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Abstract

The aim of this work was to gain some insight into the American crude oil futures market using the means of multivariate data analysis. Using these techniques, the first step was to find out if there is some identifiable behavior of the crude oil price and to which fundamental market factors such behavior is most related. Two models are developed, a descriptive model to explain the time behavior of the crue oil futures price, and a forecasting model to predict the price changes whitout calling on the speculative factors but using solely the fundamental physical factors of the market.

Résumé

Ce travail vise à apporter un éclairage sur le fonctionnement des marchés à terme pétroliers américains en utilisant l'analyse de données. La première étape vise à explorer l'existence d'un comportement identifiable du prix du pétrole brut et de rechercher les facteurs fondamentaux du marché auxquels ce comportement peut être relié. Deux modèles ont été développés; un modèle descriptif pour expliquer le comportement dans le temps des prix à terme du pétrole brut sur le Nymex et un modèle prospectif pour prédire les variations de ces prix en utilisant les seuls facteurs physiques (fondamentaux) du marché.

ANALYSIS OF THE OIL FUTURES MARKET

Karim FAID

I. INTRODUCTION

In order to formulate a general model of futures price behavior, one must first study the market determinants of price. Studies of other speculative markets such as the stock market have shown that demand theory fails to offer an adequate explanation of price behavior. However, with commodity futures, a greater variety of quantity relatives are available. Price fluctuations can be related to both speculative and physical variables. The former encompass volume of trading and open interest, while the latter include supply, demand, and stock levels. The total number of determinants of commodity prices can be classified into four groups as follows :

1/ Acting through Demand
- Consumption.
- Exports.
- Derived demand for final products.
- Government policies (long run).
- Demand relatives such as the prices of substitutable commodities, or consumption/stock ratios.

2/ Acting through Supply
- Production.
- Stocks.
- Weather.
- Government policies (long run).
- Supply relatives such as the production of substitutable commodities, or production/stock ratios.

3/ Acting through Economic Conditions
- Business conditions as reflected in industrial production, unemployment, and the general price level.
- Credit conditions which define the availability of loans for speculation or commodity storage.

4/ Acting through Market Composition
- Speculation.
- Hedging.

In this study, we will be concerned with a description of the intricate relationships between futures crude oil price and the physical variables of the energy market. It is clear that this will certainly not give the whole picture, and we even expect to get a very fuzzy picture due to the fact that the futures market is in essence a speculative market in which speculative variables play a fundamental role. In fact, two speculative parameters, short hedging and long speculating, represent the effective supply and demand for futures contracts, respectively. However, because of the fact that a commodity futures market is far from independent from the corresponding physical market, the physical variables of the market do undoubtedly play a significant role in the futures price behavior. It is this relationship we will concentrate on and try to decipher.

What we are interested in is the short run behavior of the futures crude oil price. From the outset, we start with the following hypotheses on the futures price response to the physical supply and demand:

-a/ There is a weak relationship between futures prices and supply or demand in the short run, but prices may be better related to the components of supply and demand :

Supply = Production + Stocks　　　　Demand = Consumption + Exports

-b/ For energy futures, short-term price trends are extremely responsive to variations in inventory levels. Oil traders watch closely the weekly figures of the American Petroleum Institute.

-c/ The pressure of demand on supply is a more immediate influence on price than are the influences taken individually. Different parameters can be used to measure that pressure. These are the various pressure ratios that could be used : Demand/Supply, Demand/Stocks, Exports/Stocks, Consumption/Supply, Consumption/Stocks, Stocks/Consumption, Stocks/Production.

-d/ Prices of one commodity vary with the prices or supply and demand of other commodities. One can relate the prices of a commodity through a price index to the prices of domestic commodity substitutes, foreign commodity substitutes, or to the prices of its converted products. For crude oil, we would look at its converted products since it is not a commodity that can be easily substituted, at least not in the short run we are interested in. This is why we choose to examine the prices, supply, and demand for oil products.

From the New York Mercantile Exchange (NYMEX), we gathered data concerning the monthly prices of West Texas Intermediate Crude Oil (WTI) contracts, Unleaded Regular Gasoline (HU) contracts, and No2. Heating Oil (HO) contracts. The publications of the American Petroleum Institute (API) provided us with monthly data concerning fundamental market factors such as imports of crude oil and oil products, crude oil stocks, production and stocks of oil products, etc. The data set runs from February 1987 to December 1991. The table below lists the variables used in this study.

We shall base our analysis on three approaches of multivariate data analysis. First, the Principal Components Analysis will provide a general picture of the interactions between the futures prices and the fundamental market factors considered. Second, the Factorial Discriminant Analysis will allow us to identify those variables that can best discriminate between increases and decreases in the crude oil price. Finally, the Canonical Correlation approach will provide the linear combination of the variables that is the most correlated with the crude oil futures price and which allows us to run the optimal multiple regression.

VARIABLE	Definition
WTIMP	West Texas Intermediate Monthly Price
HUMPR	Unleaded Regular Gasoline Monthly Price
HOMPR	No2. Heating Oil Monthly Price
CRIMPO	Crude Oil Imports
CRSTOC	Crude Oil Stocks
PRIMPO	Product Imports
HUPROD	Unleaded Gasoline Production
HUSTOC	Unleaded Gasoline Stocks
GAPROD	Total Gasoline Production
GASTOC	Total Gasoline Stocks
HOPROD	Heating Oil Production
HOSTOC	Heating Oil Stocks
REPROD	Residual Fuel Oil Production
RESTOC	Residual Fuel Oil Stocks
KEPROD	Jet Fuel Kerosine Production
KESTOC	Jet Fuel Kerosine Stocks
CINPUT	Input to Crude Oil Distillation Units
PEOPER	Percentage of Refinery Capacity Operated
CST/CIN	Crude Stocks/Crude Input
CST/CIM	Crude Stocks/Crude Imports
CIM/PIM	Crude Imports/Product Imports
HUS/HUP	Unleaded Gasoline Stocks/Unleaded Gasoline Production
GAS/GAP	Total Gasoline Stocks/Total Gasoline Production
HOS/HOP	Heating Oil Stocks/Heating Oil Production
RES/REP	Residual Fuel Oil Stocks/Residual Fuel Oil Production
KES/KEP	Kerosene Stocks/Kerosene Production

Notes :

1/ Stocks of unleaded and leaded motor gasoline represent only finished motor gasoline located at refineries, pipeline and bulk terminals. A large portion of motor gasoline stocks at refineries consists of components which may be blended or compounded to produce either finished leaded or unleaded motor gasoline. Therefore, these stocks cannot be classified as either finished leaded or unleaded motor gasoline. The sum of finished leaded and unleaded motor gasoline stocks plus the components stocks equals total motor gasoline stocks.

2/ We will make use also of other variables derived from the basic variables stated above. Starting from a variable Y_m corresponding to a given month m, we can compute the two variables:

$$DY_m = Y_m - Y_{m-1} \quad \text{and} \quad Y1 = Y_{m-1}$$

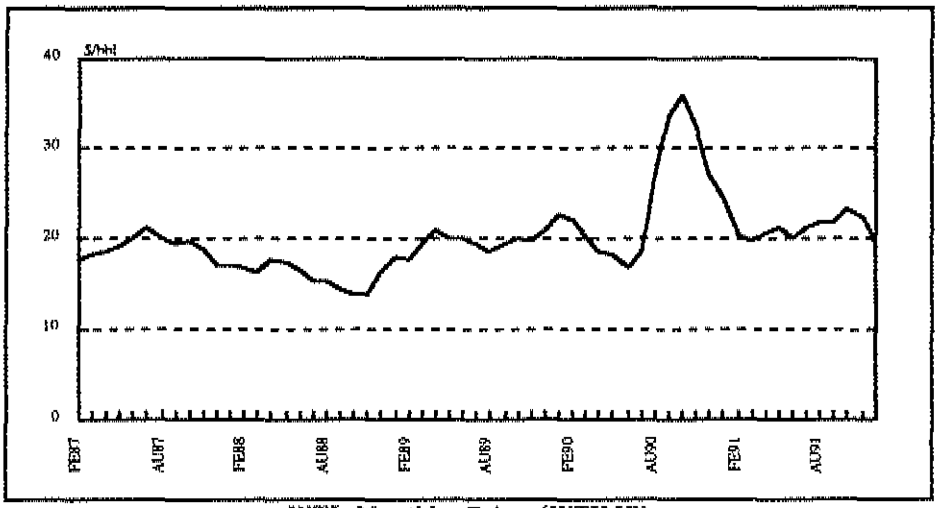
corresponding to the monthly change and the one-month lagged variable, respectively.

We shall look at the data from two different angles. From the first, hereafter referred to as the descriptive framework, we shall seek the explanatory power for the crude oil futures price in the physical determinants of the market and the oil products futures prices. We will therefore be using the variables described in the table above with no time lag. Our goal will be to find out how much of the monthly crude oil futures price (WTIMP) can be explained by the other variables used in this analysis.

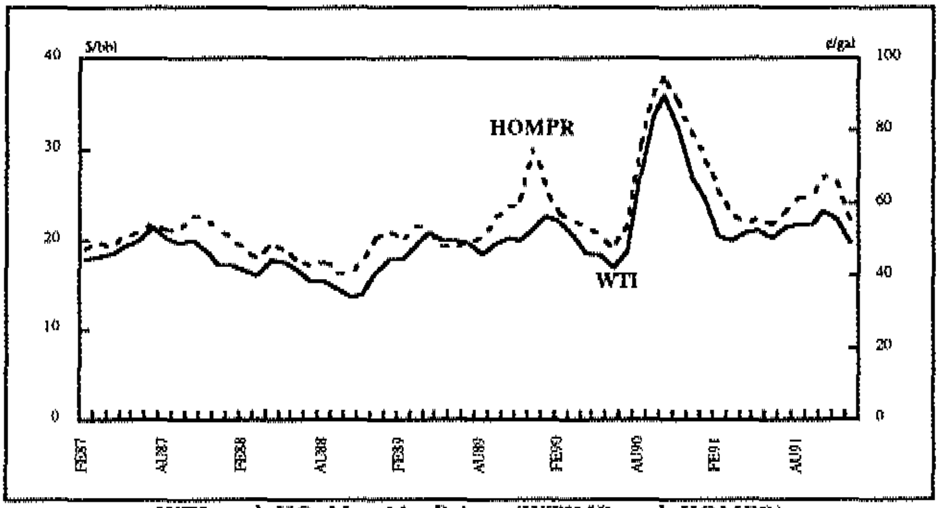
From the second angle, hereafter referred to as the predictive framework, we shall seek the forecasting power for the monthly crude oil futures price variation in the physical determinants of the market and the oil products futures prices. We will then be using the same variables but lagging the monthly crude oil futures price change (DWTIMP) by one period. This is done in order to reach our final goal, namely to find out how well this price variation can be forecasted through mainly fundamental physical factors of the oil market.

II. DATA DESCRIPTION

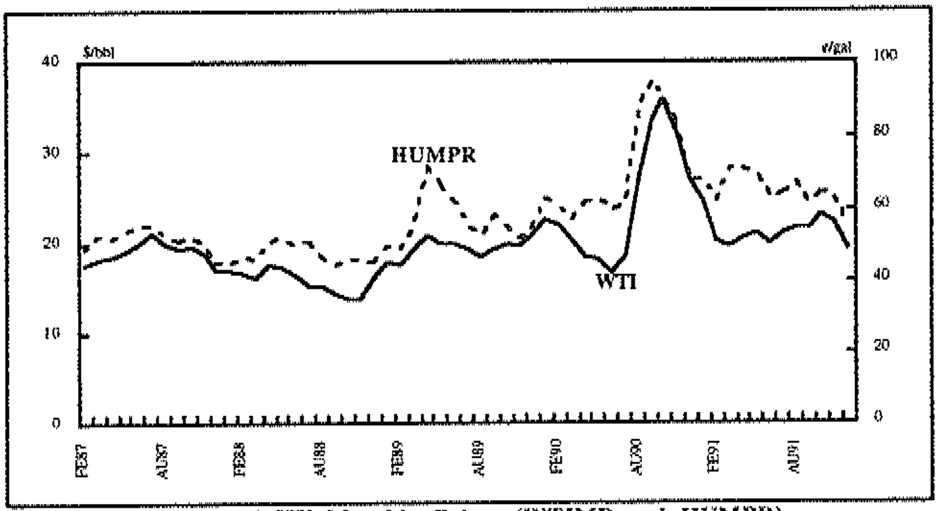
Since the variable of greatest interest is the crude oil futures price (WTIMP), we chose to depict its behavior over the time period considered, along with the prices of two oil products futures contracts traded on the NYMEX, namely Unleaded Gasoline (HUMPR) and Heating Oil (HOMPR).



WTI Monthly Price (WTIMP)



WTI and HO Monthly Prices (WTIMP and HOMPR)



WTI and HU Monthly Prices (WTIMP and HUMPR)

In these figures, it is easy to spot the peak in prices from April 1990 to March 1991 due to the Gulf war. The smaller price increase at the end of 1991 was due to the crisis in the Soviet Union. What these figures show very clearly is the high positive correlation between the prices of the crude and products futures contracts, especially between crude oil and heating oil. From the following table, showing the characterization of the monthly crude oil price WTIMP, it can be seen that the correlation between this variable and the oil products prices is equal to 0.94 for HOMPR and 0.88 for HUMPR. It is most negatively correlated with the variation in crude oil stocks (DCRSTO), as could be expected.

WTIMP CHARACTERIZATION

CHARACTERISTIC VARIABLES	CORR.	V.TEST	PROBA
WTIMP	1.000	64.838	.0000
HOMPR	.944	13.298	.0000
HUMPR	.885	10.465	.0000
RESTOC	.582	4.983	.0000
KEPROD	.580	4.958	.0000
RES/REP	.573	4.885	.0000
HUSTOC	.539	4.509	.0000
HUPROD	.463	3.753	.0001
KESTOC	.444	3.573	.0002
CIM/PIM	.380	2.994	.0014
HOSTOC	.290	2.232	.0128
PROPER	.221	1.685	.0460
HOS/HOP	.216	1.644	.0501
CRIMPO	.214	1.623	.0523
HOPROD	.153	1.151	.1248
DRESTO	.131	.988	.1616
DHOSTO	.127	.957	.1693
CINPUT	.111	.836	.2017
GAPROD	.103	.772	.2200
DKESTO	.096	.719	.2360
CRSTOC	.075	.563	.2868
HUS/HUP	.051	.379	.3524
DGASTO	.045	.338	.3678
DHUSTO	.015	.112	.4554
REPROD	-.008	-.057	.4774
CST/CIN	-.022	-.163	.4353
GAS/GAP	-.163	-1.232	.1089
GASTOC	-.171	-1.292	.0982
CST/CIM	-.219	-1.662	.0482
KES/KEP	-.251	-1.919	.0275
PRIMPO	-.287	-2.211	.0135
DCRSTO	-.324	-2.519	.0059

From the following table, showing the characterization of the monthly change in the crude oil price (DWTIMP), it can be inferred that this variable is most positively correlated with the one-month lagged changes in the prices of the oil products contracts. However, the correlation is lower than that found earlier between the monthly prices of crude and products.

DWTIMP CHARACTERIZATION

CHARACTERISTIC VARIABLES	CORR.	V.TEST	PROBA
DWTIMP	1.000	61.686	.0000
DHOMP1	.536	4.443	.0000
DHUMP1	.431	3.420	.0003
PEOPER1	.400	3.141	.0008
CINPUT1	.384	3.004	.0013
CRSTOC1	.341	2.634	.0042
GAPROD1	.335	2.588	.0048
PRIMPO1	.311	2.382	.0086
CRIMPO1	.245	1.854	.0319
REPROD1	.184	1.380	.0837
HOPROD1	.124	.928	.1768
DHOSTO1	.119	.886	.1878
HUPROD1	.102	.756	.2247
DCRSTO1	.074	.551	.2909
RES/KEP1	.059	.436	.3315
DHUSTO1	.055	.408	.3417
DRESTO1	.033	.244	.4036
DGASTO1	.026	.192	.4240
CST/CIN1	.006	.045	.4821
GASTOC1	-.011	-.079	.4686
HUSTOC1	-.041	-.305	.3804
DKESTO1	-.042	-.314	.3769
CIM/PIM1	-.069	-.512	.3042
HUMPR1	-.072	-.537	.2957
CST/CIM1	-.096	-.713	.2379
HOSTOC1	-.122	-.910	.1813
KESTOC1	-.130	-.973	.1654
GAS/GAP1	-.153	-1.144	.1263
KEPROD1	-.163	-1.221	.1111
RESTOC1	-.189	-1.415	.0785
HOS/HOP1	-.198	-1.487	.0684
HUS/HUP1	-.201	-1.508	.0657
HOMPR1	-.205	-1.542	.0616
WTIMP1	-.251	-1.903	.0285
RES/REP1	-.350	-2.708	.0034

In fact, the change in the crude oil price (DWTIMP) of one month with respect to the preceding month is most correlated with a group of variables including not only the changes in the prices of the products registered in the preceding month (DHOMP1 and DHUMP1) but also the variables describing the refinery operations in that same period (CRSTOC1, CINPUT1 and PEOPER1), the correlation ranging from 0.34 to 0.54. This is due to the fact that in the case, for example, where the two former variables (DHOMPR and DHUMPR) are positive, this will induce a very prompt response from the refiners through an increase in (1) the crude oil stocks (CRSTOC), (2) the amount of crude input to the refineries (CINPUT); and therefore, (3) the percentage of refinery capacity operated (PEOPER). These steps are taken in order to ensure the higher refining margin induced by the higher prices of products. The induced higher demand for crude would then later be reflected in an increase of the price.

The monthly variation in the crude oil price is also positively correlated with a group of lagged variables which includes the variables describing the production of refined products and the amounts of crude and products imported, the correlation ranging from 0.1 to 0.3. At the other end, it is negatively correlated with the prices of crude oil and heating oil registered in the preceding month and to the pressure of refined products supply, as measured by the stocks/production ratios, registered in that same period, the correlation ranging from -0.20 to -0.35.

In the table below are given some basic statistics of the variables.

BASIC STATISTICS *

NUM . VARIABLE	MEAN	STD.DEV.	MINIMUM	MAXIMUM
1 . WTIMP	201.56	41.66	138.36	359.18

2	HUMPR	585.08	112.62	446.81	954.55
3	HOMPR	563.20	116.03	408.97	955.58
4	CRIMPO	5437.59	713.91	3495.00	6768.00
5	CRSTOC	342840.40	15008.08	322851.00	384548.00
6	DCRSTO	110.95	8063.76	-22063.00	16236.00
7	PRIMPO	2053.46	282.47	1373.00	2808.00
8	HUPROD	6090.97	625.17	4709.00	7142.00
9	HUSTOC	155092.90	14622.45	130864.00	183361.00
10	DHUSTO	580.14	5020.27	-10237.00	17871.00
11	GAPROD	6938.47	243.98	6383.00	7379.00
12	GASTOC	223556.50	10792.35	201715.00	253729.00
13	DGASTO	-555.22	6872.62	-15002.00	21828.00
14	HOPROD	2881.49	176.70	2337.00	3330.00
15	HOSTOC	116199.90	13154.44	93585.00	141848.00
16	DHOSTO	-97.92	7946.56	-21172.00	11892.00
17	REPROD	937.20	75.30	799.00	1167.00
18	RESTOC	44406.74	3483.29	36388.00	51386.00
19	DRESTO	119.59	2173.69	-4994.00	4342.00
20	KEPROD	1215.95	90.41	1029.00	1427.00
21	KESTOC	40951.81	2386.41	35607.00	45531.00
22	DKESTO	24.24	1666.17	-5518.00	3390.00
23	CINPUT	13421.76	497.54	11994.00	14461.00
24	PEOPER	85.48	3.30	76.93	93.23
25	CST/CIN	25.56	1.10	23.22	28.23
26	CST/CIM	64.07	8.36	51.38	94.26
27	CIM/PIM	2.69	.48	1.83	4.04
28	HUS/HUP	25.53	1.52	22.87	29.88
29	GAS/GAP	32.29	2.39	28.40	39.75
30	HOS/HOP	40.36	4.19	32.30	50.27
31	RES/REP	47.56	4.21	39.36	62.76
32	KES/KEP	33.79	2.23	27.85	38.77

DWTIMP	.31	20.63	-52.62	85.27
DHUMP1	2.33	58.48	-159.77	256.12
DHOMP1	2.32	56.52	-103.93	226.94

*For computational reasons, the price of crude is expressed in $10/barrel and the prices of products are expressed in 10 cents/gallon. The physical variables are expressed in thousands of barrels per day except stocks which are in thousands of barrels. Therefore, the pressure ratios (Stocks/Production) are expressed in days and the ratio CIM/PIM is dimensionless.

III. PRINCIPAL COMPONENTS ANALYSIS

III-1. DESCRIPTIVE FRAMEWORK

a 32 Active Variables

We started the descriptive analysis of the oil futures market with a principal components analysis with all the variables for which we have gathered data activated. In this descriptive framework, the goal is to seek the relationship between the time behavior of the monthly crude oil futures price and the physical determinants of the oil market. As can be seen from the results below, the quality of the representation achieved with these 32 variables, as measured by the percentage of variance explained by the first two principal components, is somewhat poor. The quality of the representation of the individuals on the plane is also, in general, quite poor.

10 FIRST EIGENVALUES

NUM	EIGENVALUE	%	CUM.%
1	10.1931	31.85	31.85
2	4.9666	15.52	47.37
3	3.7975	11.87	59.24
4	3.5527	11.10	70.34
5	1.9711	6.16	76.50
6	1.6699	5.22	81.72
7	1.2842	4.01	85.73
8	.9089	2.84	88.57
9	.7544	2.36	90.93
10	.6048	1.89	92.82

COORDINATES ON AXES 1 TO 3

VARIABLE	1	2	3
WTIMP	-.52	.60	-.28
HUMPR	-.57	.33	-.49
HOMPR	-.55	.65	-.27
CRIMPO	-.81	-.35	-.20
CRSTOC	-.38	-.24	-.40
DCRSTO	.26	-.30	-.45
PRIMPO	.08	-.31	.44
HUPROD	-.89	.00	-.20
HUSTOC	-.60	.31	-.33
DHUSTO	-.18	.28	.73
GAPROD	-.71	-.41	.34
GASTOC	.70	.30	.28
DGASTO	-.26	.30	.74
HOPROD	-.67	-.06	.16
HOSTOC	-.39	.55	.47
DHOSTO	-.67	-.38	.25
REPROD	-.34	-.12	.07
RESTOC	-.67	.55	-.01
DRESTO	-.41	-.01	.38
KEPROD	-.68	.59	.11
KESTOC	-.46	.51	-.21
DKESTO	-.26	.03	.01
CINPUT	-.77	-.50	.18
PEDFER	-.81	-.41	.11
CST/CIN	.28	.19	-.56
CST/CIM	.78	.30	.07
CIM/PIM	-.67	.02	-.44
HUS/HUP	.61	.50	-.19
GAS/GAP	.81	.40	.03
HOS/HOP	.00	.65	.43
RES/REP	-.40	.63	-.09
KES/KEP	.38	-.20	-.29

COORDINATES, CONTRIBUTIONS AND COS^2 OF INDIVIDUALS ON AXES 1 TO 3

INDIV	COOR.			CONTR.			COS.SQU.		
IDEN	1	2	3	1	2	3	1	2	3
FE87	7.69	3.67	1.40	9.8	4.6	.9	.70	.16	.02
MA87	9.38	2.84	-1.03	14.6	2.7	.5	.84	.08	.01
AP87	6.12	1.11	.41	6.2	.4	.1	.72	.02	.00
MY87	5.51	-.26	-1.09	5.0	.0	.5	.67	.00	.03
JU87	2.75	-1.78	.17	1.3	1.1	.0	.33	.14	.00
JL87	1.11	-1.71	1.69	.2	1.0	1.3	.07	.17	.17
AU87	.97	-1.02	1.26	.2	.4	.7	.07	.08	.12
SE87	1.39	.75	1.28	.3	.2	.7	.13	.04	.11
OC87	2.22	1.77	-.32	.8	1.1	.0	.24	.15	.01
NO87	1.48	.41	-1.00	.4	.1	.4	.11	.01	.05
DE87	.52	.50	1.78	.0	.1	1.4	.01	.01	.13
JA88	2.36	1.00	3.11	.9	.3	4.3	.16	.03	.28
FE88	4.05	1.67	1.96	2.7	1.0	1.7	.52	.09	.12
MA88	3.98	-.48	-.57	2.6	.1	.1	.59	.01	.01
AP88	2.86	-2.35	-1.36	1.4	1.9	.8	.39	.27	.09
MY88	1.76	-2.01	-.95	.5	1.4	.4	.20	.26	.06
JU88	1.25	-2.47	-.85	.3	2.1	.3	.09	.34	.04
JL88	.42	-3.13	.25	.0	3.3	.0	.01	.38	.00
AU88	-.16	-2.32	2.42	.0	1.8	2.6	.00	.22	.24
SE88	.29	-.43	3.59	.0	.1	5.8	.00	.01	.51
OC88	1.74	-.96	1.61	.5	.3	1.2	.18	.05	.16
NO88	1.71	-1.91	1.43	.5	1.2	.9	.14	.17	.09
DE88	-.39	-1.28	3.98	.0	.6	7.1	.00	.05	.52
JA89	.24	.09	4.55	.0	.0	9.2	.00	.00	.57
FE89	2.46	1.70	3.02	1.0	1.0	4.1	.16	.08	.24
MA89	4.55	.21	-.84	3.4	.0	.3	.50	.00	.02
AP89	1.67	-1.84	-2.01	.5	1.2	1.8	.11	.13	.16
MY89	1.30	-3.13	-1.53	.3	3.3	1.0	.08	.46	.11
JU89	-1.54	-3.06	.45	.4	3.2	.1	.12	.46	.01
JL89	-2.63	-3.08	1.52	1.2	3.2	1.0	.27	.36	.09
AU89	-1.99	-1.87	.89	.7	1.2	.4	.26	.23	.05
SE89	-2.54	-1.28	.57	1.1	.6	.1	.43	.11	.02
OC89	-1.76	.57	.51	.5	.1	.1	.30	.03	.03
NO89	-2.40	.35	-.10	1.0	.0	.0	.30	.01	.00
DE89	-1.05	-.22	-.75	.2	.0	.3	.03	.00	.02
JA90	-.83	-1.37	.37	.1	.6	.1	.01	.04	.00
FE90	-1.91	2.19	3.49	.6	1.6	5.4	.07	.09	.23
MA90	1.94	1.40	-3.19	.6	.7	4.5	.11	.06	.30
AP90	1.14	-1.10	-5.14	.2	.4	11.8	.04	.03	.75
MY90	-.11	-1.47	-3.20	.0	.7	4.6	.00	.09	.44
JU90	-2.15	-2.55	-1.38	.8	2.2	.9	.17	.24	.07
JL90	-4.52	-2.48	-.80	3.4	2.1	.3	.54	.16	.02
AU90	-5.54	-.65	-1.01	5.1	.1	.5	.66	.01	.02
SE90	-6.59	2.62	.18	7.2	2.3	.0	.63	.10	.00
OC90	-4.22	7.21	-1.12	3.0	17.8	.6	.21	.60	.01
NO90	-3.09	5.47	-1.82	1.6	10.2	1.5	.19	.59	.07
DE90	-2.01	4.48	.04	.7	6.8	.0	.14	.69	.00
JA91	-.47	4.06	-1.96	.0	5.6	1.7	.01	.57	.13
FE91	-.34	2.30	-2.18	.0	1.8	2.1	.00	.14	.13
MA91	1.22	-.66	-3.85	.2	.2	6.6	.05	.01	.50
AP91	.30	-1.17	-2.61	.0	.5	3.0	.01	.08	.38
MY91	-2.33	-1.65	-.88	.9	.9	.3	.35	.17	.05
JU91	-4.14	-1.47	-.02	2.8	.7	.0	.53	.07	.00
JL91	-2.99	-.98	-1.00	1.5	.3	.4	.63	.07	.07

AU91	-4.85	-1.10	-.68	3.9	.4	.2	.77	.04	.02
SE91	-4.83	1.21	1.24	3.9	.5	.7	.70	.04	.05
OC91	-2.28	2.41	-1.29	.9	2.0	.7	.22	.25	.07
NO91	-2.38	1.60	-1.26	.9	.9	.7	.20	.09	.06
DE91	-4.30	1.66	2.61	3.1	.9	3.0	.48	.07	.18

Despite the fact that the quality of the representation achieved is quite poor, some interesting features of the oil market can be deduced, and thus some insight gained, from the representation of variables and individuals which follows.

REPRESENTATION OF VARIABLES

AXE 1

VARIABLE	MEAN	STD.DEV	COORDINATE
HUPROD	6090.97	625.17	-.89
CRIMPO	5437.59	713.91	-.81
PROPER	85.48	3.30	-.81
CINPUT	13421.76	497.54	-.77
GAPROD	6938.47	243.98	-.71
KEPROD	1215.95	90.41	-.68

C E N T R A L   Z O N E

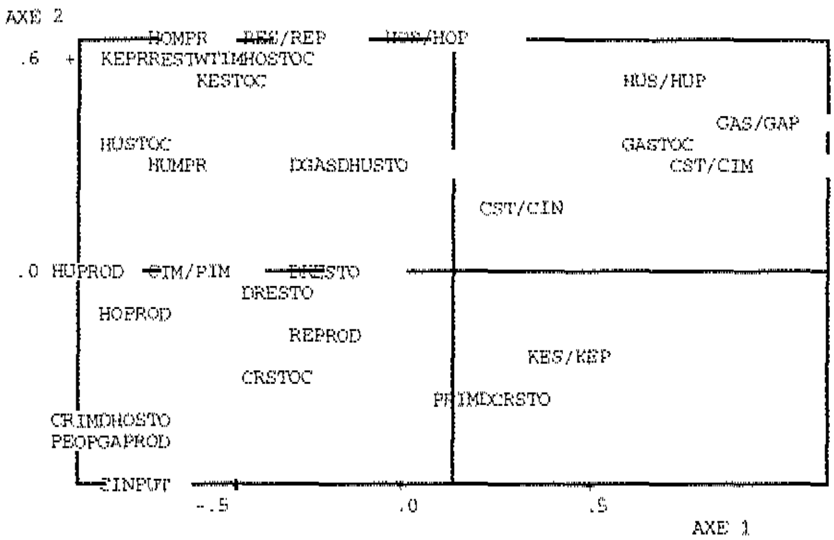
CST/CIN	25.56	1.10	.28
KES/KEP	33.79	2.23	.38
HUS/HUP	25.53	1.52	.61
GASTOC	223556.50	10792.35	.70
CST/CIM	64.07	8.36	.78
GAS/GAP	32.29	2.39	.81

AXE 2

VARIABLE	MEAN	STD.DEV	COORDINATE
CINPUT	13421.76	497.54	-.50
PEOPER	85.48	3.30	-.41
GAPROD	6938.47	243.98	-.41
DHOSTO	-97.92	7946.56	-.38
CRIMPO	5437.59	713.91	-.35
PRIMPO	2053.46	282.47	-.31

C E N T R A L   Z O N E

HOSTOC	116199.90	13154.44	.55
KEPROD	1215.95	90.41	.59
WTIMP	201.56	41.66	.60
RES/REP	47.56	4.21	.63
HOS/HOP	40.36	4.19	.65
HOMPR	563.20	116.03	.65



A close study of this figure allows one to define four different directions :

*** North-East :** Direction of Pressure Ratios

HUS/HUP	Unleaded Gasoline Stocks/Unleaded Gasoline Production
GAS/GAP	Total Gasoline Stocks/Total Gasoline Production
HOS/HOP	Heating Oil Stocks/Heating Oil Production
CST/CIM	Crude Stocks/Crude Imports
CST/CIN	Crude Stocks/Crude Input

*** North-West :** Direction of Prices and Stocks

HOMPR	No2. Heating Oil Monthly Price
WTIMP	West Texas Intermediate Monthly Price
HUMPR	Unleaded Regular Gasoline Monthly Price
HUSTOC	Unleaded Gasoline Stocks
HOSTOC	Heating Oil Stocks
RESTOC	Residual Fuel Oil Stocks
KESTOC	Kerosene Stocks

*** West :** Direction of Refined Products Production Levels

HUPROD	Unleaded Gasoline Production
HOPROD	Heating Oil Production

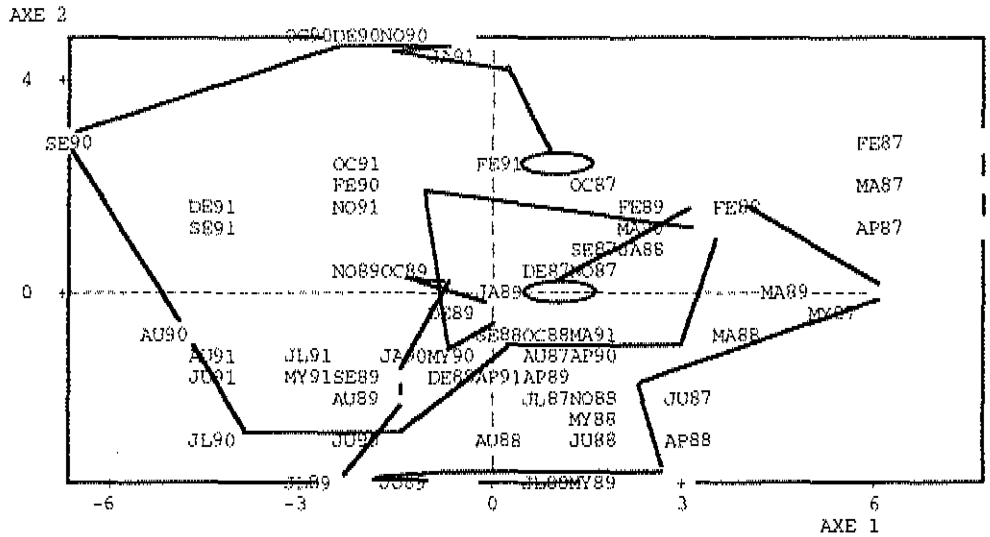
* **South-West** : Direction of Refinery Operations

CINPUT	Input to Crude Oil Distillation Units
PEOPER	Percentage of Refinery Capacity Operated

One can then see that prices are more correlated with stocks than with production levels, refinery operations variables, or pressure ratios. The 180° angle between the directions of pressure ratios and refinery operations reflects the high negative correlation between these two groups of variables due to the fact that when stocks, compared to daily production levels, become too high and represent many days of production, the refinery operations will tend to slow down through a decrease of the crude input to the refineries and the percentage of refinery capacity operated. The graph shows that, as a consequence, the amounts of crude imported (CRIMPO) and total gasoline produced (GAPROD) will also tend to fall.

We now turn to the representation of the 59 months used in this analysis. Four points, too far away from the centre, were brought back to the border of the graph. Two of these, OC90 and NO90, are from the Gulf war period. In the graph, the Gulf crisis period distinguishes itself very well with the corresponding months far away from the mean.

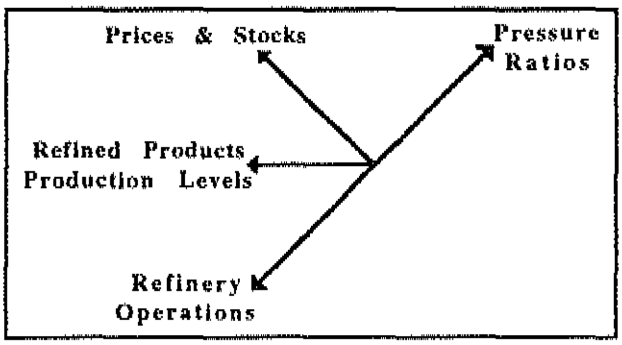
REPRESENTATION OF INDIVIDUALS



A close study of the graph above shows that it can be divided into four quadrants corresponding to the four seasons :

FALL	**WINTER**
SUMMER	**SPRING**

These quadrants are, in general, crossed clockwise by a line joining the various months of the year, as the example of the line joining JA89 to FE91 shows. Let us recall that we found four directions defined by four groups of variables :



Putting the variables and individuals representations together, we can draw the following picture of the oil market dynamics :

- In summer, the refineries operate at high capacity to satisfy the high demand for gasoline in the American market. The summer quadrant is crossed by the refinery operations direction characterised by the crude input (CINPUT), percentage of refinery capacity operated (PEOPER), and total gasoline production (GAPROD). This high level of refinery operations also helps build stocks of heating oil in expectation of the coming cold season.
- Between summer and fall, we see high levels of heating oil and unleaded gasoline production as shown by the westward direction of the refined products production levels. In fall, the stocks are high and prices climb in response to the increasing demand of the cold season. The fall quadrant is crossed by the prices and stocks direction defined mainly by the price of heating oil.
- Between fall and winter, the production of refined products starts to fall and therefore the stocks, in terms of daily production, increase. We end up in the winter quadrant which is crossed by the direction of pressure ratios. Going from winter to spring, these ratios start to decrease when production picks up in spring. The production of refined products continues to increase, especially that of gasoline in expectation of the coming increase in demand, until we reach again the high level of refinery operated capacity in summer.

b 6 Active Variables

Because the quality of the representation, as measured by the percentage of variance explained by the first two principal components, achieved in the analysis above with 32 variables was somewhat poor, we chose to restrain the number of active variables to six : WTIMP, HUMPR, HOMPR, CRIMPO, CRSTOC, and CINPUT.

As the results below show, the quality of the representation was very much improved. However, many parts of the picture drawn in the preceding analysis are now missing. The active variables now clearly define only two of the directions found earlier; namely the direction of prices and stocks, and the direction of refinery operations. As a consequence, the seasonal discrimination in the representation of individuals, especially between winter and spring, is quite poor. Not much insight into the problem was gained through this analysis.

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6 FIRST EIGENVALUES

NUM	EIGENVALUE	%	CUM. %
1	3.1199	52.00	52.00
2	1.8267	30.45	82.44
3	.6292	10.49	92.93
4	.2188	3.65	96.58
5	.1785	2.98	99.55
6	.0269	.45	100.00

COORDINATES ON AXES 1 TO 3

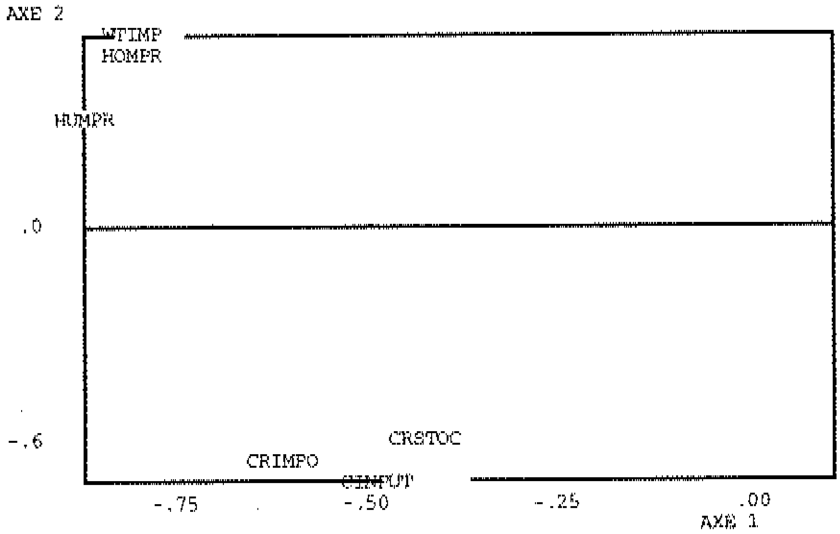
VARIABLE	1	2	3
WTIMP	-.86	.49	-.03
HUMPR	-.91	.25	.05
HOMPR	-.84	.47	.01
CRIMPO	-.64	-.65	-.24
CRSTOC	-.44	-.59	.68
CINPUT	-.51	-.73	-.33

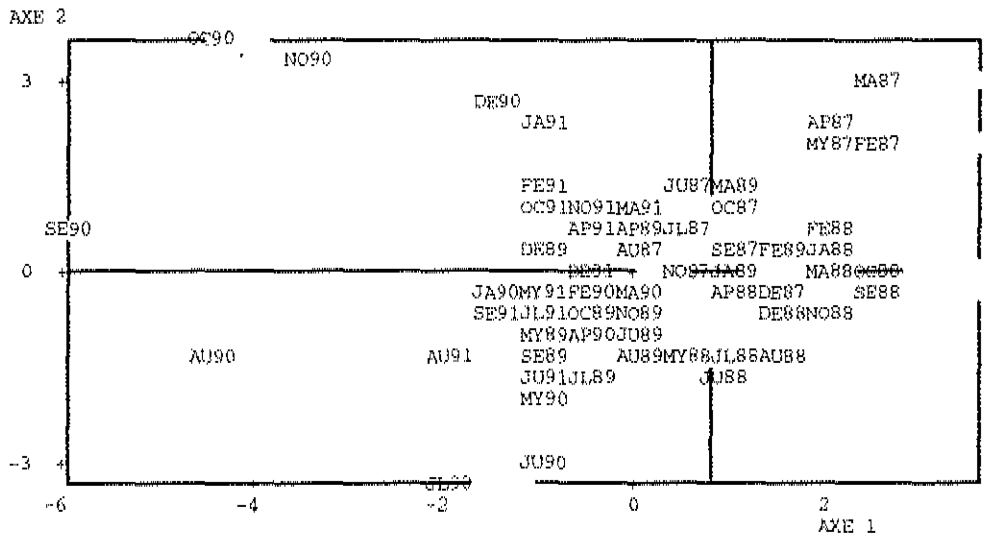
COORDINATES, CONTRIBUTIONS AND COS^2 OF INDIVIDUALS ON AXES 1 TO 3

INDIV	COOR.			CONTR.			COS.SQU.		
IDEN	1	2	3	1	2	3	1	2	3
FE87	2.63	1.88	.62	3.8	3.3	1.0	.64	.32	.04
MA87	2.82	2.77	1.23	4.3	7.1	4.1	.46	.44	.09
AP87	2.37	1.96	.50	3.1	3.6	.7	.56	.38	.03
MY87	1.86	1.89	.18	1.9	3.3	.1	.48	.50	.00
JU87	1.09	1.01	-.68	.6	.9	1.2	.43	.36	.16
JL87	.39	.52	-1.24	.1	.3	4.1	.07	.13	.71
AU87	.59	.11	-1.04	.2	.0	2.9	.23	.01	.71
SE87	1.02	.38	-.14	.6	.1	.1	.75	.10	.01
OC87	.96	.97	.50	.5	.9	.7	.41	.42	.11
NO87	.71	-.03	1.12	.3	.0	3.4	.23	.00	.58
DE87	1.37	-.29	1.30	1.0	.1	4.5	.42	.02	.38
JA88	1.81	.30	.52	1.8	.1	.7	.81	.02	.07
FE88	2.25	.67	.50	2.8	.4	.7	.88	.08	.04
MA88	2.02	-.10	.49	2.2	.0	.7	.91	.00	.05
AP88	.97	-.48	.84	.5	.2	1.9	.46	.12	.35
MY88	.69	-1.20	.93	.3	1.3	2.3	.16	.48	.29
JU88	.97	-1.48	.86	.5	2.0	2.0	.20	.47	.16
JL88	1.20	-1.42	.26	.8	1.9	.2	.34	.48	.02
AU88	1.41	-1.39	-.64	1.1	1.8	1.1	.39	.38	.08
SE88	2.42	-.40	-.99	3.2	.1	2.7	.81	.02	.14
OC88	2.45	-.38	-.50	3.3	.1	.7	.92	.02	.04

NO88	1.95	-.76	-.02	2.1	.5	.0	.83	.13	.00
DE88	1.37	-.58	-.22	1.0	.3	.1	.74	.13	.02
JA89	1.21	.14	-.93	.8	.0	2.3	.54	.01	.32
FE89	1.53	.39	-.62	1.3	.1	1.1	.80	.05	.13
MA89	.94	.82	-.04	.5	.6	.0	.53	.41	.00
AP89	-.23	.75	-.66	.0	.5	1.2	.02	.20	.15
MY89	-.31	-.55	-.18	.1	.3	.1	.07	.22	.02
JU89	-.23	-.96	-.82	.0	.9	1.8	.02	.39	.28
JL89	-.26	-1.47	-1.76	.0	2.0	8.3	.01	.40	.57
AU89	.02	-1.44	-1.38	.0	1.9	5.2	.00	.51	.47
SE89	-.50	-.96	-1.39	.1	.9	5.2	.08	.29	.62
OC89	-.37	-.56	-.60	.1	.3	1.0	.09	.22	.25
NO89	-.16	-.59	-.14	.0	.3	.0	.02	.28	.01
DE89	-.92	.26	-.13	.5	.1	.0	.28	.02	.01
JA90	-1.35	-.23	-.32	1.0	.0	.3	.76	.02	.04
FE90	-.66	-.29	-.22	.2	.1	.1	.65	.12	.07
MA90	-.19	-.38	.80	.0	.1	1.7	.02	.08	.37
AP90	-.42	-1.03	1.71	.1	1.0	7.9	.04	.23	.63
MY90	-.81	-1.83	1.75	.4	3.1	8.2	.09	.44	.40
JU90	-.84	-2.93	1.58	.4	8.0	6.8	.06	.71	.21
JL90	-1.80	-3.38	.94	1.8	10.6	2.4	.21	.73	.06
AU90	-4.64	-1.14	.65	11.7	1.2	1.1	.91	.05	.02
SE90	-5.87	.75	.35	18.7	.5	.3	.94	.02	.00
OC90	-4.76	3.43	.35	12.3	10.9	.3	.65	.34	.00
NO90	-3.51	3.11	.26	6.7	8.9	.2	.56	.44	.00
DE90	-1.58	2.46	-.15	1.4	5.6	.1	.28	.68	.00
JA91	-.97	2.29	-.50	.5	4.9	.7	.13	.71	.03
FE91	-.27	.82	-.43	.0	.6	.5	.06	.50	.14
MA91	-.02	1.07	.15	.0	1.1	.1	.00	.47	.01
AP91	-.35	.66	.11	.1	.4	.0	.08	.28	.01
MY91	-1.06	-.45	-.36	.6	.2	.4	.57	.10	.06
JU91	-1.20	-1.69	-.45	.8	2.6	.5	.31	.62	.04
JL91	-1.07	-.64	-.22	.6	.4	.1	.69	.25	.03
AU91	-1.89	-1.22	-.74	1.9	1.4	1.5	.61	.25	.09
SE91	-1.25	-.65	-1.08	.8	.4	3.2	.48	.13	.36
OC91	-1.01	.89	.05	.5	.7	.0	.50	.39	.00
NO91	-.74	.89	.56	.3	.7	.8	.31	.44	.17
DE91	.23	-.28	-.52	.0	.1	.7	.10	.15	.54

REPRESENTATION OF VARIABLES AND INDIVIDUALS





III-2. PREDICTIVE FRAMEWORK

a 35 Active Variables

In this predictive framework, the goal is to seek the relationship between the variation in the crude oil price of one month (DWTIMP) and the physical determinants of the oil market in the preceding month. In a first stage, all the variables available were activated in the analysis. The results below show that the quality of the representation achieved with these 35 variables, as measured by the percentage of variance explained by the first two principal components, is somewhat poor. The quality of the representation of the individuals on the plane is also, in general, quite poor.

10 FIRST EIGENVALUES

NUM	EIGENVALUE	%	CUM.%
1	10.1848	29.10	29.10
2	5.3454	15.27	44.37
3	3.8702	11.06	55.43
4	3.6846	10.53	65.96
5	2.4028	6.87	72.82
6	1.8453	5.27	78.09
7	1.7175	4.91	83.00
8	1.0378	2.97	85.97
9	.8739	2.50	88.46
10	.7917	2.26	90.73

COORDINATES ON AXES 1 TO 3

VARIABLE	1	2	3
DWTIMP	-.13	-.53	.08
WTIMP1	-.52	.61	-.25
DHUMP1	.01	-.33	-.27
HUMPR1	-.59	.33	-.46
DHOMP1	-.34	-.24	.06
HOMPR1	-.56	.65	-.25
CRIMPO1	-.82	-.31	-.21
CRSTOC1	-.42	-.25	-.38
DCRSTO1	.23	-.28	-.45
PRIMPO1	.04	-.37	.38
HUPROD1	-.88	.03	-.23
HUSTOC1	-.58	.32	-.39
DHUSTO1	-.12	.25	.72
GAPROD1	-.72	-.41	.36
GASTOC1	.71	.24	.26
DGASTO1	-.20	.28	.73
HOPROD1	-.66	-.07	.11
HOSTOC1	-.34	.55	.50
DHOSTO1	-.67	-.32	.32
REPROD1	-.22	-.16	-.06
RESTOC1	-.63	.57	-.04
DRESTO1	-.40	.00	.43
KEPROD1	-.64	.61	.08
KESTOC1	-.43	.54	-.14
DKESTO1	-.25	.08	.10
CINPUT1	-.80	-.48	.20
PROPER1	-.83	-.39	.14
CST/CIN1	.27	.16	-.56
CST/CIM1	.78	.25	.09
CIM/PIM1	-.65	.09	-.42
HUS/HUP1	.61	.47	-.22
GAS/GAP1	.82	.36	.00
HOS/HOP1	.05	.63	.47
RES/REP1	-.38	.67	.00
KES/KEP1	.36	-.19	-.20

COORDINATES, CONTRIBUTIONS AND COS² OF INDIVIDUALS ON AXES 1 TO 3

INDIV	COOR.			CONTR.			COS.SQU.		
IDEN	1	2	3	1	2	3	1	2	3
MA87	7.78	3.19	1.49	10.3	3.3	1.0	.71	.12	.03
AP87	9.26	2.14	-.97	14.5	1.5	.4	.82	.04	.01
MY87	6.05	.77	.65	6.2	.2	.2	.71	.01	.01
JU87	5.29	-.61	-.86	4.7	.1	.3	.62	.01	.02
JL87	2.57	-1.93	.39	1.1	1.2	.1	.29	.16	.01
AU87	.96	-1.56	1.88	.2	.8	1.6	.05	.14	.21
SE87	.94	-.71	1.53	.2	.2	1.0	.06	.04	.17
OC87	1.35	.80	1.68	.3	.2	1.3	.12	.04	.18
NO87	2.14	1.74	-.02	.8	1.0	.0	.22	.14	.00
DE87	1.44	.68	-.70	.3	.1	.2	.10	.02	.02
JA88	.54	.62	2.00	.0	.1	1.8	.01	.01	.15
FE88	2.40	.74	2.74	1.0	.2	3.3	.17	.02	.22
MA88	4.15	1.43	1.61	2.9	.7	1.2	.54	.06	.08
AP88	3.86	-.78	-.75	2.5	.2	.3	.55	.02	.02
MY88	2.61	-2.53	-1.62	1.2	2.1	1.2	.32	.30	.12
JU88	1.66	-1.80	-.91	.5	1.0	.4	.18	.21	.05
JL88	1.16	-2.11	-.65	.2	1.4	.2	.07	.24	.02
AU88	.27	-2.92	.53	.0	2.7	.1	.00	.33	.01
SE88	-.22	-1.92	2.74	.0	1.2	3.3	.00	.14	.29
OC88	.37	-.15	3.89	.0	.0	6.7	.01	.00	.57
NO88	1.68	-.94	1.76	.5	.3	1.4	.17	.05	.19
DE88	1.48	-2.24	1.48	.4	1.6	1.0	.09	.22	.09
JA89	-.57	-1.65	3.74	.1	.9	6.2	.01	.08	.43
FE89	.21	-.22	4.04	.0	.0	7.3	.00	.00	.44
MA89	2.49	1.33	2.78	1.1	.6	3.4	.16	.05	.20
AP89	4.34	-.47	-1.42	3.2	.1	.9	.44	.01	.05
MY89	1.53	-2.03	-2.44	.4	1.3	2.7	.07	.12	.18
JU89	1.19	-2.81	-1.49	.2	2.5	1.0	.06	.35	.10
JL89	-1.67	-2.62	.70	.5	2.2	.2	.13	.32	.02
AU89	-2.75	-2.49	1.77	1.3	2.0	1.4	.27	.22	.11
SE89	-2.11	-1.64	1.11	.8	.9	.6	.28	.17	.08
OC89	-2.73	-1.29	.65	1.3	.5	.2	.43	.10	.02
NO89	-1.81	.79	.67	.6	.2	.2	.29	.05	.04
DE89	-2.45	.43	-.06	1.0	.1	.0	.29	.01	.00
JA90	-1.43	-.82	-1.20	.3	.2	.6	.05	.02	.04
FE90	-.73	-1.45	-.67	.1	.7	.2	.01	.04	.01
MA90	-1.64	2.52	3.34	.5	2.1	5.0	.05	.11	.19
AP90	1.92	1.63	-3.37	.6	.9	5.1	.11	.08	.33
MY90	.96	-1.05	-5.18	.2	.4	12.0	.03	.03	.75
JU90	-.21	-1.15	-3.25	.0	.4	4.7	.00	.06	.44
JL90	-2.29	-2.37	-1.16	.9	1.8	.6	.18	.20	.05
AU90	-4.92	-3.23	-.51	4.1	3.4	.1	.43	.19	.00
SE90	-6.21	-2.18	-1.16	6.5	1.5	.6	.42	.05	.01
OC90	-6.90	2.06	.43	8.1	1.4	.1	.61	.05	.00
NO90	-4.13	7.61	-.54	2.9	18.7	.1	.19	.64	.00
DE90	-2.83	6.38	-1.39	1.4	13.1	.9	.13	.67	.03
JA91	-1.71	5.24	.39	.5	8.9	.1	.07	.65	.00
FE91	-.23	4.60	-2.08	.0	6.8	1.9	.00	.62	.13
MA91	-.14	2.71	-2.34	.0	2.4	2.4	.00	.18	.13
AP91	1.21	-.81	-4.35	.2	.2	8.4	.04	.02	.56
MY91	.16	-1.07	-2.65	.0	.4	3.1	.00	.06	.39
JU91	-2.41	-1.22	-.81	1.0	.5	.3	.36	.09	.04
JL91	-4.18	-1.03	.31	3.0	.3	.0	.50	.03	.00
AU91	-3.17	-.85	-.82	1.7	.2	.3	.66	.05	.04
SE91	-4.98	-.88	-.61	4.2	.2	.2	.78	.02	.01
OC91	-4.84	1.52	1.75	4.0	.7	1.4	.65	.06	.09
NO91	-2.38	2.51	-.96	1.0	2.0	.4	.23	.25	.04
DE91	-2.35	2.09	-1.10	.9	1.4	.5	.18	.14	.04

REPRESENTATION OF VARIABLES AND INDIVIDUALS

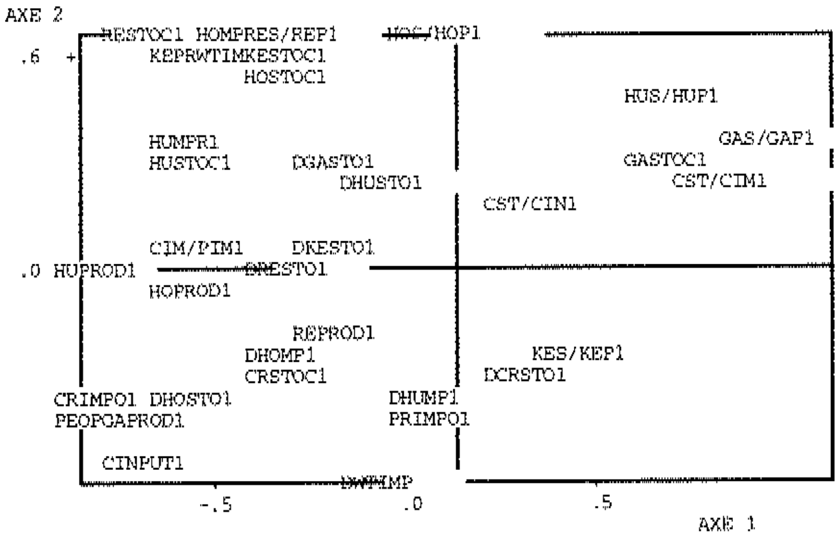
AXE 1

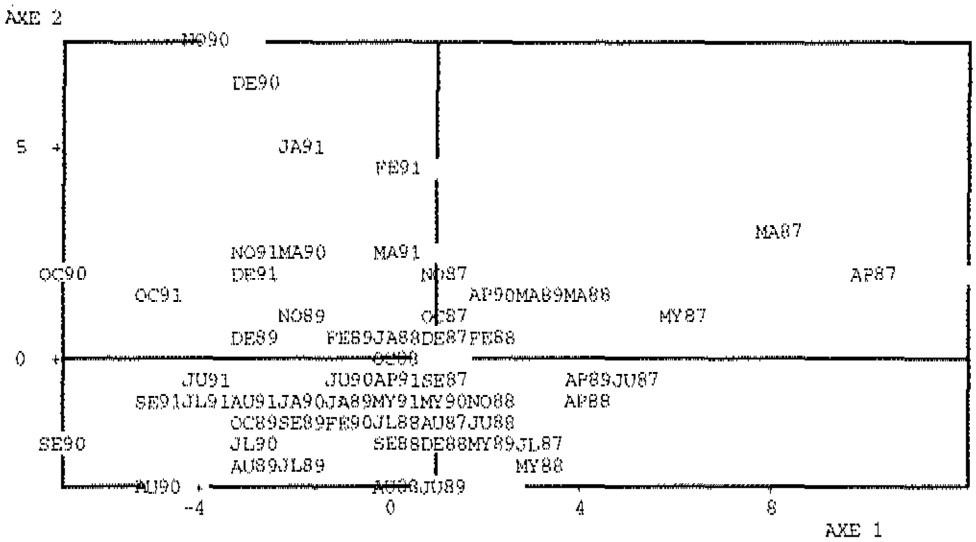
VARIABLE	MEAN	STD.DEV	COORDINATE
HUPROD1	6072.59	614.84	-.88

PEOPER1	85.47	3.33	-.83
CRIMPO1	5432.09	718.87	-.82
CINPUT1	13420.31	501.70	-.80
GAPROD1	6931.54	240.79	-.72
DHOSTO1	-181.98	7988.57	-.67
HOPROD1	2877.31	175.75	-.66
C E N T R A L E Z O N E			
DCRSTO1	279.92	8028.77	.23
CST/CIN1	25.57	1.10	.27
KES/KEP1	33.81	2.24	.36
HUS/HUP1	25.56	1.52	.61
GASTOC1	223716.70	10814.95	.71
CST/CIM1	64.16	8.40	.78
GAS/GAP1	32.34	2.38	.82

AXE 2

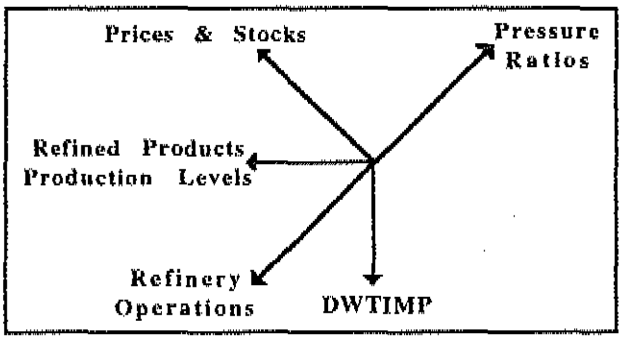
VARIABLE	MEAN	SDT.DEV	COORDINATE
DWTIMP	.31	20.63	-.53
CINPUT1	13420.31	501.70	-.48
GAPROD1	6931.54	240.79	-.41
PEOPER1	85.47	3.33	-.39
PRIMPO1	2057.85	282.55	-.37
DHUMP1	2.33	58.48	-.33
DHOSTO1	-181.98	7988.57	-.32
C E N T R A L Z O N E			
HOSTOC1	115757.40	12825.13	.55
RESTOC1	44316.70	3444.91	.57
WTIMP1	201.66	42.01	.61
KEPROD1	1213.12	89.13	.61
HOS/HOP1	40.27	4.17	.63
HOMPR1	563.48	117.00	.65
RES/REP1	47.55	4.24	.67





This new principal components analysis actually does not add much to the basic picture we draw from the first analysis. It simply defines one more direction in addition to the four defined earlier. The new direction is the southward direction characterized mainly by the variation in the crude oil price DWTIMP. The graph representing the individuals is still comprised of four quadrants corresponding to the four seasons, which are crossed clockwise by the line joining the various months of the year.

FALL	WINTER
SUMMER	SPRING



Along this new direction, which falls between spring and summer, we also find the variation in the price of unleaded gasoline DHUMP1 registered in the preceding month. The picture of the oil market structure is the same as the one drawn earlier and this new direction enters simply to reflect the jump in the gasoline price in response to the increase in demand in summer. This is followed by the jump in the crude oil price when demand for crude increases due to the fact that input to refineries is increased in order to meet that demand for gasoline and to build up stocks of heating oil in expectation of the coming cold season.

b 6 Active Variables

As before, because the quality of the representation, as measured by the percentage of variance explained by the first two principal components, achieved in the analysis above with 35 variables was somewhat poor, we chose to restrain the number of active variables to the six following variables : DWTIMP, WTIMP1, DHUMP1, HUMPR1, DHOMP1, HOMPR1.

As shown by the results below, the quality of the representation was very much improved. However, many parts of the picture drawn in the preceding analysis were again lost. The active variables now clearly define only two directions, one characterized by the variations in prices and the other by the price levels. As a consequence, the seasonal discrimination in the representation of individuals is lost. With respect to these variables, the individuals are very much clustered around the mean. Only the months corresponding to the Gulf crisis are able to distinguish themselves, as one could very well expect. Thus, not much insight into the problem is gained through this analysis. This suggests that prices alone are far from being able to provide a complete picture of the oil futures market.

6 FIRST EIGENVALUES

NUM	EIGENVALUE	%	CUM.%
1	2.8946	48.24	48.24
2	1.9839	33.07	81.31
3	.5534	9.22	90.53
4	.3953	6.59	97.12
5	.1407	2.34	99.47
6	.0320	.53	100.00

COORDINATES ON AXES 1 TO 3

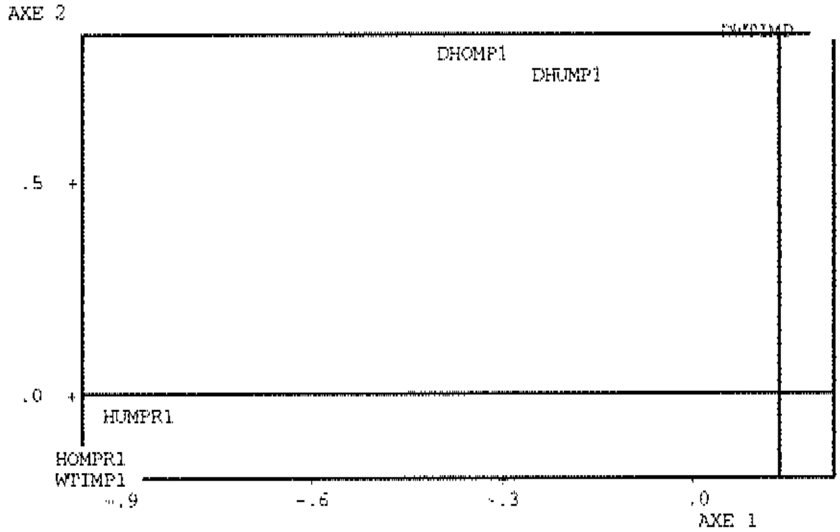
VARIABLE	1	2	3
DWTIMP	.10	.85	.31
WTIMP1	-.96	-.22	.06
DHUMP1	-.26	.76	-.59
HUMPR1	-.93	-.03	-.11
DHOMP1	-.38	.78	.28
HOMPR1	-.94	-.18	.14

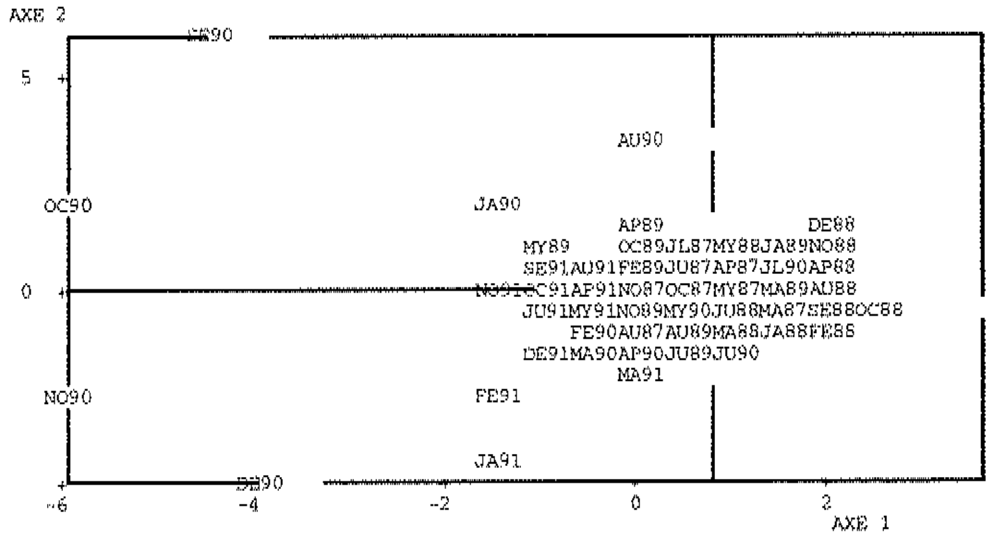
COORDINATES, CONTRIBUTIONS AND COS^2 OF INDIVIDUALS ON AXES 1 TO 3

INDIV	COOR.			CONTR.			COS.SQU.		
IDEN	1	2	3	1	2	3	1	2	3
MA87	1.46	-.29	-.10	1.3	.1	.0	.82	.03	.00
AP87	.77	.65	-.34	.4	.4	.4	.49	.35	.09
MY87	.99	.19	.11	.6	.0	.0	.88	.03	.01
JU87	.41	.75	-.03	.1	.5	.0	.20	.67	.00
JL87	.38	.56	.12	.1	.3	.0	.23	.49	.02
AU87	-.07	-.09	.00	.0	.0	.0	.01	.01	.00
SE87	.61	-.70	.18	.2	.4	.1	.37	.49	.03
OC87	.72	-.06	.34	.3	.0	.4	.69	.00	.16
NO87	.11	.20	-.14	.0	.0	.1	.01	.04	.02
DE87	.68	-.72	.06	.3	.5	.0	.31	.35	.00
JA88	1.50	-.70	.58	1.3	.4	1.0	.68	.15	.10
FE88	1.36	-.10	-.18	1.1	.0	.1	.82	.00	.02
MA88	1.62	-.25	-.59	1.6	.1	1.1	.83	.02	.11
AP88	1.81	.52	.23	1.9	.2	.2	.86	.07	.01
MY88	.71	.87	-.62	.3	.7	1.2	.22	.32	.16
JU88	1.17	-.23	-.44	.8	.0	.6	.80	.03	.11
JL88	1.60	-.51	-.38	1.5	.2	.5	.84	.08	.05
AU88	1.66	.25	-.36	1.6	.1	.4	.91	.02	.04
SE88	1.87	-.37	.34	2.1	.1	.4	.79	.03	.03
OC88	2.29	-.27	-.17	3.1	.1	.1	.96	.01	.01
NO88	2.18	.51	-.35	2.8	.2	.4	.90	.05	.02
DE88	1.91	1.39	.57	2.2	1.7	1.0	.61	.32	.06
JA89	1.26	1.20	.89	.9	1.3	2.5	.37	.34	.19
FE89	.72	.61	-.43	.3	.3	.6	.34	.24	.12
MA89	1.27	.27	.18	1.0	.1	.1	.71	.03	.01
AP89	.12	1.40	-.34	.0	1.7	.4	.01	.91	.05
MY89	-.92	1.02	-2.58	.5	.9	20.8	.10	.12	.77
JU89	.31	-.83	.12	.1	.6	.0	.04	.30	.01
JL89	.39	-.53	.41	.1	.2	.5	.11	.20	.12
AU89	.64	-.75	.74	.2	.5	1.7	.19	.25	.25
SE89	.86	.23	.61	.4	.0	1.2	.62	.05	.32
OC89	-.25	1.20	-.29	.0	1.2	.3	.03	.76	.04
NO89	.03	-.18	.69	.0	.0	1.5	.00	.04	.60
DE89	.35	.04	.88	.1	.0	2.4	.10	.00	.65
JA90	-1.47	1.99	1.27	1.3	3.4	5.0	.20	.36	.15
FE90	-.72	-.69	-1.72	.3	.4	9.2	.08	.08	.47
MA90	-.06	-1.58	-.52	.0	2.2	.9	.00	.82	.09
AP90	.22	-1.08	-.02	.0	1.0	.0	.04	.85	.00
MY90	.13	.28	-.89	.0	.1	2.4	.02	.08	.78
JU90	.30	-.55	-.83	.1	.3	2.1	.06	.21	.48
JL90	1.05	.07	.40	.7	.0	.5	.43	.00	.06
AU90	.18	3.22	1.81	.0	9.0	10.2	.00	.57	.18
SE90	-4.62	5.90	-.57	12.7	30.2	1.0	.38	.62	.01
OC90	-5.92	1.82	.53	20.9	2.9	.9	.90	.09	.01
NO90	-5.76	-2.00	.57	19.7	3.5	1.0	.87	.11	.01
DE90	-4.05	-3.86	-.07	9.8	12.9	.0	.52	.48	.00
JA91	-1.74	-3.69	1.41	1.8	11.8	6.2	.16	.70	.10
FE91	-1.70	-2.26	-.99	1.7	4.4	3.0	.31	.55	.11
MA91	-.10	-1.74	.23	.0	2.6	.2	.00	.72	.01
AP91	-.43	.25	-1.72	.1	.1	9.2	.03	.01	.51
MY91	-.55	-.08	-.13	.2	.0	.1	.24	.00	.01
JU91	-.63	-.50	-.18	.2	.2	.1	.30	.19	.02
JL91	.16	-.42	.94	.0	.2	2.8	.01	.09	.46

AU91	-.73	.50	.13	.3	.2	.1	.56	.26	.02
SE91	-1.07	.44	-.12	.7	.2	.0	.80	.13	.01
OC91	-.49	-.23	1.20	.1	.0	4.5	.12	.03	.73
NO91	-1.50	.21	.04	1.3	.0	.0	.79	.02	.00
DE91	-1.01	-1.30	-.50	.6	1.5	.8	.30	.50	.05

REPRESENTATION OF VARIABLES AND INDIVIDUALS





IV. FACTORIAL DISCRIMINANT ANALYSIS

With the factorial discriminant analysis, our aim was to find out which of the physical determinants of the oil market and of the prices of futures contracts in one month can best forecast the sign of the crude oil price change in the following month. In other words, the problem is to seek those one-month lagged variables that can best discriminate between the two groups of observations defined as

$$DWTIMPP = \{ \text{Observations} / DWTIMP \geq 0 \}$$
$$DWTIMPN = \{ \text{Observations} / DWTIMP < 0 \}$$

Due to a practical problem of insufficient memory, we were constrained to the use of a maximum of nine variables in a factorial discriminant analysis. Given this constraint, we chose to run three discriminant analyses with three different small groups of variables to get as much insight into the problem as possible under the circumstances.

IV-1. GROUP OF PRESSURE RATIOS

The first group contains the eight pressure ratios we have defined. The power of discrimination as measured by the percentage of observations well classified reaches 60%. This suggests that physical factors by themselves, as expected, can hardly be sufficient for building a performing forecasting tool.

LINEAIR DISCRIMINANT ANALYSIS OF GROUPS DWTIMPP AND DWTIMPN

DESCRIPTION

EFFECTIVES		27	31		
		DWTIMPP	DWTIMPN	T	PROB
	MEAN	25.494	25.639	.490	.626
CST/CIN1	SDT.DEV	(.923)	(1.738)		
	MAXI	27.790	28.230		
	MINI	23.750	23.220		
	MEAN	64.613	63.774	.373	.710
CST/CIM1	SDT.DEV	(10.434)	(6.082)		
	MAXI	94.260	77.220		
	MINI	51.380	52.380		
	MEAN	2.638	2.722	.654	.516
CIM/PIM1	SDT.DEV	(.520)	(.438)		
	MAXI	3.760	4.040		
	MINI	1.830	1.840		
	MEAN	25.450	25.650	.492	.625
HUS/HUP1	SDT.DEV	(1.738)	(1.301)		
	MAXI	29.880	29.010		
	MINI	22.870	22.930		
	MEAN	32.259	32.411	.239	.812
GAS/GAP1	SDT.DEV	(2.986)	(1.673)		
	MAXI	39.750	36.070		
	MINI	28.400	28.950		
	MEAN	40.387	40.164	.201	.842
HOS/HOP1	SDT.DEV	(4.043)	(4.267)		
	MAXI	50.270	46.870		
	MINI	34.010	32.300		
	MEAN	47.033	47.992	.848	.400
RES/REP1	SDT.DEV	(3.080)	(5.001)		
	MAXI	54.140	62.760		
	MINI	40.850	39.360		
	MEAN	34.204	33.476	1.228	.225
KES/KEP1	SDT.DEV	(2.317)	(2.118)		
	MAXI	38.770	36.900		
	MINI	29.950	27.850		

CLASSIFICATION

GROUPS OF AFFECTATION

GROUPS OF ORIGIN	DWTIMPP	DWTIMPN
DWTIMPP	15	12
DWTIMPN	11	20

PERCENTAGES

GROUPS OF ORIGIN	GOOD	BAD	TOTAL
DWTIMPP	15.00	12.00	27.00
	(55.56)	(44.44)	(100.00)
DWTIMPN	20.00	11.00	31.00
	(64.52)	(35.48)	(100.00)
TOTAL	35.00	23.00	58.00

```
                              (60.34)      (39.66)      (100.00)
                         --------------------------------------------------
IDENTIFICATION OF MISCLASSIFIED INDIVIDUALS
 GROUP DWTIMPP :
AP88  MA89  AP89  SE89  OC89  JL90  OC90  AP91  MY91  JL91  SE91  OC91
 GROUP DWTIMPN :
AU87  SE87  MY88  SE88  OC88  JU89  JL89  AU89  FE90  JA91  DE91
```

DISCRIMINANT LINEAR FUNCTION

VARIABLES NUM:	NAME	CORRELATIONS VARIABLES WITH F.L.D (Threshold=.26)	DISCRIMINANT FUNCTION COEFFICIENTS	REGRESSION COEFFICIENTS	STD DEVT (RESULTS OF REGRESSION TYPE)	T STUDENT (RESULTS OF REGRESSION TYPE)	PROBABILITY
28	CST/CIN1	-.072	-.228661	-.108504	.1633	.6644	.5096
29	CST/CIM1	.055	.033758	.016019	.0351	.4558	.6506
30	CIM/PIM1	-.095	-.938296	-.445238	.4820	.9238	.3601
31	HUS/HUP1	-.072	.984538	.467180	.4452	1.0494	.2992
32	GAS/GAP1	-.035	-.827768	-.392790	.3394	1.1574	.2527
33	HOS/HOP1	.029	.081755	.038794	.0492	.7879	.4346
34	RES/REP1	-.123	-.117838	-.055916	.0504	1.1095	.2726
35	KES/KEP1	.177	.198473	.094179	.0731	1.2881	.2037
	CONSTANT		3.394514	1.616391	4.6343	.3488	.7287

```
     R2 =   .08150     F  =    .54351    PROBA =    .81783
     D2 =   .34434     T2 =   4.96919    PROBA =    .81783
```

HISTOGRAMMES

```
   -1.6   -1.4   -1.2   -1.0    -.8    -.6    -.4    -.2    -.1     .1     .3     .5     .7     .9    1.1
-1.7   -1.5   -1.3   -1.1    -.9    -.7    -.5    -.3    -.1     .0     .2     .4     .6     .8    1.0    1.2
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
DWTIMPP
                                                                                    AU91
                                                                  AU90              SE90                   DE88
                                                     JL91SE91OC91OC89MY91DE89       JA90AU88               MY87
                MA89                          AP89   JL90OC90AP88SE89AP91JA89  OC87 JL87AP87      NO88     MA87   JU87
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
  0   0   0   0   1   0   0   0   0   0   0   1   0   2   2   2   2   2   3   0   1   0   4   2   0   1   0   3   0   1

DWTIMPN
                                                              FE91
                                            DE90          JU91MA90
                                            AP90     JU88NO89JU90JL88               FE90DE91          JL89JA91
NO90                     MA88MA91           FE88MY90DE87FE89JA88NO87NO91MY89MY88SE88OC88AU89          SE87JU89        AU87
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
  1   0   0   0   0   1   1   0   0   0   3   1   2   2   3   4   1   1   1   2   2   1   0   2   2   0   0   1   0   0
```

IV-2. GROUP OF PRICES

The second group consists of the lagged prices of the three oil contracts (WTIMP1, HUMPR1, and HOMPR1) and the lagged variations in the prices of the oil products contracts (DHUMP1, and DHOMP1). The power of discrimination is around 64%. The results of the analysis show that the variables considered can be ordered by decreasing power of forecasting the sign of the crude oil price change : DHOMP1, DHUMP1, WTIMP1, HOMP1, HUMP1. One ought to note the important role played by the changes in the prices of the refined products futures contracts. The overall power of discrimination of 64% is only slightly better than the one obtained with only supply pressure ratios, suggesting that prices by themselves cannot make up a performing forecasting tool either, the oil futures market not being a purely speculative market but one that is linked to a physical market.

LINEAIR DISCRIMINANT ANALYSIS OF GROUPS DWTIMPP AND DWTIMPN

DESCRIPTION

EFFECTIVES		27 DWTIMPP	31 DWTIMPN	T	PROB
WTIMP1	MEAN	195.500	207.031	1.034	.305
	STD.DEV	(38.315)	(44.282)		
	MAXI	336.880	359.180		
	MINI	138.360	144.870		
DHUMP1	MEAN	17.310	-10.713	1.842	.071
	STD.DEV	(59.543)	(54.260)		
	MAXI	256.120	157.640		
	MINI	-64.650	-159.770		
HUMPR1	MEAN	581.689	589.319	.251	.803
	STD.DEV	(118.278)	(108.974)		
	MAXI	954.550	918.600		
	MINI	453.330	446.810		
DHOMP1	MEAN	24.601	-17.079	2.960	.004
	STD.DEV	(63.371)	(40.864)		
	MAXI	226.940	53.840		
	MINI	-80.750	-103.930		
HOMPR1	MEAN	551.415	573.986	.723	.472
	STD.DEV	(107.053)	(124.074)		
	MAXI	906.390	955.580		
	MINI	408.970	412.400		

CLASSIFICATION

GROUPS OF AFFECTATION

GROUPS OF ORIGIN	DWTIMPP	DWTIMPN
DWTIMPP	18	9
DWTIMPN	12	19

PERCENTAGES

GROUPS OF ORIGIN	GOOD	BAD	TOTAL
DWTIMPP	18.00 (66.67)	9.00 (33.33)	27.00 (100.00)
DWTIMPN	19.00 (61.29)	12.00 (38.71)	31.00 (100.00)
TOTAL	37.00 **(63.79)**	21.00 **(36.21)**	58.00 **(100.00)**

IDENTIFICATION OF MISCLASSIFIED INDIVIDUALS

GROUP DWTIMPP :

MA87 MY87 JL87 OC87 AP88 MA89 DE89 AP91 OC91

GROUP DWTIMPN :

NO87 MY88 SE88 OC88 FE89 MY89 JL89 NO89 MY90 JU90 JU91 NO91

DISCRIMINANT LINEAR FUNCTION

VARIABLES NUM;	NAME	CORRELATIONS VARIABLES WITH F.L.D (Threshold=.26)	DISCRIMINANT FUNCTION COEFFICIENTS	REGRESSION COEFFICIENTS	STD DEVT	T STUDENT	PROBABILITY
					(RESULTS OF REGRESSION TYPE)		
2	WTIMP1	-.142	-.043421	-.017773	.0126	1.4141	.1633
3	DHUMP1	.247	-.001886	-.000772	.0028	.2748	.7846
4	HUMPR1	-.035	.008496	.003478	.0027	1.2721	.2090
5	DHOMP1	.380	.017409	.007126	.0027	2.6183	.0116
6	HOMPR1	-.099	.004050	.001658	.0034	.4871	.6282
CONSTANT			1.425977	.598091	.7043	.8491	.3997

R2 = .20769 F = 2.72610 PROBA = .02903

D2 = 1.01718 T2 = 14.67898 PROBA = .02903

HISTOGRAMMES

```
  -2.8   -2.3   -1.9   -1.5   -1.0    -.6    -.2     .3     .7    1.2    1.6    2.0    2.5    2.9    3.4
-3.0   -2.6   -2.1   -1.7   -1.2    -.8    -.4     .1     .5     .9    1.4    1.8    2.3    2.7    3.1    3.6
+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
DWTIMPP
                                                        JL91
                                                 DE89   SE89    AU91SE91
                                         MA89AP91AP88   JU87MY91JL90OC90                 AU90
                                   MA87  OC87MY87JL87OC91AP87AP89AU88NO88OC89JA89        DE88            JA90            SE90
+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
  0    0    0    0    0    0    0    0    1    0    2    2    3    1    4    2    3    3    1    1    0    2    0    0    0    1    0    0    0    1

DWTIMPN
                                                             NO91
                                              DE91    AU89    JU91
                                              FE88JU89JL89FE89JU90
                      FE91                AP90JA88JL88MY89OC88MY90SE88
DE90JA91FE90   MA90   NO90     SE87MA91MA88AU87DE87JU88NO87NO89MY88
+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
          1    1    1    0    1    0    2    0    1    1    2    4    3    4    3    5    2    0    0    0    0    0    0    0    0    0    0    0    0    0
```

IV-3. GROUP OF PRICES & PHYSICAL VARIABLES

Finally, we considered a third group consisting of the price variables considered above (WTIMP1, HUMPR1, HOMPR1, DHUMP1, DHOMP1) and physical variables related only to crude and refinery operations (CRIMPO1, CRSTOC1, CINPUT1, PEOPER1). With this mixed group of variables, the power of discrimination jumps to more than 72%. If we order again the variables according to their decreasing forecasting power, we obtain in this case the following sequence : DHOMP1, DHUMP1, WTIMP1, PEOPER1, HOMPR1, CINPUT1, HUMPR1, CRIMPO1, CRSTOC1. This shows the central role played by the variables describing refinery operations.

LINEAIR DISCRIMINANT ANALYSIS OF GROUPS DWTIMPP AND DWTIMPN

DESCRIPTION

EFFECTIVES		27 DWTIMPP	31 DWTIMPN	T	PROB
	MEAN	195.500	207.031	1.034	.305
WTIMP1	SDT.DEV	(38.315)	(44.282)		
	MAXI	336.880	359.180		
	MINI	138.360	144.870		
	MOY	17.310	-10.713	1.842	.071
DHUMP1	SDT.DEV	(59.543)	(54.260)		
	MAXI	256.120	157.640		
	MINI	-64.650	-159.770		
	MEAN	581.689	589.319	.251	.803
HUMPR1	SDT.DEV	(118.278)	(108.974)		
	MAXI	954.550	918.600		
	MINI	453.330	446.810		
	MEAN	24.601	-17.079	2.960	.004
DHOMP1	SDT.DEV	(63.371)	(40.864)		
	MAXI	226.940	53.840		
	MINI	-80.750	-103.930		
	MEAN	551.415	573.986	.723	.472
HOMPR1	SDT.DEV	(107.053)	(124.074)		
	MAXI	906.390	955.580		
	MINI	408.970	412.400		
	MEAN	5447.074	5419.033	.146	.885
CRIMPO1	SDT.DEV	(907.681)	(498.935)		
	MAXI	6768.000	6323.000		
	MINI	3495.000	4477.000		
	MEAN	343015.1	342871.6	.035	.972

CRSTOC1	SDT.DEV	(********)	(********)		
	MAXI	384547.000	378996.000		
	MINI	323647.000	322851.000		
	MEAN	13462.780	13383.320	.593	.556
CINPUT1	SDT.DEV	(623.109)	(360.322)		
	MAXI	14461.000	14263.000		
	MINI	11994.000	12731.000		
	MEAN	85.845	85.145	.789	.434
PEDPER1	SDT.DEV	(4.201)	(2.272)		
	MAXI	93.230	91.580		
	MINI	76.930	81.320		

CLASSIFICATION

GROUPS OF AFFECTATION

GROUPS OF ORIGIN	DWTIMPP	DWTIMPN
DWTIMPP	20	7
DWTIMPN	9	22

PERCENTAGES

GROUPS OF ORIGIN	GOOD	BAD	TOTAL
DWTIMPP	20.00 (74.07)	7.00 (25.93)	27.00 (100.00)
DWTIMPN	22.00 (70.97)	9.00 (29.03)	31.00 (100.00)
TOTAL	42.00 **(72.41)**	16.00 **(27.59)**	58.00 **(100.00)**

IDENTIFICATION OF MISCLASSIFIED INDIVIDUALS

GROUP DWTIMPP :

OC87 MA89 AP89 DE89 JL90 JL91 OC91

GROUP DWTIMPN :

NO87 SE88 OC88 JL89 AU89 NO89 MY90 JU91 NO91

DISCRIMINANT LINEAR FUNCTION

VARIABLES NUM;	NAME	CORRELATIONS VARIABLES WITH F.L.D (Threshold=.26)	DISCRIMINANT FUNCTION COEFFICIENTS	REGRESSION COEFFICIENTS	SDT DEVT	T STUDENT	PROBABILITY
					(RESULTS OF REGRESSION TYPE)		
2	WTIMP1	-.140	-.100620	-.035438	.0148	2.3894	.0209
3	DHUMP1	.244	-.003936	-.001386	.0030	.4694	.6409
4	HUMPR1	-.034	.020829	.007336	.0034	2.1761	.0345
5	DHOMP1	.375	.021922	.007721	.0032	2.4438	.0183
6	HOMPR1	-.098	.011027	.003884	.0037	1.0376	.3047
7	CRIMPO1	.020	-.001070	-.000377	.0003	1.1098	.2726
8	CRSTOC1	.005	-.000042	-.000015	.0000	1.4987	.1405
26	CINPUT1	.080	-.007091	-.002497	.0012	2.0602	.0448
27	PEDPER1	.107	1.221716	.430285	.1984	2.1689	.0351
CONSTANT			12.675510	4.486287	5.5618	.8066	.4239

R2 = .31827 F = 2.48992 PROBA = .02005

D2 = 1.81166 T2 = 26.14412 PROBA = .02005

HISTOGRAMMES

```
    -3.5    -3.0    -2.4    -1.9    -1.3    -.8     -.2     .3      .9      1.4     2.0     2.5     3.1     3.6     4.1
-3.8    -3.2    -2.7    -2.1    -1.6    -1.0    -.5     .0      .6      1.1     1.7     2.2     2.8     3.3     3.9     4.4
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
```

DWTIMPP

```
                                                            AU91                MY91
                                            DE89            SE89    AP91        AU90
                                            AP89OC91    SE91AP88    OC90        DE88
                            MA89            OC87JL91JL90AU88MA87JA89JL87NO88MY87JU87AP87OC89                    JA90SE90
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
   0   0   0   0   0   0   0   1   0   0   0   3   2   1   2   4   1   3   1   1   4   1   1   0   0   0   0   0   1   1
DWTIMPN
                                                    ND91
                                                    MA91
                                                    MY90
                                                    JU89
                                                    FE89
            JA91                                    FE88    NO89
DE90        ND90            FE91MY88        MY89JU90NO87    JL89JU91
FE90        MA90JU88JL88    AP90SE87DE87DE91JA88MA88AU87SE88OC88AU89
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
   2   0   0   3   1   1   0   2   2   1   1   2   2   8   1   3   2   0   0   0   0   0   0   0   0   0   0   0   0   0
```

V. CANONICAL CORRELATION

The third method of multivariate data analysis we used is the canonical correlation method. In a first stage, within the descriptive framework, it is used to build a linear model for explaining the time behavior of the monthly crude oil price WTIMP. In a second stage, within the predictive framework, it is used to build a linear model for forecasting the time behavior of the monthly change of crude oil price DWTIMP.

V-1. DESCRIPTIVE FRAMEWORK

The descriptive model is based on the following linear equation :

$$WTIMP(t) = \sum_i c_i X_i(t)$$

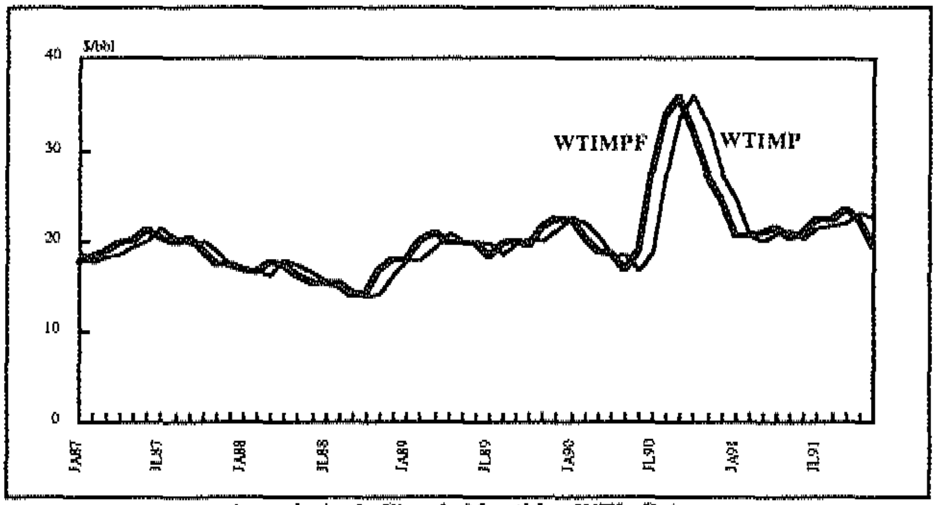
where c stands for a constant and X for the variables introduced. For this descriptive model, 24 variables were found to enter the optimal multiple linear regression which is able to explain a very high percentage of the variance in WTIMP, measured by the adjusted R^2 which is equal to 99.3%.

ADJUSTMENT OF LINEAR MODEL
ENDOGENOUS VARIABLE : WTIMP

R2AJ= .993 F(R2)= 326.4909 PROBA= .0000 V-TEST= 11.9955

VARIABLE	COEFFICIENT	STUDENT	PROBA	TEST-VALUE
HUMPR	.1656	9.9597	.0000	6.7694
HOMPR	.2203	12.2620	.0000	7.5336
CRIMPO	.0250	4.5847	.0001	4.0169
CRSTOC	-.0044	3.7364	.0007	3.3957
DCRSTO	.0002	1.7205	.0944	1.6725
PRIMPO	-.0599	4.9890	.0000	4.2915
HUPROD	-.0142	4.5315	.0001	3.9798
GAPROD	.1774	4.5296	.0001	3.9785
GASTOC	-.0047	3.7007	.0008	3.3682
DGASTO	.0004	2.4767	.0184	2.3576
HOPROD	-.1989	4.8695	.0000	4.2117
HOSTOC	.0038	3.7843	.0006	3.4324
DHOSTO	.0011	6.6512	.0000	5.2869
REPROD	.3904	5.0190	.0000	4.3113
RESTOC	-.0072	4.4257	.0001	3.9052
DRESTO	-.0007	1.8994	.0660	1.8383
KEPROD	.0875	4.5912	.0001	4.0214
CINFUT	.1072	3.3548	.0020	3.0957
PEDPER	-1.6256	1.6195	.1146	1.5779
CST/CIN	55.2132	3.4640	.0015	3.1829
CIM/PIM	-49.8041	5.4295	.0000	4.5754
GAS/GAP	34.1631	4.0773	.0003	3.6529
HOG/HOP	-12.3743	4.3932	.0001	3.8821
RES/REP	7.8171	5.2232	.0000	4.4443

In the following graph are shown the actual monthly crude oil price WTIMP and the fitted crude oil price WTIMPF obtained from the linear regression above. It is clear that the variables selected above have together, in the given combination, a very high explanatory power for the time behavior of the futures crude oil price WTIMP.



Actual And Fitted Monthly WTI Prices

V-2. PREDICTIVE FRAMEWORK

The forecasting model in turn is based on the following equation :

$$DWTIMP(t) = \sum_i c_i X_i(t-1)$$

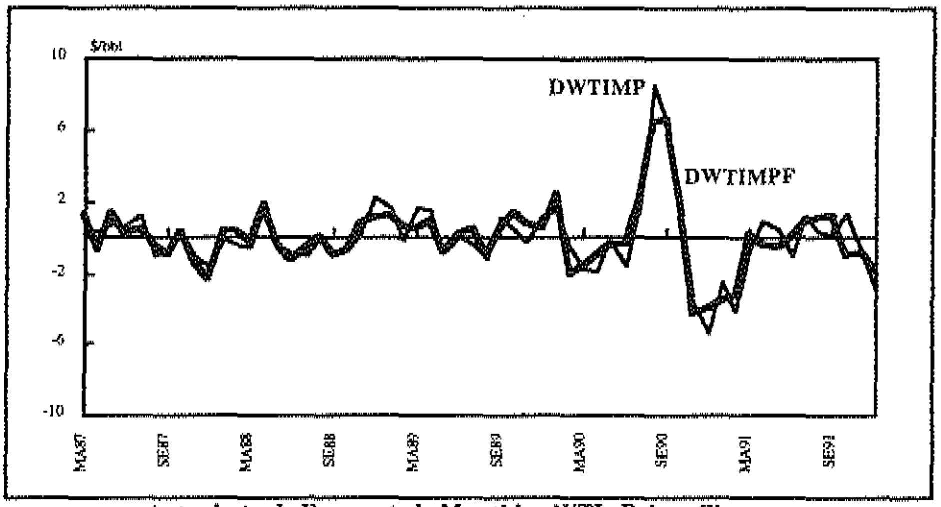
For this forecasting model, 15 variables were found to enter the optimal multiple linear regression for DWTIMP, with an adjusted R^2 equal to 76.8%.

ADJUSTMENT OF LINEAR MODEL
ENDOGENOUS VARIABLE : DWTIMP

R2AJ= .768 F(R2)= 13.5599 PROBA= .0000 V-TEST= 6.6444

VARIABLE	COEFFICIENT	STUDENT	PROBA	TEST-VALUE
WTIMP1	-.6563	5.6745	.0000	4.8613
HUMPR1	.1548	3.7353	.0006	3.4508
DHOMP1	.1675	5.6116	.0000	4.8201
CRSTOC1	.0158	5.1714	.0000	4.5232
DCRSTO1	.0006	2.3155	.0255	2.2331
GAPROD1	.2345	2.8864	.0061	2.7407
GASTOC1	-.0065	2.5659	.0140	2.4585
DGASTO1	-.0005	1.5399	.1311	1.5098
HOPROD1	.0198	1.5386	.1314	1.5086
KEPROD1	.0716	2.4030	.0208	2.3124
CINRUT1	-.4642	5.5569	.0000	4.7840
PEDFER1	11.5842	4.9950	.0000	4.4001
CST/CIN1	-218.9830	5.2526	.0000	4.5790
CST/CIM1	1.2384	3.3316	.0018	3.1200
GAS/GAP1	49.4736	2.9065	.0058	2.7582

The following graph, showing the forecasted values of the change in crude oil price (DWTIMPF) resulting from the forecasting model above along with the actual values of the price change (DWTIMP), depicts the relatively good quality of this forecasting model.



Actual And Forecasted Monthly WTI Price Changes

VI. CONCLUSION

An analysis of the oil futures market was carried out through the means of multivariate data analysis. In addition to the monthly prices of the three futures contracts traded on the NYMEX, this analysis was based on the data published by the API describing fundamental factors of the energy market for a period of five years. Although such analysis can by no means be expected to give the whole picture of the energy futures market, it has certainly provided some insight into this market's dynamics.

The first approach, the Principal Components Analysis, gave a general picture of the interactions between the futures prices and the fundamental market parameters. A graphical representation extracted from the data an interesting seasonal discrimination showing how futures prices are linked to the basic physical factors of the market at various seasons.

The second approach, the Factorial Discriminant Analysis, identified those variables that can best discriminate between increases and decreases in the crude oil price. Such discrimination could be used as a tool to predict the sign of future price change. The analysis showed that neither physical factors nor prices by themselves can be sufficient for building an accurate forecasting tool. Instead a mixed group of prices and physical variables proved to have the highest discriminating power, with the variables describing refinery operations playing an important role.

The last approach, the Canonical Correlation, provided the optimal multiple linear regression for a simple descriptive model of the monthly crude oil futures price. A high percentage of the variance could be accounted for by a group of 24 variables in which products prices but also physical pressure ratios play a central role. This approach allowed us also to find the optimal single-equation forecasting model of the monthly crude oil futures price change. Of course, the percentage of the variance accounted for by the 15 variables in this model was lower than the one in the descriptive model but was, nonetheless, just below 77%. This in itself is an interesting result given the fact that the analysis, which was based mainly on physical variables, did not take into account the technical factors of the market. These technical or speculative variables play a fundamental role in the futures market, which is in essence a speculative market. That is even more so in the short run perspective, which was that of this study. It would be interesting to look at the effects of two speculative parameters in particular, short hedging and long speculating, which represent the effective supply and demand for futures contracts, respectively. Among the speculative variables are of course the volume and open interest, but also some important parameters which are derived and watched closely by traders, such as the relative strength index, the on-balance volume, etc.

This analysis showed that physical variables are important parts of the futures market dynamics. This contributes to proving that the oil futures market, like any commodity futures market, is far from being independent from the corresponding physical market.

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