# Skewness and Asymmetry in Futures Returns and Volumes

## Abstract

**Abstract**

In this paper we investigate the distribution of futures market returns and volumes. A variety of contracts are selected from agriculture, foreign exchange, industrial, equity, and interest rate market sectors. Daily closing prices and volumes are used to construct two series of data representing daily and monthly returns and volumes. Tests of normality indicate that all daily returns and daily volumes are not normally distributed. Monthly returns and volumes display mixed results. Further, negative and positive excess returns are compared graphically for each contract. Nonparametric tests are then used to assess whether returns and volumes are symmetric about the mean concluding that daily returns and volumes are asymmetric. However, the results for monthly data are mixed. The Wilcoxon rank sum test suggests that although most contract returns appear asymmetric, soybean, cocoa, and 10 year US Treasury note returns are symmetric. Results for the monthly volume data are also mixed suggesting that the distributions may become more normal as the time period examined increases.

## 1. Introduction

This paper examines the distributions of both returns and volumes across a variety of high volume futures contracts. Much previous research has concentrated on equities, traditionally separating the analyses of the higher moments of returns and volume.

Previous research examining financial asset data has long recognized that many asset returns do not follow a normal distribution (Fama (1963), Arditti and Levy (1975), Simkowitz and Beedles (1978)). To better understand the characteristics of their distributions, many researchers have attempted to model the returns of financial assets (Mandelbrot (1963), Press (1967), Ball and Torous (1983), Kon (1984), Gray and French (1990)). More recently, Bhar and Hamori (2005) observe daily crude oil futures returns finding evidence of non-normality as well. Discovery of non-normality in the return distributions of financial assets leads to questions concerning the existence and role of higher moments in returns. For example, investigations into the role of returns skewness has increased because variance, the second moment and usual measure of risk, is limited in its ability to capture the true risk of an asset as it does not distinguish between the number of returns above and below the mean.

The third moment of these distributions, skewness, has garnered increasing importance in the literature. Empirical studies assessing the existence of returns skewness in emerging equity markets such as that by Hwang and Satchell, (1999) developed a CAPM which takes into account returns skewness and kurtosis. Harvey and Siddique (2000) also suggest an asset pricing model which includes returns skewness. Equity markets and the role of returns skewness have continued attracting research: Singleton and Wingender (1986), Aggarwal, Rao and Hiraki (1989), Alles and Kling (1994), Piero (1994, 1999, 2002), Cont (2001) and Jondeau and Rockinger (2003) all examined national as well as international equity markets and found widely varying degrees of returns skewness.

The fourth moment, kurtosis, has received less, but growing, consideration in the analytical literature. Previous research examining higher moments in commodities markets has found that they are characterized by various degrees of kurtosis. An example of this includes Stevenson and Bear (1970) who examined the corn and soybeans futures markets, concluding that returns distributions are leptokurtic. Dusak (1973) documents nonlinearities in the distribution of futures contract returns while both Hudson, Leuthold, and Sarassora (1987) as well as Hall, Brorsen, and Irwin (1989) report significant levels of leptokurtosis in the futures contracts studied. More recently, Hilliard and Reis (1999) found evidence that logarithmic intra-day price changes in soybean futures were not normally distributed over the period July 1990 to June 1992. Finally, Christie-David and Chaudry (2001) assessed 28 futures contracts comparing the average coefficients of multiple determination values between two, three and four moment regressions. Results indicate that the average $R^2$ of the model improves as the higher moments are included. The four moment model, which may be considered a four moment CAPM, explains returns better than the two moment model. Also, the four moment model has the largest average $R^2$ of the models used.

Both the findings of non-normal return distributions in a variety of financial assets, and the additional explanatory power of returns when higher moments are included in models question the existence and role of higher moments in futures market returns. Two important questions are begged by previous research: 1) are the returns symmetrical about their mean? And 2) is the probability of a return above the mean equal to that of one below?

The issue of non-normal returns distributions which may be skewed or asymmetric is important to futures markets. To begin with, the optimal hedge in futures markets depends on the underlying probability distribution. However, estimates of this distribution depend on the financial analysts' assumed model of the distribution (Tomek and Peterson, 2001). If the estimated distribution is inappropriate, the optimal hedge would not be optimal. Also, if the probability distribution of the futures contract is modeled incorrectly, then modeling option prices based on the futures contract would also be inaccurate.

In addition to the role of higher moments in financial asset returns, there is also considerable analysis of the distribution of volume data. Much of the research investigates the use of volume as a proxy for unobservable information arrival into the market. The two most often studied hypotheses used to understand volume in this context are the mixture of distributions hypothesis (MDH) (Epps and Epps, 1976) and the sequential information arrival hypothesis (SIAH) developed by Copeland (1976) and Jennings (1981). The MDH is used to measure the amount of disagreement among investors as they reassess their market standing based on the arrival of new information into the market. Under the MDH, trading volume increases as the level of disagreement among investors increases. This suggests a positive causal relationship from trading volume to absolute returns. Although similar, the SIAH differs slightly as it considers there to be a positive causal relationship between volume and returns in both directions, i.e., each determines the other. Finally, He and Wang (1995) investigated correlated trading volume patterns. They argue that the observed correlated trading volume pattern reflects the flow and nature of the information. Specifically, the arrival of new public information into the market generates a clustering of trades when the flow of the information is serially correlated. However, the arrival of private information generates trading for current and future periods. This suggests that where public information influences the trading behaviour of both individuals and institutions, private information influences mostly institutions.

Typical of previous literature examining the use of volume as a proxy for news flow is Bohl and Henke (2003) who test the MDH through observing 20 Polish stocks during the period 1999-2000 and note that volatility persistence disappears when trading volume is included in the conditional variance equation. Under this scenario, volume increases as information flows into the market - the more information that arrives about the financial asset, the more interpretation required, and therefore the higher the volume. The increased information gives investors a greater number of expected reactions to the news creating more incentive to trade the financial asset. Huang and Yang (2001) also inspect the MDH, their study analyzing 5 minute interval stock returns from the Taiwan Stock

Exchange (TSI). Through the use of intraday data they are able to assess news flow into the market determining if news flow reflects changes in expectations of individual investors and floor traders as the day progresses. Although their findings suggest that the MDH is unable to explain away the ARCH phenomenon, they do note that the existence of price limits in addition to a very small number of informed investors may have influenced the results. Different from many western stock exchanges, the TSI consists of only 5% informed investors with the remainder classified as uninformed. The authors note that such a composition may indicate a more nervous group of investors than in other markets -specifically the markets examined in this paper.

Observing inter-market relationships, Lee and Rui (2002) gathered data from three markets: London, New York and Tokyo. Although they find that volume does not Granger cause stock market returns for the three markets, they discovered a positive feedback relationship between trading volume and return volatility in all three markets. While New York trading volume was unable to predict New York returns, it was able to predict New York volatility, in addition to returns, volatility and volume for both London and Tokyo markets.

Corvig and Ng (2003) inspect the daily correlation of volume in the AMEX and NYSE finding that 95% of the stocks exhibit statistically significant positive serial correlation. Their results suggest that the average volume autocorrelation coefficient for stocks held mostly by individual investors is greater than for stocks primarily held by institutional investors. This implies that the greater the arrival of new information, the more persistent the volume autocorrelation, and that a stock with an abnormally high volume will continue to have high trading volume.

Pyun, Lee, and Nam (2000) examine the Korean stock exchange. Their results note that once volume is used as a proxy for information flow, the conditional variance is dramatically reduced. They also distinguish between large and small firms noting that shocks to the volatility of small firms predict shocks to larger firms and vice versa. Xu and Wu (1999) further the analysis in this context through an examination of average trade size and frequency of transactions. Although the size of the average trade does contain limited information for the return volatility, the frequency of trades contained high explanatory power for return volatility.

While average trade size does contain information during short periods, this tends to disappear as the time interval gets larger. Darrat, Rahman, and Zhong (2003) assess the contemporaneous as well as lead-lag relation between trading volume and volatility in all stocks comprising the Dow Jones Industrial Average. Using 5 minute intraday data their findings are contrary to the MDH as the vast majority of stocks show no contemporaneous correlation between volume and volatility.

Finally, research into the behaviour of volume and its effect on returns by Moosa and Silvapulle (1999) examined crude oil futures contracts finding some evidence of a causal relationship between volume and price. Ciner (2002) focused on the predictive power of volume in the Tokyo commodity exchange (TOCOM). The findings indicate a positive contemporaneous relationship between volume and absolute returns supporting the MDH. Lastly, Chng and Gannon (2003) investigate volatility across three parallel markets on the Sydney Futures Exchange (SFE). Using 30 minute observations, the authors confirm the poor ability of GARCH models to fit intraday data. However, using a simultaneous volatility model the authors were able to find a significant contemporaneous volume effect within the futures market between SPI futures and SPI options on futures.

If volume is a measure of news entering futures markets, then the characteristics of daily and monthly volume should allow observers to understand changes in the news arrival process. The volume section of this paper attempts to answer the following questions: 1) Do different types of contracts exhibit similar patterns of volume? 2) Do any of the distributions display heavy tails, suggesting that the amount information entering the market varies markedly through time? 3) Is the average volume traded an accurate proxy for information flow?

The focus of the analyses embodied in this paper is the skewness of the relevant data distributions. This is because skewness is an often used to measure of symmetry. The importance of skewness with respect to returns and volume can be illustrated by considering two investors and which futures contract they may prefer. First, assume that two contracts have the same variance yet the returns of one contract are positively skewed while the other is negatively skewed. The two assets would not be priced the same as the investor purchasing the positively skewed asset would require compensation for the lower number of returns above the mean. Second, assuming all other variables (such as return variance) are equal. If the volume of one of the contracts reported significant negative skewness, this would indicate that more days (or months) have volume greater than the mean, and therefore have more days with greater liquidity than the mean.

Research into the role of higher moments in financial markets has led to questions concerning the appropriateness of the skewness measure used. Early work concerning higher moments has concentrated on the conventional measure of skewness (Beedles, 1979). This paper incorporates other, alternative measures of skewness (symmetry).

The above example illustrates why the skewness of returns and volumes is important in asset pricing. However, although skewness measures symmetry, it does make assumptions concerning the shape of the underlying distribution as will be shown in more detail in section 2. For this reason it is natural when attempting to model returns and volumes to use measures that make fewer assumptions about the distribution as the results may prove to be more accurate. Specifically, measures of symmetry should also be used which make fewer assumptions than skewness makes. This is where nonparametric tests may be used in addition to skewness when investigating the symmetry of futures contract returns.

This paper examines the symmetry of futures contract returns and contract volumes. Section 2 presents the data description and preliminary statistical and graphical evidence.

Section 3 presents nonparametric tests of symmetry. Finally section 4 summarizes the main results and conclusions while appendix A contains all tables.

## 2. Data Description and Preliminary Evidence

The data consist of daily observations on 14 futures contracts across various commodity categories. These contracts encompass agricultural, foreign exchange, industrial, equity, and interest rate market sectors. Equities are represented e-mini S&P ,e-mini Nasdaq, E-mini S&P and FTSE 100; Interest rates are represented by  3 month Eurodollar and 10 year US Treasury note; agriculture is represented by cocoa, corn and soybean; foreign exchange contracts by Euro, Japanese Yen, and British Pounds Sterling ; and these are joined by Gold, Brent crude, and high grade copper

Due to the finite lifetime of a futures contract, there are various contract months for the same underlying asset each with their own expiration date at any given time. This is done to give hedgers added flexibility in minimizing their risk. Because of this, exchanges provide additional market data (other than closing price) in the form of open interest and volume. While open interest represents the total long (or short) positions of a specific contract, volume represents the total number of contracts traded for all maturities of a specific contract type (i.e. corn). Therefore, the daily volume data used represents the total number of contracts traded each day, for each asset represented.

Additionally, returns must be transformed into a continuous time series. The continuous time series used in this study have been provided by Datastream International Ltd. The complete futures contract list as well as start dates and number of observations are presented in Table 1. Returns are calculated from the closing price of each contract and obtained by a logarithmic difference using the formula: $R_t = \log(I_t / I_{t-1})$. We examine daily and monthly returns. Due to the relatively recent introduction of contracts such as e-mini contracts for both S&P 500 and Nasdaq indexes in addition to euro contracts, the number of observations in the calendar month time series is limited. However, other than these exceptions, all other data collected began prior to 1990 with sterling and yen contract data starting in 1977.

Peiro (1999) presents the traditional concept of symmetry, illustrating that a distribution is symmetric about $\mu$ if for any *n*:

$$f(\mu + n) = f(\mu - n) \tag{1}$$

The sample skewness statistic, $\hat{\alpha}$, often used by researchers is:

$$\hat{\alpha} = \frac{\left(\sum_{n=1}^{N} (R_n - \overline{R})^3 / \mathrm{N}\right)}{\sigma^3} \tag{2}$$

Where $\overline{R}$ and $\sigma$ are the mean and standard deviation of X. The numerator is divided by the standard deviation cubed.

Symmetric distributions are said to have zero skewness, while asymmetric distributions may be either positive (thin tail to the right side of the mean, larger tail to the left of the mean) or negative (thin tail to the left of the mean, larger tail to the right of the mean). In a perfectly symmetrical, non-skewed distribution, the mean, median and mode are equal. When positive skewness is present, the mean is greater than the median. Therefore, for return data, most returns are less than the average return. For negative skewness, the median is greater than the mean. Under the same scenario, more returns would occur above the mean than below. For this reason an investor would prefer to have a financial asset where returns are negatively skewed than one with positive skewness, even if both assets had the same mean return. If the data are the volume of a financial asset, most volume observations are less than the average volume traded. For negative skewness, the median is greater than the mean. Under the same scenario, more volume observations would occur above the mean than below.

### 2.1 The Distribution of the Contract Returns Data

Table 2 gives descriptive details for the daily return time series while Table 3 does the same for monthly data. Using the conventional measure of skewness, positive skewness values and excess kurtosis indicate positive skewness and leptokurtosis, while negative skewness values and negative excess kurtosis indicate negative skewness and platykurtosis. Skewness results from the daily time series indicate that the returns are negatively skewed for all contracts except 10 year notes, yen, and cocoa contracts. Monthly returns are found to display an equal number of positively and negatively skewed contracts. Kurtosis results of the daily time series vary from a low of 0.4836 (Euro contracts) to a high of 153.0046 (10 Year Notes). Kurtosis of monthly contract returns also found euro contracts to have the lowest value (2.5775). However, corn contracts had the largest kurtosis value (12.5103). The average kurtosis value across all contracts for daily data is 23.3814, this value decreases once monthly returns of the contracts are used, to an average of 5.7753.

Examining intraday returns for soybean and corn futures contracts from the CBOT, Hall and Kofman (2001) present similar evidence of excess kutosis and negative skewness during 1988. Although skewness values are similar and negative, the kurtosis values are larger suggesting than returns may be more leptokurtic for intraday than daily returns. Also, Christie-David and Chaudhry (2001) provide monthly skewness and kurtosis values for some of the same contracts using data from the period 1982-1996. Their results differ. Specifically, skewness values in this study are larger for corn, cocoa, and eurodollar contracts while soybean, Japanese yen, and gold contracts all display less skewness. Additionally, corn, cocoa, British pounds, and Japanese yen contracts are all found to display greater excess kurtosis here as well. This suggests that these values may be time period specific.

**2.2 The Distribution of the Contract Volume Data**

Table 4 and 5 present the same descriptive statistics for daily and monthly volume data. Skewness results from the daily series indicate that volume is positively skewed for all contracts. The two e-mini contracts: nasdaq 100 and S&P 500 display the least amount of skewness with values of 0.2010 and 0.7213 reported. Cocoa contracts were the most skewed with a value of 4.5159. Monthly skewness values are all lower, yet still positive. The only exception to this is the e-mini nasdaq 100 contracts which volume data that is slightly negatively skewed with a value of -0.2546. Kurtosis results of the daily series vary from a low of -0.8878 (e-mini S&P 500 contracts) to a high of 56.1256 (cocoa). Of particular interest are the values for both e-mini S&P 500 and e-mini nasdaq 100 contracts which are both negative: -0.8878 and -0.6347. Kurtosis of monthly contract volume also found e-mini S&P 500 contracts to have the lowest value (-1.4561). However, FTSE 100 contracts had the largest kurtosis value (4.0624). The average kurtosis value across all contracts for daily data is 12.1982. This value decreases markedly to an average of 0.5958 once monthly volumes of the contracts are used.

Both the Kolmogorov-Smirnov (KS) and Jarque-Bera (JB) tests are used to assess whether the returns and volumes are normally distributed. The Kolmogorov-Smirnov test is a goodness of fit test used for any distribution which relies on an asymptotically normally distributed sample cumulative density function value. It finds the greatest discrepancy between the observed and expected cumulative frequencies. If this discrepancy is greater than the critical statistic for the sample size the null hypothesis of normality is rejected. The Jarque-Bera statistic also tests if the distribution is normal. This test examines whether the coefficients of both the third and fourth moments of the distribution are jointly zero. The null hypothesis of normality is rejected when the residuals of the model have significant skewness or kurtosis.

**2.3 KS and JB: Returns**

Tables 6 and 7 provide the values of the Kolmogorov-Smirnov and Jarque-Bera statistics for returns. The null hypothesis of normality is rejected in all daily return series. The only exception to these are the results of the Kolmogorov-Smirnov test for British Pounds indicating that daily returns may be normal. However, the Jarque-Bera statistic for British pounds contradicts this rejecting the null hypothesis of normality. Results of the monthly returns are mixed. While results of the Jarque-Bera test do not reject the null of normality for both e-mini Nasdaq 100 and e-mini S&P 500 contracts, the results from the Kolmogorov-Smirnov test differ considerably. First, all contracts except Japanese Yen and British Pounds are found to be normal. Second, corn, soybean and gold contracts report p-values of 0.05.

## 2.4 KS and JB: Volume

Tables 8 and 9 provide the values of the Kolmogorov-Smirnov and Jarque-Bera statistics for daily and monthly volume. Observations of daily volume reject the null hypothesis of normality in all series. Results of monthly volumes are mixed. While results of the Jarque-Bera test do not reject the null of normality for Japanese Yen, British Pounds and e-mini nasdaq 100 contracts, the results from the Kolmogorov-Smirnov test differ considerably. First, all contracts except Japanese Yen and British Pounds are found to be normal. Second, corn, soybean and gold contracts report p-values of 0.05.

## 2.5 Histogram Analyses: Returns

As in Peiro (1999) histograms of the excess returns are generated to provide a graphical insight into the relative shape of positive and negative returns. Figures one and two illustrate the daily and monthly returns for Japanese Yen[1]. For each series of returns, the mean is subtracted from the absolute value of the excess return. This creates two data series representing positive and negative excess returns such that:

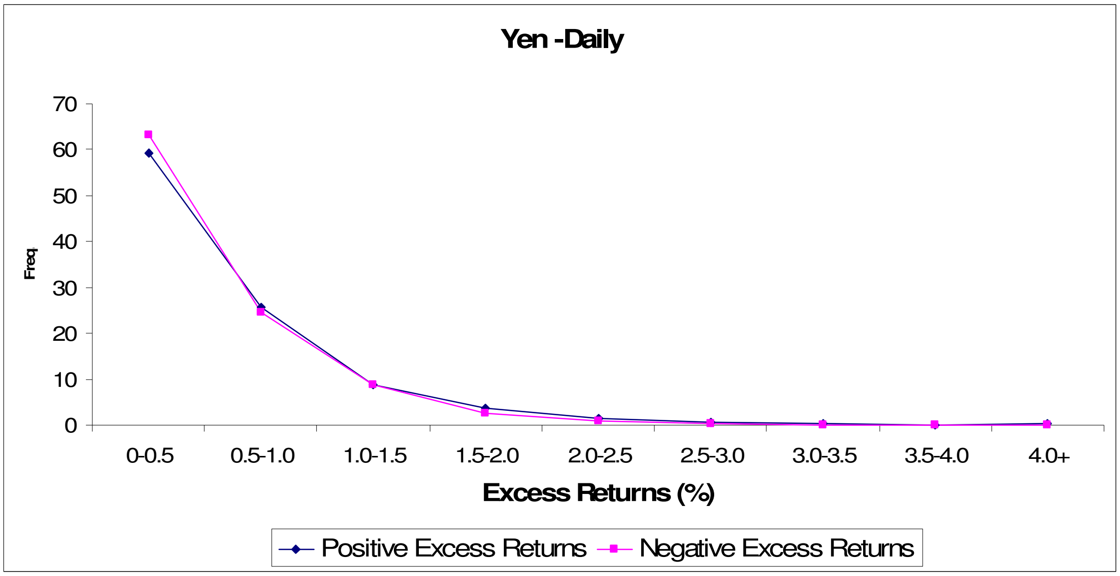
$$\left|R^{-}\right| = \left\{\overline{R} - R_t \mid R_t < \overline{R}\right\} \tag{3}$$

$$R^{+} = \left\{R_t - \overline{R} \mid R_t > \overline{R}\right\} \tag{4}$$

[1] Given the large number of contracts, we do not present the comparable figures for each. Details are available on request.

If the return series is symmetric the two series generated from equations 3 and 4 should have the same distribution. Additionally, the numbers of positive and negative excess returns are provided for each contract in Tables 10 and 11.

Figure 1



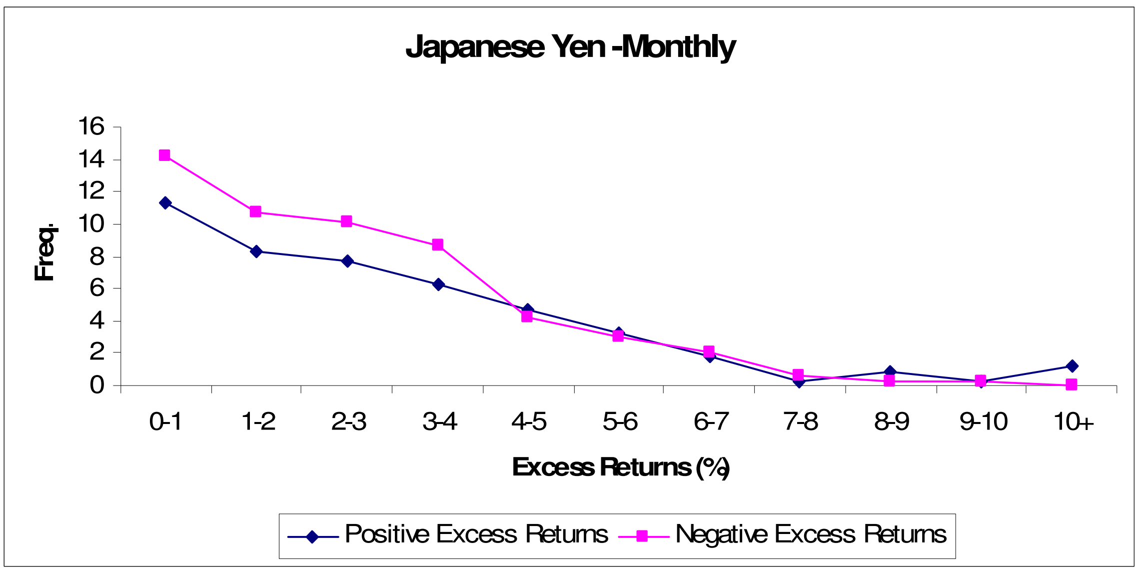

Quick visual inspection of the daily excess return charts shows most to appear symmetrical. Little difference can be noted between positive and negative excess returns for soybean, euro, yen, sterling, high-grade copper, gold, FTSE 100, 10 year treasury notes, and 3 month eurodollars contracts. Without the assistance of statistical measures it would be easy to assume a normal or symmetrical distribution between the positive and negative returns of these contracts. However, as noted in Table 6, only sterling contracts provided evidence of normal daily returns.

The excess return charts for brent crude, e-mini S&P 500, corn and cocoa contracts indicate a slightly more noticeable difference between positive and negative excess returns. Corn and cocoa contract returns are characterized by a difference in excess returns 1.5% or less. Excess returns greater than this tend to follow a similar distribution.

Negative and positive excess returns for brent crude and e-mini S&P 500 contracts have a similar shape, however, space between the two plots hints that there may be significant difference between the two groups of returns.

The only daily excess return chart to show strong visual signs of asymmetry is the e-mini Nasdaq contract. The two plots each have a different shape with noticeable space between the two series of returns. Of the daily excess return charts, e-mini Nasdaq contracts provide the most visual evidence of asymmetry.

Figure 2




Monthly charts indicate stronger evidence of differences in the shape of positive and negative excess returns. The monthly excess returns of 10 year Treasury note, 3 month Eurodollar, FTSE 100, e-mini S&P 500, and gold contracts provide limited visual evidence of differences in the two distributions. However, many of the other contracts indicate stronger preliminary evidence of asymmetry. Where gold and sterling excess returns display space between the two series, they still have a similar trend. Brent crude and e-mini Nasdaq contracts each display more visual evidence of asymmetry with both contracts displaying a greater occurrence of negative excess return spikes. Soybean and yen contracts each indicate possible asymmetry as well. Monthly excess soybean returns are more often negative for excess returns between 5-7%. There is also a greater frequency of negative excess returns for yen contracts, specifically for excess returns less than 4%.

The greatest indication of asymmetry in monthly excess returns occurs with corn, cocoa, euro, and high-grade copper contracts. For corn contracts the occurrence of negative excess returns appears to be twice as likely as that of positive excess returns while returns are 5% or less. Cocoa contracts also appear asymmetrical as there is a greater frequency of negative excess returns above 10% in addition to the large area between the two plots. Excess returns for euro contracts are more often negative than positive when returns are less than 3%. Similarly, high-grade copper returns display a noticeably greater frequency of negative returns less than 4% while also noting a much larger relative frequency of positive returns greater than 10%.

The previous charts illustrate that although the visual evidence provided by plotting a distribution appears normal (or symmetrical) the null hypothesis of normality (or symmetry) at a statistical level can still be rejected.

### 2.6 Histogram Analyses: Volume

Table 12 presents daily volume information. Both the number of observations above and below the daily mean volume, in addition to percentage values are presented. Table 13 provides the same for monthly volume data. E-mini nasdaq 100 contracts are found to have the most positively skewed days with 50.51% of observations above the mean. The contract found to have the most days traded below the mean volume was the FTSE 100 contract (also an index). 31.57% of volume observations for the FTSE 100 contract traded below the mean volume. Generally, results of the monthly volume data appear to become more even as the number of monthly volume observations above the mean increases for all contracts except euro futures. Specifically, the results note that e-mini nasdaq 100 contracts have the largest percentage of monthly volume traded above the mean while FTSE 100 contract have the most monthly volume traded below the mean.

**3. Distribution-Free Tests**

Given that the traditional measure of symmetry (skewness) is based on the sample mean, it is particularly sensitive to outliers which may affect the accuracy of the reported value. Additionally, this measure makes assumptions concerning the underlying distribution of the time series. For these reasons other tests of symmetry may be used which do not possess these limitations.

Unlike the conventional skewness measure, nonparametric tests do not make assumptions about the underlying distribution. Specifically, they do not assume a normal distribution. However, although they have fewer assumptions they still assume that there is equality in the population variances. Peiro (1999) assessed returns considering them symmetric about their mean if the possibility of a negative or positive excess return is equal, and if the distributions of both positive and negative excess returns are equal as well. In this paper, volume is also considered symmetric by the same criteria. Two nonparametric tests are performed in this paper: the Wilcoxon rank sum test and the Kolmogorov-Smirnov two sample test. Each of these are two sample tests which detect differences in location and dispersion about the mean (Kearney and Lynch, 2004).

Under the Wilcoxon rank sum test, if the null hypothesis is true the sum of the ranks are close each other.

$$\mu_W = \frac{n_1(\mathrm{N}+1)}{2} \tag{5}$$

Where the standard deviation can be shown as:

$$\sigma_W = \sqrt{\frac{n_1 n_2(\mathrm{N}+1)}{12}} \tag{6}$$

In the above formulae *N* represents the sample and $n$ the sub sample size. It tests whether the two samples (positive and negative excess volumes) are drawn from the same population.

The Kolmogorov-Smirnov two sample test is a nonparametric measure which also examines whether two independent samples have been drawn from the same population, or from populations with different distributions. Primarily, the Kolmogorov-Smirnov test is concerned with establishing the amount of agreement between two cumulative distributions. If the negative and positive excess returns and volumes are from the same population distribution then the cumulative distribution of each series should be similar as they would only display random deviations from the population distribution.

However, if the two series cumulative distributions are too dissimilar it suggests they may be from different populations. The test statistic is:

$$D_{mn} = \max_x \left| \left( pos_n(x) - neg_m(x) \right) \right| \tag{7}$$

Where $pos_n$ and $neg_m$ represent the positive and negative excess return or volume.

Tables 13 and 14 present the return results of the two nonparametric measures. Daily returns of all fourteen futures contracts are found to be nonsymmetrical about the mean with both tests. This is surprising considering how similar some of the excess return charts appeared. The daily returns of all contracts reject the null hypothesis of symmetry at very high levels of significance for both Kolmogorov-Smirnov and Wilcoxon rank sum tests. The results differ for monthly return data. All futures contracts, regardless of the market sector they represent are found to be nonsymmetrical when the Kolmogorov-Smirnov two-sample test is used. Of particular interest are the results of soybean, cocoa, and 10 year Treasury note contracts, all reject the null of symmetry with the Kolmogorov-Smirnov test, yet results of the Wilcoxon rank sum test find these returns to be symmetrical. This contrasts with their Jarque-Bera statistics as the same contracts reject the null hypothesis of a normal distribution. However, results from the Wilcoxon rank sum test indicate that although monthly returns from these contracts may not be normal, they may be symmetric about the mean.

The results of the nonparametric tests for daily and monthly volume are presented in Tables 15 and 16. Daily volumes for all fourteen futures contracts are found to be nonsymmetrical about the mean with both tests. The daily volumes of all contracts also reject the null hypothesis of symmetry at very high levels of significance for both Kolmogorov-Smirnov and Wilcoxon rank sum tests. The results are slightly different for monthly volume data. All futures contracts, regardless of the market sector they represent are found to be nonsymmetrical when the Kolmogorov-Smirnov two-sample test is used. Specifically, the volumes of cocoa and 10 year Treasury note contracts generate unusual results. While all contracts reject the null of symmetry with the Kolmogorov-Smirnov test, the results of the Wilcoxon rank sum test find these volumes to be symmetrical. This contrasts with their Jarque-Bera statistics as the same contracts reject the null hypothesis of a normal distribution. However, results from the Wilcoxon rank sum test indicate that although monthly volume from these contracts may not be normal, they may be symmetric about the mean.

**4. Conclusion:**

The aim of this paper is to provide insight into the shape of the distribution of futures contract returns and volumes. A wide variety of contracts are analyzed from major futures exchanges such as Chicago Board of Trade, Chicago Mercantile Exchange, New York Mercantile Exchange, London International Financial Futures Exchange, and the International Petroleum Exchange. Agricultural, industrial, foreign exchange, equity, and interest rate markets sectors are all included within the futures contract selection. Both daily and monthly returns and volumes are investigated.

Results indicate that while we are able to reject the null hypothesis of normality in the daily returns of each contract, Jarque-Bera statistics for monthly data indicate that returns may be normally distributed for euro, e-mini S&P 500, and e-mini Nasdaq contract. Also, when comparing the percentage of excess returns above and below the mean, daily returns for 3 month Eurodollar contracts had the greatest percentage of negative excess returns at 57%. The daily excess returns for e-mini Nasdaq contracts have the largest percentage of positive excess returns with 52%. Monthly data display a greater variation between positive and negative excess returns. Although the FTSE 100 futures contract had the largest percentage of positive excess returns with 52%, 3 month Eurodollar and high-grade copper contracts had the most excess negative returns with 65% and 57% respectively.

The results for the futures contract volumes find that although Jarque-Bera and Kolmogorov-Smirnov tests reject normality for all daily data, monthly volumes report mixed results between the two tests. E-mini nasdaq 100 contracts display the most number of days with trading volume above the mean (50.51%). FTSE 100 contracts had the smallest percentage of days traded above the mean with 31.57%. For monthly volumes FTSE 100 contracts also show the least percentage of observations traded above the mean (33.61%). However, the equality between trading volumes above and below the mean increase for each contract once monthly data is used.

Nonparametric tests were incorporated to give a less restrictive test of symmetry. Results of the Kolmogorov-Smirnov two-sample test and Wilcoxon rank-sum test indicate that all daily returns are nonsymmetrical. Again, monthly results were mixed. Although Kolmogorov-Smirnov statistics reject the null hypothesis of symmetry for all contracts, the Wilcoxon rank-sum test reports that soybean, cocoa, and 10 year Treasury note contracts are all statistically symmetric.

Volume results of the nonparametric tests are similar. Results for daily volumes find that all contracts are nonsymmetrical. As with return data, the monthly volume results are mixed between Kolmogorov-Smirnov and Wilcoxon rank-sum tests. While the Wilcoxon rank-sum test finds ten year Treasury note and cocoa contracts symmetrical, Kolmogorov-Smirnov results reject symmetry for both contracts.

Further research into the return distributions of futures contracts data might consider other measures of symmetry, different time periods, in addition to quarterly and annual returns and volumes. Investigation into the returns and volumes of different contracts of the same commodity across markets may also prove fruitful in understanding the pricing and return distribution of this financial asset in addition to the dynamics of information flow between markets.

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## Appendix A: Tables

### Table 1: Futures Contracts: Daily and Monthly Observations

| *Market Sector* | *Contract* | *Start Date* | *DailyObs* | *MonthlyObs* | *Exchange* |
|---|---|---|---|---|---|
| Agriculture | Corn | 3-Jan-79 | 6575 | 313 | Chicago Board of Trade |
| | Soybeans | 3-Jan-79 | 6580 | 313 | Chicago Board of Trade |
| | Cocoa | 1-Feb-80 | 6334 | 289 | London International Financial Futures Exchange |
| Foreign Exchange | Euro | 4-Jan-99 | 1523 | 73 | Chicago Mercantile Exchange |
| | Japanese Yen | 4-Jan-77 | 7178 | 337 | Chicago Mercantile Exchange |
| | British Pounds Sterling | 4-Jan-77 | 7251 | 337 | Chicago Mercantile Exchange |
| Industrial | High Grade Copper | 10-Oct-89 | 3840 | 181 | New York Mercantile Exchange |
| | Gold | 3-Jan-79 | 6574 | 313 | New York Mercantile Exchange |
| | Brent Crude | 15-Feb-89 | 4039 | 181 | International Petroleum Exchange |
| Equity | E-Mini S&P 500 | 10-Sep-97 | 1855 | 85 | Chicago Mercantile Exchange |
| | E-Mini Nasdaq 100 | 30-Aug-99 | 1360 | 61 | Chicago Mercantile Exchange |
| | FTSE 100 | 4-May-84 | 5257 | 241 | London International Financial Futures Exchange |
| Interest Rate | 10 Year US Treasury Notes | 3-May-82 | 5734 | 265 | Chicago Board of Trade |
| | 3mth EuroDollar | 5-Jan-82 | 5812 | 277 | Chicago Mercantile Exchange |

### Table 2: Statistics of Daily Return Data

| *Market Sector* | *Contract* | *Mean* | *Standard Deviation* | *Kurtosis* | *Skewness* |
|---|---|---|---|---|---|
| Agriculture | Corn | -0.0023 | 0.0139 | 16.6202 | -0.62712 |
| | Soybeans | -0.0040 | 0.0140 | 4.1632 | -0.36821 |
| | Cocoa | -0.0088 | 0.0168 | 4.7394 | 0.33008 |
| Foreign Exchange | Euro | 0.0064 | 0.0067 | 0.4836 | -0.08182 |
| | Japanese Yen | 0.0142 | 0.0072 | 5.7965 | 0.56992 |
| | British Pounds Sterling | 0.0008 | 0.0067 | 3.3701 | -0.05010 |
| Industrial | High Grade Copper | 0.0027 | 0.0146 | 3.7831 | -0.34641 |
| | Gold | 0.0096 | 0.0123 | 8.8675 | -0.04181 |
| | Brent Crude | 0.0272 | 0.0231 | 33.4054 | -1.74202 |
| Equity | E-Mini S&P 500 | 0.0116 | 0.0131 | 2.9733 | -0.07416 |
| | E-Mini Nasdaq 100 | -0.0350 | 0.0266 | 3.2685 | -0.00748 |
| | FTSE 100 | 0.0274 | 0.0116 | 12.0131 | -0.79499 |
| Interest Rate | 10 Year US Treasury Notes | 0.0098 | 0.0062 | 153.0046 | 0.01576 |
| | 3mth EuroDollar | 0.0022 | 0.0011 | 74.8507 | -2.30110 |

**Table 3: Statistics of Monthly Return Data**

| *Market Sector* | *Contract* | *Mean* | *Standard Deviation* | *Kurtosis* | *Skewness* |
|---|---|---|---|---|---|
| Agriculture | Corn | -0.0073 | 0.0652 | 12.5103 | 1.1206 |
| | Soybeans | -0.0023 | 0.0626 | 5.0724 | 0.0340 |
| | Cocoa | -0.0048 | 0.0778 | 5.5682 | 0.9359 |
| Foreign Exchange | Euro | 0.0003 | 0.0310 | 2.5775 | 0.2961 |
| | Japanese Yen | 0.0010 | 0.0354 | 4.3007 | 0.5727 |
| | British Pounds Sterling | 0.0027 | 0.0303 | 5.2340 | 0.2675 |
| Industrial | High Grade Copper | 0.0045 | 0.0640 | 3.6168 | 0.3906 |
| | Gold | -0.0010 | 0.0620 | 7.0303 | 0.4815 |
| | Brent Crude | 0.0051 | 0.0920 | 6.1262 | 0.8664 |
| Equity | E-Mini S&P 500 | -0.0023 | 0.0462 | 3.1195 | -0.2386 |
| | E-Mini Nasdaq 100 | -0.0121 | 0.0994 | 3.1066 | 0.0490 |
| | FTSE 100 | 0.0015 | 0.0471 | 7.7923 | -0.8879 |
| Interest Rate | 10 Year US Treasury Notes | 0.0036 | 0.0250 | 8.2084 | -0.5589 |
| | 3mth EuroDollar | 0.0011 | 0.0045 | 6.5907 | 1.2019 |

**Table 4: Statistics of Daily Volume**

| *Market Sector* | *Contract* | *Mean* | *Standard Deviation* | *Kurtosis* | *Skewness* |
|---|---|---|---|---|---|
| Agriculture | Corn | 54987 | 25820.6900 | 6.0193 | 1.4958 |
| | Soybeans | 50360 | 20469.3920 | 2.3802 | 0.7877 |
| | Cocoa | 5935 | 4493.8000 | 56.1256 | 4.5159 |
| Foreign Exchange | Euro | 35147 | 30274.1690 | 4.6806 | 1.8874 |
| | Japanese Yen | 17433 | 14111.1080 | 5.5907 | 1.5936 |
| | British Pounds Sterling | 9385 | 7031.5640 | 12.3290 | 2.2264 |
| Industrial | High Grade Copper | 9858 | 5597.4800 | 33.0536 | 3.0790 |
| | Gold | 31767 | 19567.6440 | 12.5822 | 2.3867 |
| | Brent Crude | 52606 | 31081.2240 | 0.4482 | 0.8600 |
| Equity | E-Mini S&P 500 | 294920 | 288412.9870 | -0.8878 | 0.7213 |
| | E-Mini Nasdaq 100 | 195110 | 113870.3750 | -0.6347 | 0.2010 |
| | FTSE 100 | 24397 | 35484.3670 | 24.2296 | 3.9361 |
| Interest Rate | 10 Year US Treasury Notes | 68619 | 360635.3000 | 9.9385 | 2.0803 |
| | 3mth EuroDollar | 335304 | 360635.3000 | 4.9199 | 1.8531 |

## Table 5: Statistics of Monthly Volume

| *Market Sector* | *Contract* | *Mean* | *Standard Deviation* | *Kurtosis* | *Skewness* |
|---|---|---|---|---|---|
| Agriculture | Corn | 1154898 | 406878.4640 | 0.3239 | 0.4931 |
| | Soybeans | 1059262 | 350399.7270 | 0.5816 | 0.4773 |
| | Cocoa | 124926 | 49975.9090 | 3.0573 | 0.9994 |
| Foreign Exchange | Euro | 733268 | 547171.6110 | 1.4975 | 1.4134 |
| | Japanese Yen | 366346 | 220683.2760 | -0.5099 | 0.0616 |
| | British Pounds Sterling | 197215 | 99669.5510 | 0.4135 | 0.1862 |
| Industrial | High Grade Copper | 205985 | 56567.8540 | 0.0025 | 0.5158 |
| | Gold | 665897 | 263918.3110 | 1.6654 | 1.1030 |
| | Brent Crude | 1107053 | 545234.2760 | -0.8106 | 0.4139 |
| Equity | E-Mini S&P 500 | 6162094 | 5731000.0000 | -1.4561 | 0.4929 |
| | E-Mini Nasdaq 100 | 4071714 | 2133000.0000 | -1.1029 | -0.2546 |
| | FTSE 100 | 513450 | 612137.9740 | 4.0624 | 1.9361 |
| Interest Rate | 10 Year US Treasury Notes | 1438410 | 1109000.0000 | -0.4802 | 0.5916 |
| | 3mth EuroDollar | 7036543 | 6618000.0000 | 1.0961 | 1.1997 |

## Table 6: Normality Tests of Daily Data

| | | *Daily Data* | | | |
|---|---|---|---|---|---|
| *Market Sector* | *Contract* | *Kolmogorov-Smirnov* | *p-value* | *JB stat* | *p-value* |
| Agriculture | Corn | 0.0660 | 0.0110 | 76106.3879 | 0.0000 |
| | Soybeans | 0.0560 | 0.0110 | 4900.6485 | 0.0000 |
| | Cocoa | 0.0640 | 0.0110 | 6043.0075 | 0.0000 |
| Foreign Exchange | Euro | 0.0820 | 0.0230 | 16.5393 | 0.0003 |
| | Japanese Yen | 0.0630 | 0.0100 | 10436.0539 | 0.0000 |
| | British Pounds Sterling | 0.0660 | 0.0660 | 3434.4201 | 0.0000 |
| Industrial | High Grade Copper | 0.0640 | 0.0140 | 2366.6851 | 0.0000 |
| | Gold | 0.1040 | 0.0110 | 21540.7786 | 0.0000 |
| | Brent Crude | 0.0820 | 0.0140 | 189842.9776 | 0.0000 |
| Equity | E-Mini S&P 500 | 0.0820 | 0.0210 | 685.0167 | 0.0000 |
| | E-Mini Nasdaq 100 | 0.0680 | 0.0240 | 605.4053 | 0.0000 |
| | FTSE 100 | 0.0490 | 0.0120 | 32164.8501 | 0.0000 |
| Interest Rate | 10 Year US Treasury Notes | 0.1710 | 0.0120 | 5593135.0394 | 0.0000 |
| | 3mth EuroDollar | 0.1940 | 0.0120 | 1361899.6021 | 0.0000 |

## Table 7: Normality Tests of Monthly Return Data

| | | Monthly Data | | | |
|---|---|---|---|---|---|
| *Market Sector* | *Contract* | *Kolmogorov-Smirnov* | *p-value* | *JB stat* | *p-value* |
| Agriculture | Corn | 0.0480 | 0.0500 | 1245.0880 | 0.0000 |
| | Soybeans | 0.0630 | 0.0500 | 56.0696 | 0.0000 |
| | Cocoa | 0.0710 | 0.0520 | 121.6090 | 0.0000 |
| Foreign Exchange | Euro | 0.0810 | 0.1040 | 1.6098 | 0.4471 |
| | Japanese Yen | 0.0650 | 0.0480 | 42.1750 | 0.0000 |
| | British Pounds Sterling | 0.0370 | 0.0480 | 74.0975 | 0.0000 |
| Industrial | High Grade Copper | 0.0780 | 0.0660 | 7.4711 | 0.0239 |
| | Gold | 0.0770 | 0.0500 | 223.9379 | 0.0000 |
| | Brent Crude | 0.1150 | 0.0660 | 96.3544 | 0.0000 |
| Equity | E-Mini S&P 500 | 0.0760 | 0.0960 | 0.8571 | 0.6515 |
| | E-Mini Nasdaq 100 | 0.0510 | 0.1130 | 0.0532 | 0.9737 |
| | FTSE 100 | 0.0560 | 0.0570 | 262.2860 | 0.0000 |
| Interest Rate | 10 Year US Treasury Notes | 0.1150 | 0.0540 | 313.3252 | 0.0000 |
| | 3mth EuroDollar | 0.1720 | 0.0530 | 215.4980 | 0.0000 |

## Table 8: Normality Tests of Daily Volume

| | | Daily Data | | | |
|---|---|---|---|---|---|
| *Market Sector* | *Contract* | *Kolmogorov-Smirnov* | *p-value* | *JB stat* | *p-value* |
| Agriculture | Corn | 0.0660 | 0.0110 | 12376.1089 | 0.0000 |
| | Soybeans | 0.0350 | 0.0110 | 2234.7547 | 0.0000 |
| | Cocoa | 0.1360 | 0.0110 | 819090.8254 | 0.0000 |
| Foreign Exchange | Euro | 0.1530 | 0.0230 | 2294.4248 | 0.0000 |
| | Japanese Yen | 0.1080 | 0.0110 | 12220.7827 | 0.0000 |
| | British Pounds Sterling | 0.0980 | 0.0110 | 50704.8897 | 0.0000 |
| Industrial | High Grade Copper | 0.1360 | 0.0140 | 178142.0920 | 0.0000 |
| | Gold | 0.1280 | 0.0110 | 49506.9930 | 0.0000 |
| | Brent Crude | 0.1760 | 0.0140 | 501.3534 | 0.0000 |
| Equity | E-Mini S&P 500 | 0.1990 | 0.0210 | 212.3254 | 0.0000 |
| | E-Mini Nasdaq 100 | 0.1280 | 0.0250 | 29.9371 | 0.0000 |
| | FTSE 100 | 0.2460 | 0.0120 | 137164.7483 | 0.0000 |
| Interest Rate | 10 Year US Treasury Notes | 0.1760 | 0.0120 | 26868.5356 | 0.0000 |
| | 3mth EuroDollar | 0.1760 | 0.0120 | 9189.6342 | 0.0000 |

**Table 9: Normality Tests of Monthly Volume**

| | | Monthly Data | | | |
|---|---|---|---|---|---|
| *Market Sector* | *Contract* | *Kolmogorov-Smirnov* | *p-value* | *JB stat* | *p-value* |
| Agriculture | Corn | 0.0660 | 0.0500 | 14.0506 | 0.0009 |
| | Soybeans | 0.0390 | 0.0500 | 16.2958 | 0.0003 |
| | Cocoa | 0.1360 | 0.0520 | 160.6674 | 0.0000 |
| Foreign Exchange | Euro | 0.2080 | 0.1040 | 31.1272 | 0.0000 |
| | Japanese Yen | 0.1020 | 0.0480 | 3.8642 | 0.1448 |
| | British Pounds Sterling | 0.0980 | 0.0480 | 4.3478 | 0.1137 |
| Industrial | High Grade Copper | 0.1360 | 0.0660 | 8.0250 | 0.0181 |
| | Gold | 0.1280 | 0.0500 | 99.6353 | 0.0000 |
| | Brent Crude | 0.1760 | 0.0660 | 10.1243 | 0.0063 |
| Equity | E-Mini S&P 500 | 0.2110 | 0.0960 | 10.9515 | 0.0042 |
| | E-Mini Nasdaq 100 | 0.1280 | 0.1130 | 3.7507 | 0.1533 |
| | FTSE 100 | 0.2460 | 0.0570 | 316.2810 | 0.0000 |
| Interest Rate | 10 Year US Treasury Notes | 0.1760 | 0.0540 | 18.0051 | 0.0001 |
| | 3mth EuroDollar | 0.1760 | 0.0530 | 80.3142 | 0.0000 |

**Table 10: Negative and Positive Daily Excess Returns**

| *Market Sector* | *Contract* | *Positive* | *Negative* | *Percent Postive* | *Percent Negative* |
|---|---|---|---|---|---|
| Agriculture | Corn | 3358 | 3217 | 51.0722 | 48.9278 |
| | Soybeans | 3381 | 3199 | 51.3830 | 48.6170 |
| | Cocoa | 3210 | 3124 | 50.6789 | 49.3211 |
| Foreign Exchange | Euro | 769 | 754 | 50.4924 | 49.5076 |
| | Japanese Yen | 3353 | 3824 | 46.7122 | 53.2739 |
| | British Pounds Sterling | 3552 | 3699 | 48.9863 | 51.0137 |
| Industrial | High Grade Copper | 1876 | 1964 | 48.8542 | 51.1458 |
| | Gold | 3190 | 3384 | 48.5245 | 51.4755 |
| | Brent Crude | 2056 | 1983 | 50.9037 | 49.0963 |
| Equity | E-Mini S&P 500 | 949 | 906 | 51.1590 | 48.8410 |
| | E-Mini Nasdaq 100 | 717 | 643 | 52.7206 | 47.2794 |
| | FTSE 100 | 2647 | 2610 | 50.3519 | 49.6481 |
| Interest Rate | 10 Year US Treasury Notes | 2772 | 2962 | 48.3432 | 51.6568 |
| | 3mth EuroDollar | 2485 | 3327 | 42.7564 | 57.2436 |

**Table 11: Negative and Positive Monthly Excess Returns**

| *Market Sector* | *Contract* | *Positive* | *Negative* | *Percent Postive* | *Percent Negative* |
|---|---|---|---|---|---|
| Agriculture | Corn | 151 | 162 | 48.2428 | 51.7572 |
| | Soybeans | 156 | 157 | 49.8403 | 50.1597 |
| | Cocoa | 138 | 151 | 47.7509 | 52.2491 |
| Foreign Exchange | Euro | 33 | 40 | 45.2055 | 54.7945 |
| | Japanese Yen | 155 | 182 | 45.9941 | 54.0059 |
| | British Pounds Sterling | 160 | 177 | 47.4777 | 52.5223 |
| Industrial | High Grade Copper | 77 | 104 | 42.5414 | 57.4586 |
| | Gold | 144 | 169 | 46.0064 | 53.9936 |
| | Brent Crude | 84 | 97 | 46.4088 | 53.5912 |
| Equity | E-Mini S&P 500 | 44 | 41 | 51.7647 | 48.2353 |
| | E-Mini Nasdaq 100 | 31 | 30 | 50.8197 | 49.1803 |
| | FTSE 100 | 126 | 115 | 52.2822 | 47.7178 |
| Interest Rate | 10 Year US Treasury Notes | 133 | 132 | 50.1887 | 49.8113 |
| | 3mth EuroDollar | 99 | 178 | 35.7401 | 64.2599 |

**Table 12: Daily Negative and Positive Excess Volume**

| *Market Sector* | *Contract* | *Positive* | *Negative* | *Postive Percent* | *Negative Percent* |
|---|---|---|---|---|---|
| Agriculture | Corn | 2935 | 3639 | 44.65 | 55.35 |
| | Soybeans | 3098 | 3485 | 47.06 | 52.94 |
| | Cocoa | 2243 | 3840 | 36.87 | 63.13 |
| Foreign Exchange | Euro | 545 | 978 | 35.78 | 64.22 |
| | Japanese Yen | 3057 | 4025 | 43.17 | 56.83 |
| | British Pounds Sterling | 2879 | 4203 | 40.65 | 59.35 |
| Industrial | High Grade Copper | 1459 | 2323 | 38.58 | 61.42 |
| | Gold | 2448 | 4113 | 37.31 | 62.69 |
| | Brent Crude | 1632 | 2177 | 42.85 | 57.15 |
| Equity | E-Mini S&P 500 | 691 | 1085 | 38.91 | 61.09 |
| | E-Mini Nasdaq 100 | 643 | 630 | 50.51 | 49.49 |
| | FTSE 100 | 1601 | 3471 | 31.57 | 68.43 |
| Interest Rate | 10 Year US Treasury Notes | 2250 | 3305 | 40.50 | 59.50 |
| | 3mth EuroDollar | 2145 | 3668 | 36.90 | 63.10 |

**Table 13: Nonparametric Return Measures –Daily**

| *Market Sector* | *Contract* | *Kolmogorov-Smirnov* | *p-value* | *Wilcoxon Rank Sum* | *p-value* |
|---|---|---|---|---|---|
| Agriculture | Corn | 40.5338 | 0.0000 | -49.1235 | 0.0000 |
| | Soybeans | 40.543 | 0.0000 | -48.9859 | 0.0000 |
| | Cocoa | 39.7895 | 0.0000 | -48.4084 | 0.0000 |
| Foreign Exchange | Euro | 19.5118 | 0.0000 | -23.7881 | 0.0000 |
| | Japanese Yen | 42.2672 | 0.0000 | -50.151 | 0.0000 |
| | British Pounds Sterling | 42.5676 | 0.0000 | -51.6175 | 0.0000 |
| Industrial | High Grade Copper | 30.9757 | 0.0000 | -37.5149 | 0.0000 |
| | Gold | 40.5224 | 0.0000 | -48.917 | 0.0000 |
| | Brent Crude | 31.7713 | 0.0000 | -38.5697 | 0.0000 |
| Equity | E-Mini S&P 500 | 21.529 | 0.0000 | -26.0744 | 0.0000 |
| | E-Mini Nasdaq 100 | 18.4117 | 0.0000 | -21.9687 | 0.0000 |
| | FTSE 100 | 36.2516 | 0.0000 | -44.2478 | 0.0000 |
| Interest Rate | 10 Year US Treasury Notes | 37.8407 | 0.0000 | -45.6001 | 0.0000 |
| | 3mth EuroDollar | 37.7161 | 0.0000 | -43.1755 | 0.0000 |

**Table 14: Nonparametric Return Measures –Monthly**

| *Market Sector* | *Contract* | *Kolmogorov-Smirnov* | *p-value* | *Wilcoxon Rank Sum* | *p-value* |
|---|---|---|---|---|---|
| Agriculture | Corn | 8.8404 | 0.0000 | -10.6599 | 0.0000 |
| | Soybeans | 8.8459 | 0.0000 | -0.4671 | 0.6404 |
| | Cocoa | 8.4913 | 0.0000 | -0.7682 | 0.4423 |
| Foreign Exchange | Euro | 4.2523 | 0.0000 | -4.7617 | 0.0000 |
| | Japanese Yen | 9.1492 | 0.0000 | -10.3579 | 0.0000 |
| | British Pounds Sterling | 9.167 | 0.0000 | -10.9459 | 0.0000 |
| Industrial | High Grade Copper | 6.6761 | 0.0000 | -7.6238 | 0.0000 |
| | Gold | 8.8176 | 0.0000 | -9.3772 | 0.0000 |
| | Brent Crude | 6.7306 | 0.0000 | -7.5459 | 0.0000 |
| Equity | E-Mini S&P 500 | 4.6068 | 0.0000 | -4.6585 | 0.0000 |
| | E-Mini Nasdaq 100 | 3.9046 | 0.0000 | -3.7331 | 0.0002 |
| | FTSE 100 | 7.7539 | 0.0000 | -7.5769 | 0.0000 |
| Interest Rate | 10 Year US Treasury Notes | 8.1393 | 0.0000 | -1.4354 | 0.1512 |
| | 3mth EuroDollar | 7.9760 | 0.0000 | -8.4325 | 0.0000 |

**Table 15: Nonparametric Volume Tests –Daily**

| *Market Sector* | *Contract* | *Kolmogorov-Smirnov Z* | *p-value* | *Wilcoxon Rank Sum* | *p-value* |
|---|---|---|---|---|---|
| Agriculture | Corn | 40.3070 | 0.0000 | -46.8843 | 0.0000 |
| | Soybeans | 40.4977 | 0.0000 | -38.0038 | 0.0000 |
| | Cocoa | 37.6289 | 0.0000 | -40.9686 | 0.0000 |
| Foreign Exchange | Euro | 18.7076 | 0.0000 | -19.1164 | 0.0000 |
| | Japanese Yen | 41.6824 | 0.0000 | -47.5450 | 0.0000 |
| | British Pounds Sterling | 41.3354 | 0.0000 | -46.3750 | 0.0000 |
| Industrial | High Grade Copper | 29.9358 | 0.0000 | -33.0851 | 0.0000 |
| | Gold | 39.1742 | 0.0000 | -42.8529 | 0.0000 |
| | Brent Crude | 30.5410 | 0.0000 | -34.8780 | 0.0000 |
| Equity | E-Mini S&P 500 | 20.5462 | 0.0000 | -22.7701 | 0.0000 |
| | E-Mini Nasdaq 100 | 17.8386 | 0.0000 | -11.2888 | 0.0000 |
| | FTSE 100 | 33.1004 | 0.0000 | -34.0745 | 0.0000 |
| Interest Rate | 10 Year US Treasury Notes | 36.5877 | 0.0000 | -35.4203 | 0.0000 |
| | 3mth EuroDollar | 36.7899 | 0.0000 | -40.1137 | 0.0000 |

**Table 16: Nonparametric Volume Tests –Monthly**

| *Market Sector* | *Contract* | *Kolmogorov-Smirnov Z* | *p-value* | *Wilcoxon Rank Sum* | *p-value* |
|---|---|---|---|---|---|
| Agriculture | Corn | 8.8357 | 0.0000 | -10.4998 | 0.0000 |
| | Soybeans | 8.8422 | 0.0000 | -3.7230 | 0.0002 |
| | Cocoa | 8.4779 | 0.0000 | -0.0223 | 0.9822 |
| Foreign Exchange | Euro | 4.0544 | 0.0000 | -4.1033 | 0.0000 |
| | Japanese Yen | 9.1574 | 0.0000 | -10.4321 | 0.0000 |
| | British Pounds Sterling | 9.1719 | 0.0000 | -10.7152 | 0.0000 |
| Industrial | High Grade Copper | 6.7094 | 0.0000 | -6.9216 | 0.0000 |
| | Gold | 8.7620 | 0.0000 | -7.1532 | 0.0000 |
| | Brent Crude | 6.6623 | 0.0000 | -7.6679 | 0.0000 |
| Equity | E-Mini S&P 500 | 4.5166 | 0.0000 | -5.0862 | 0.0000 |
| | E-Mini Nasdaq 100 | 3.8793 | 0.0000 | -4.5167 | 0.0000 |
| | FTSE 100 | 7.3332 | 0.0000 | -6.7587 | 0.0000 |
| Interest Rate | 10 Year US Treasury Notes | 8.1366 | 0.0000 | -0.1869 | 0.8518 |
| | 3mth EuroDollar | 8.2550 | 0.0000 | -2.8129 | 0.0049 |