The Integration of Oil Futures Contracts with other Commodities

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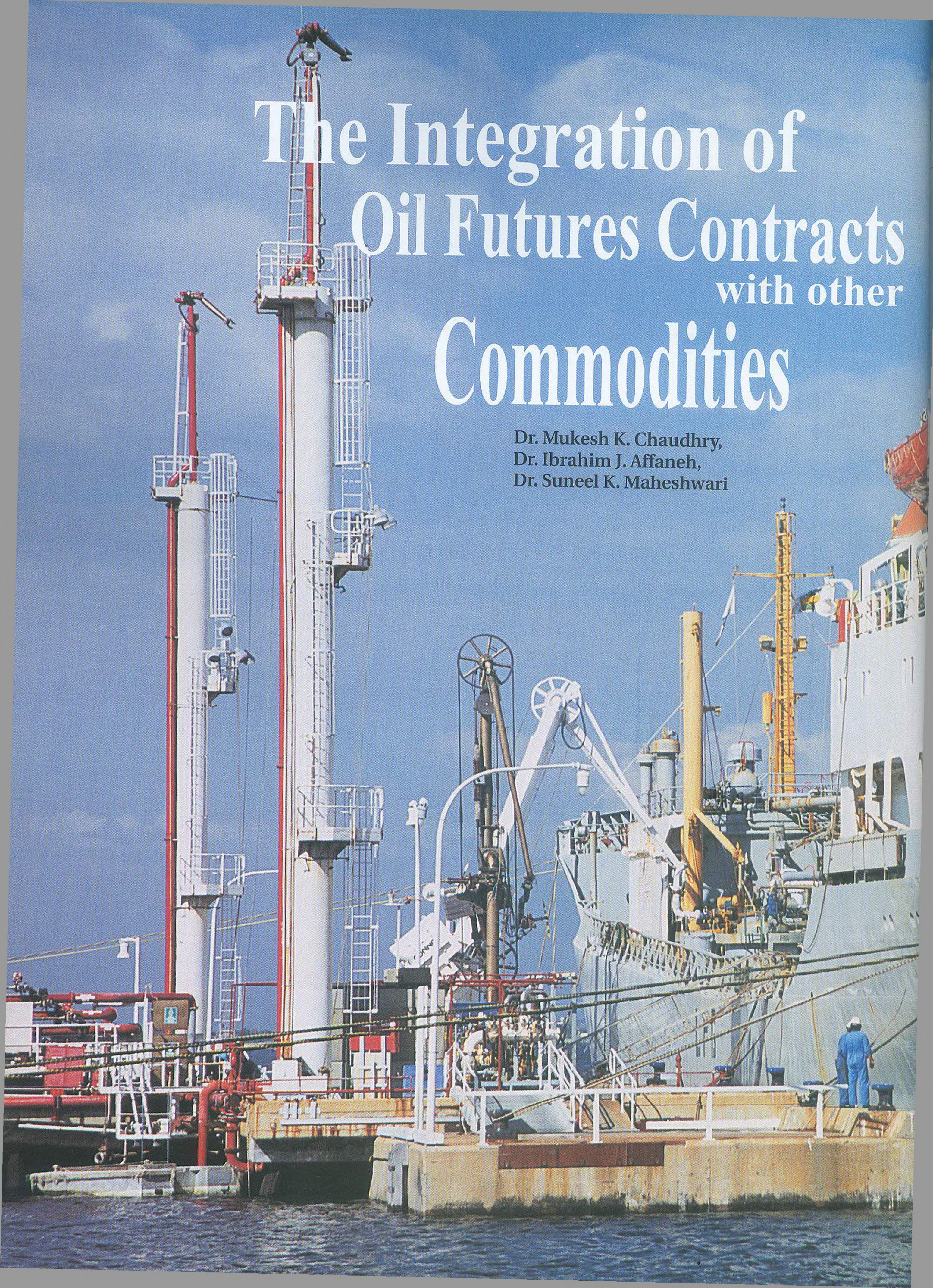

ABSTRACT

Oil as a commodity has played an important role for the world economies. In this regard futures market has played an important role as the traders have developed important hedging techniques using these contracts. Hence, the policy makers of various governments and the central banks of different countries constantly monitor this commodity and study its corresponding impact on fundamental macroeconomic variables. In addition, the political factors superimpose themselves in such a manner that in some instances the macroeconomic factors are overshadowed by these developments.

We have used daily data from the Futures Industry Institute to disentangle the economic news and the political factors in order to develop an understanding of how these factors affect Oil price. Methodology developed by Johansen is used to test for co-integration amongst the variables. Further, the new information causes protracted volatility, accompanied by persistence of volatility reflecting changes in traders' incentive and motivation to trade. Hence, in this study, a nonparametric measure of volatility is employed to develop deeper understanding of the role that volatility plays from the point-of-view of the traders.

The results of the study show a high level of co-integration between Oil Futures, Soft Commodities (SC), Grains and Oil Seeds (GO), and Live Stock (LS). Investors may be able to use futures positions on SC, GO, and LS to hedge against Oil Future holdings in the short-run. Assets that lacked co-integration with Oil Futures may be useful to those investors seeking to diversify their portfolios. The results of this study can be useful to investors wanting a framework for their portfolios.

INTRODUCTION

Oil as a commodity has played an important role for the world economies. Production of a number of products and their relative price depends upon the efficient pricing of this commodity. Futures contracts on oil have played a significant role as important hedging techniques have been developed using these instruments. Policy makers of various governments and the central banks of different countries constantly monitor this commodity and study its corresponding impact on fundamental economic variables. Hence, using daily data, we will disentangle the economic news and the political factors in order to develop an understanding of how these factors affect this commodity's price. Further a nonparametric measure of volatility will be employed to develop deeper understanding of the role that volatility plays from the point-of-view of the traders who are using these financial contracts as arbitrageurs, hedgers, or speculators.

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In this study, we will disentangle the economic news in order to develop an understanding of how these factors affect this commodity's price. Further, as documented in various studies, the new information causes protracted volatility, accompanied by persistence of volatility, reflecting changes in traders' incentive and motivation to trade. Hence, in this study, a nonparametric measure of volatility will be employed to develop deeper understanding of the role that volatility plays from the point-of-view of the traders who are using these financial contracts as arbitrageurs, hedgers, or speculators.

Most studies that have examined oil futures contracts use daily data. But, as pointed out, Harvey and Huang (1991), and Ederington and Lee (1993), most information is incorporated in financial instruments and commodity prices within minutes of news release, although the adjustments can continue for several minutes thereafter. Daily data therefore, has a severe limitation in this regard.

As the movement of prices typically, results from the unanticipated news, we would create news surprises from the forecasted and the actual values. In examining the surprises, we would create further bifurcation based on the sign and the size of surprise. As a result, we would be able to dissect the news information in its finer elements in order to develop a deeper understanding of the traders and their motivation to trade and the impact that such an understanding would have on other financial market instruments. The results from this study may also have corresponding implications on the response by the policymakers of different governments and central banks.

RESEARCH DESIGN AND DATA

Most time-series are nonstationary and the use of cointegrated methodologies accounts for this characteristic.[1] Engle and Granger (1987) suggest that if a system of variables is cointegrated, then economic forces interact to bind these variables together in a long-run equilibrium relationship. They suggest that an error correction model (ECM) can represent the cointegrated variables.[2] In general, the ECM shows the dependence of this period's price change on the last period's price change, thus providing a measure of how far the system is out of its long-run equilibrium.

There are preliminaries a researcher has to observe before applying the methods of cointegration. Specifically, before testing for cointegration between two or more series, it is necessary to test whether the different time series are integrated to the same order.[3] This is done by applying conventional unit roots tests, described below.

Stationary (Unit Root) Tests for Individual Time Series

In general, most texts on stationarity of a time series (TS_t) will probably begin with estimation of the following regression equation, if no linear trend is considered.

$$\Delta TS_t = \alpha_0 + \alpha_1 TS_{t-1} + \sum_{j=1}^{\rho} \gamma_j \Delta TS_{t-j} + \varepsilon_t \qquad (1)$$

and by equation (2) when linear trend and a parameter for drift are considered:

$$\Delta TS_t = \alpha_0 + \alpha_1 TS_{t-1} + \alpha_2 t + \sum_{j=1}^{\rho} \gamma_j \Delta TS_{t-j} + \varepsilon_t \qquad (2)$$

where Δ represents differences (first difference unless otherwise noted), α_0 represents the term for drift in the series, α_1 allows testing for a unit root, and α_2 verifies the presence of a trend. The error-correcting mechanism is represented by ΔTS_{t-j} in the model. If the hypothesis $\alpha_1 = 0$ cannot be rejected, then the series is said to have a unit root and is nonstationary. Conversely, if the hypothesis, $\alpha_1 = 0$ is rejected, it is concluded that the series does not contain a unit root and is stationary. Tests involving parameters α_0 and α_2 verify the presence of drift and trend, respectively. Inclusion of the p lagged values ensures a white-noise series. The number of lags is determined by a test of significances, such as the Akaike Information Criterion (AIC) (Akaike, 1973).[5] Importantly, the distribution of the ordinary t and F statistics computed for the regressions do not have their expected distribution. Thus, in order to test the various hypotheses, critical values have been computed using Monte Carlo techniques and are tabulated in various references (see, e.g., Davidson and MacKinnon, 1993). Tests for stationarity and cointegration use the Philips-Perron (P&P) non-parametric testing procedure. The P&P procedure is used since the crucial *iid* error assumption is not needed.[6]

INTEGRATION/SEGMENTATION TESTS

This part of the analysis uses the methodology developed by Johansen (1988). This method is preferred to alternatives since it enables testing for the presence of more than one cointegrating vector. The description that follows draws from Johansen (1988, 1991, 1994) and Johansen and Juselius (1990, 1991).

The Johansen method provides some distinct advantages. For example, identification of the number of co integrating vectors is possible with the Johansen test. Such inferences are based on the number of significant eigen values. Also, many argue that the statistical properties and power for Johansen's test are generally higher than for alternative procedures. To check for stationarity arising from a linear combination of variables, the following AR representation for a vector VTS made up of n variables is used,

$$VTS_t = c + \sum_{i=1}^{s-1} \phi_i Q_{it} + \sum_{i=1}^{k} \pi_i VTS_{t-i} + \varepsilon_t \quad (3)$$

where VTS is at most I(1), Q_{it} are seasonal dummies (i.e., a vector of non-stochastic variables) and c is a constant. It is not necessary that all variables that make up VTS be I(1). To find cointegration in the system, only two variables in the system need be I(1). However, if only two time series are examined (bivariate representation) then both have to be I(1). If an error-correction term is appended, then:

$$\Delta VTS_t = c + \sum_{i=1}^{s-1} \phi_i Q_{it} + \sum_{i=1}^{k-1} \Gamma_I \Delta VTS_{t-i} + \Pi VTS_{t-k} + \varepsilon_t \quad (4)$$

which is basically a vector representation of equation (1) with seasonal dummies added. All long-run information is contained in the levels terms, ΠVTS_{t-k} and short-run information in the differences ΔVTS_{t-i}. The above equation would have the same degree of integration on both sides only if $\Pi = 0$ (the series are not cointegrated) or ΠVTS_{t-k} is (0), which infers cointegration. In order to test for cointegration, the validity of $H_1(r)$, shown below, is tested as:

$$H_1(r): \Pi = \gamma\beta' \quad (5)$$

where β is a matrix of cointegrating vectors and γ represents a matrix of error correction coefficients. The hypothesis $H_1(r)$ implies that the process ΔVTS_t is stationary, VTS_t is nonstationary, and β VTS_t is stationary (Johansen, 1991). The Johansen method yields the Trace and the λ_{max} statistics that enable determination of the number of cointegrating vectors.

Description of Data

The data used in this study are obtained from the Futures Industry Institute. Futures prices for fifteen assets are sampled. The sample spans the period January 1987 through September 2002.

RESULTS OF EMPIRICAL TESTS

In order to eliminate autocorrelations in the time-series, the appropriate lag length is found using the Akaike Information Criterion (AIC). The lag length is selected by minimizing the AIC over different choices for the length of the lag. The values of AIC are formulated by computing the value of the equation $T \log (RSS) + 2K$, where K is the number of regressors, T is the number of observations and RSS is the residual sum of squares. These results are shown in Table 1 (see Nlags) along with the results of the Philips-Perron unit root tests. From Table 1 it becomes clear that the time series require a range of lags in order to correct for the presence of autocorrelation. For instance, for the time series belonging to sugar a lag length of 6 is needed to minimize the AIC and purge autocorrelations, whereas wheat requires a lag length of 11 to correct for autocorrelations. For some assets, shorter lag corrections are required. In these instances autocorrelations that are present decay quickly. We next test for stationarity.

Tests for Stationarity of Each Time Series Using the Philips-Perron (P&P) Test

The time series are tested for a unit root using the P&P tests. The P&P tests suggest that all of the time series are nonstationary without trend (i.e., non-rejection of $\alpha_1 = 0$), and in most instances with trend, clearly suggesting the need for cointegrated methodologies (critical values at the 10% level are provided in the last row of Table 1). The time-series more often reject the presence of drift ($\alpha_0 = 0$) than trend ($\alpha_2 = 0$). Thus, the inclusion of a drift term may not be as important. While it is reassuring to note the non-rejection of nonstationarity, this is not altogether surprising since many other studies find nonstationary in time series (Phillips and Perron, 1988, Brenner and Kroner, 1995, Doukas and Rahman, 1987).

Johansen Tests for Cointegration Rank for Systems (Real Estate and Asset Groups)

The results for systems (composed of Oil Futures and an asset group) using Johansen's method are presented in Table 2. Two statistics, the L_{max} statistic and the Trace statistic, are reported. These are basically likelihood ratio tests where the null hypothesis is $L_{r+1} = L_{r+2} = \ldots\ldots = L_p = 0$, indicating that the system has *p-r* unit roots, where *r* is the number of cointegrating vectors. The rank is then determined using a sequential approach starting with the hypothesis of *p* unit roots. If this is rejected then the next hypothesis $L_2 = L_3 = \ldots\ldots = L_p = 0$ is tested and so on.[9]

In order to consider hedging possibilities, the relationship between Crude Oil and Heating Oil Futures with another asset group, such as soft commodities, is analyzed. For each system there can be at most n-1 cointegrating vectors (or common factors) that bind the assets in the system (n being the number of time-series in the system). For example, for Crude Oil Futures with soft commodities, there can be at most 2 (3-1) common factors.

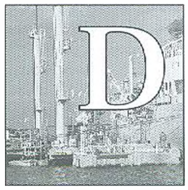
The L_{max} and Trace Values are shown for the full range of cointegrating vectors (i.e., for n-1 vectors). For example, for Crude Oil Futures with soft commodities, the L_{max} and Trace values are from r=0 to r=2. The rejection of r=0 indicates that at least one cointegrating vector is present. The rejection of r=1 indicates the presence of at least two cointegrating vectors and so on.

Highly Cointegrated Systems

The most striking result in Table 2 is the high level of cointegration between Oil Futures and Soft Commodities (SC), Grains and Oil Seeds (GO), and Live Stock (LS). There is evidence of cointegration between two and three cointegrating vectors (maximum =2, where n=3 for this system, i.e., cointegration at the n-1 level) between the Oil Futures and these three group. Clearly, the evidence suggests close linkages between Oils and SC, GO, and LS. The reader will also note the large coefficient values associated with these systems. For example, Trace coefficient value for Oils and LS 79.22 when compared against 90% value of 64.44. Similar values are also noted for Oils and GO and SC. These results might have a straightforward explanation, given that energy prices are closely linked to supply-side inflation. It is likely that inflationary pressures highly cointegrate energy prices with REIT prices. The results suggest that futures positions on LS, GO, and SC might serve as a useful hedge against Oil Futures holdings.

Moderately and Less Cointegrated Systems

Several systems show moderate cointegration (i.e, n-2 levels of cointegration). For instance Oil Futures and Metals provide evidence of at least one cointegrating vector (i.e., r=0 is rejected). However Oil Futures and currencies do not provide any evidence of cointegration. In these instances, r=0 is not rejected, suggesting no common factors that bind these assets.



DISCUSSION OF THE RESULTS AND CONCLUSION

Taken cumulatively the results seem intuitive. While it is likely that the prices of Oil Futures and LS, GO, and SC would be highly cointegrated as inflation seems to be the common binding factor.

Cointegration between assets suggests that their prices exhibit a long-run relationship with each other. Higher levels of cointegration, noted by the number of cointegrating vectors, suggest potential hedging candidates. This exercise overcomes some of the biases in standard econometric techniques, this approach might prove better at identifying potential hedging candidates for Oil Futures investors. Investors might examine cross-hedging opportunities between these markets, especially if these markets differ in liquidity. Portfolios, heavily weighted in Oil Futures, held over long periods of time, can be hedged over the short-run with futures on LS, GO, and SC. Also, the lack of cointegration between Oil Futures and some assets, such as Foreign Currencies, may be useful for investors seeking to diversify their portfolios. In summary, an analysis such as performed in this study, might aid in setting up a framework for building portfolios and for setting up hedging strategies.

Table 1
Tests of Stationarity for Oil and Futures Contracts Using Phillips-Perron Test (P&P)

Series	No Trend Nlags	$\alpha_1=0$	With Trend $\alpha_0=\alpha_1=0$	$\alpha_1=0$	$\alpha2=0$	$\alpha_0=\alpha_1=\alpha_1=\alpha_2=0$	Akaike Criterion (minimized)
Energy (E)							
Crude Oil	7	0.01	3.75	-3.12	3.37	4.99	-7965.7
Heating Oil	6	-0.18	4.58*	-3.29*	3.71	5.51	-9273.4
Soft Commodities (SC)							
Sugar	6	-0.62	3.19	-2.88	2.94	4.40	-8255.7
Coffee	7	-1.12	2.99	-2.47	2.10	3.09	-7751.9
Grain and Oilseeds (GO)							
Wheat	11	-0.15	3.43	-2.66	2.39	3.54	-7073.5
Soybean	7	-0.32	4.20*	-3.12	3.34	5.00	-6851.9
Corn	6	-0.29	5.23*	-3.21*	3.53	5.26	-7540.6
Livestock (LS)							
Feeder Cattle	9	0.16	2.96	-2.40	2.01	2.96	-7141.8
Pork	3	-0.63	4.35*	-3.65*	4.54	6.80*	-8196.8
Hog	6	-0.73	6.64*	-3.82*	4.90*	7.34*	-8131.3
Precious Metal (PM)							
Gold	8	-0.78	1.21	-2.70	2.52	3.66	-6644.9
Foreign Currencies (FC)							
Swiss Franc	5	-0.16	2.85	-2.48	2.08	3.12	-8508.7
Japanese Yen	4	0.07	2.87	-2.35	1.93	2.83	-8802.7
Canadian $	9	-0.91	0.41	-2.91	4.13*	5.73*	-7898.3
British Pound	1	-0.11	4.42^{8}	-3.90*	5.14*	7.71*	-7836.9

The optimal lag length for Johansen Cointegration Model is obtained from an examination of the residual autocorrelation functions of the cointegrating regressions. Critical values for Johansen tests are taken from tables in Johansen and Juselius (1990) paper. The * denotes a significance level of 10 percent.

Table 2
Long-Term Relationship between Crude Oil and Futures Contracts Using Johansen's Cointegration Methodology

Group	r	L-Max	Trace
Crude Oil and SC			
	0	16.11*	30.47*
	1	11.45*	14.36*
	2	2.92	2.92
Crude Oil and GO			
	0	31.35*	96.43*
	1	26.24*	65.08*
	2	18.45*	38.84
	3	9.74	20.39
	4	7.36	10.65
	5	3.30	3.30
Crude Oil and LS			
	0	34.72*	79.22*
	1	23.51*	44.50*
	2	13.93*	20.98
	3	0.69	0.69
Crude Oil and PM			
	0	13.87*	15.97*
	1	2.10	2.10
Crude Oil and FC	0	25.49	52.54
	1	13.96	27.05
	2	9.90	13.10
	3	3.17	3.19
	4	0.02	0.02

The optimal lag length for Johansen Cointegration Model is obtained from an examination of the residual autocorrelation functions of the cointegrating regressions. Critical values for Johansen tests are taken from tables in Johansen and Juselius (1990) paper. The * denotes a significance level of 10 percent.

Table 3
Long-Term Relationship between Heating Oil and Futures Contracts Using Johansen's Cointegration Methodology

Group	r	L-Max	Trace
Heating Oil and SC			
	0	15.50 *	30.08 *
	1	11.56*	14.58*
	2	3.02 *	3.02 *
Heating Oil and GO			
	0	31.35*	96.43*
	1	26.24 *	65.08 *
	2	18.45 *	38.84
	3	9.74	20.39
	4	7.36	10.65
	5	2.30	2.30
Heating Oil and LS			
	0	34.01*	79.04*
	1	24.81*	45.03*
	2	12.95	20.22
	3	6.52	7.27
	4	0.75	0.75
Heating Oil and PM			
	0	13.39*	15.42*
	1	2.03	2.03
Heating Oil and FC			
	0	26.68 *	55.09
	1	15.38	28.41
	2	9.98	13.03
	3	3.03	3.04
	4	0.01	0.01

The optimal lag length for Johansen Cointegration Model is obtained from an examination of the residual autocorrelatio functions of the cointegrating regressions. Critical values for Johansen tests are taken from tables in Johansen and Juselius (1990 paper. The * denotes a significance level of 10 percent.

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