's closing price and this remained until the current time.

[6] Special care was taken to assure that the close to opening return on the subsequent day was made with the next futures contract (and not between the expiring futures closing price and the opening price of the subsequent futures contract). The data obtained from Bloomberg was a "nearby" futures contract. To avoid biases in the estimation of returns on the expiration date of the nearby futures, the returns for these days were eliminated.

[7] This is a common result. See Lo & MacKinlay (1988) who show that US stock returns are non-normal and they conclude that stock prices do not follow a standard diffusion process.

[8] See Schwert (1989) as representative of this literature.

[9] For the variance test, we used an F-test and having found all variances were significantly less than those of the close to close variance, we then tested mean differences using a T-test assuming unequal variances. For the skewness test, we tested a null hypothesis that $\lfloor (skew_p - skew_{C/C}) / sqrt(6/N) \rfloor = 0$ and for the kurtosis test, we tested a null hypothesis that $\lfloor (kurt_p - kurt_{C/C}) / sqrt(24/N) \rfloor = 0$, with the subscript p indicating the estimation of the higher moment for period p (non-traded or traded) and subscript *C/C* indicating the estimation of the higher moment for the close to close period. N is the number of return observations.

[10] See Levy (1992) for a complete survey of stochastic dominance and the application in financial economics.

[11] For the FTSE, we needed to drop three observations from the sample, for the Nikkei one observation and we used all observations for the DAX.

[12] The usual approach to the calculation of Sharpe ratios is to take the excess return divided by the standard deviation of the return. In this instance, as we are trading stock index futures contracts, the expected excess return is zero. Therefore, any return can be interpreted as an excess return.

[13] This represents the VaR adjusted standard deviation as required by Basle I. The VaR multiplies this adjusted standard deviation by 2.33 to yield a 99% confidence interval for the determination of risk capital to be set aside to support the risk of market risk.

[14] This can be generalized for the choice of a particular base currency by the use of a standard "quanto" structure. While this would change the absolute amounts of the investment strategy, it would not change the relative rankings of the fund performances, unless the opening and closing prices of futures have a different covariance relationship to the exchange rate of the stock index futures and the chosen base currency. For the sake of simplicity this is ignored.

[15] The cumulative performance of the alternative strategies diverged to such an extent that standard scaling did not lend itself to meaningful comparisons. Given that the scale is in Log_{10}, this provides a clearer picture of the monetary wealth associated with each strategy over time.

[16] It could be possible that given the S&P 500 futures can be traded almost 24 hours on the GLOBEX electronic platform; this could explain the non-trading period low returns. However, prior to September 9, 1999, the S&P 500 futures were solely traded on the floor of the Chicago Mercantile Exchange from 8:15 AM to 3:15 PM. After this point of time, when the floor trading ceased, electronic trading took over. An examination of the returns for the periods prior to and post the introduction of GLOBEX showed that the returns were insignificantly different. Thus, the introduction of 24 trading of the S&P 500 futures did not change the low returns realized over non-traded periods.

[17] We chose not to consider this in this research for the simple reason that the interactions seemed inverse to what would be expected. For example, when the Japanese Market is open the European markets are

closed. We find that the Japanese market has significantly negative traded period returns while the European markets have significantly positive non-traded period returns. It may be the case that there is some link with the US markets, as positive returns are determined during traded periods (when both the European and Japanese markets are closed). However, we leave this for future research.