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CRUDE OIL AND PRODUCT PRICES: AN INVESTIGATION

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1. INTRODUCTION: THE LITERATURE

The history of the world oil market and of oil price movements in the past 20 years is not a dull story. Changes in the industry's structure consisted of the appearance of a new and apparently dominant group of producers, OPEC, the breaking up of the vertical and horizontal integration of the majors and an increased number of actors on both the demand and supply sides. In terms of oil prices the declining trend of the 1960's was dramatically reversed with the 1973 and the 1979 crises that led to $34/bbl for Arabian Light in 1981 as compared to $1.80 in 1970.

The literature attempting to explain these price movements is extensive and it is primarily concerned with defining the precise form and operation of the OPEC cartel. Indeed, the conventional wisdom of most models is that since 1973 the world price of oil has been consistently above the competitive price level. This is seen as a confirmation of the presence of discretionary power over price, power exercised by the OPEC cartel.

Among early models of OPEC offering a monopolistic interpretation of the group were those by Kalymon (1975), Kennedy (1974), Nordhaus(1973), et al. None of these models analysed the role of expectations or the question of OPEC stability, whilst they all treat non-OPEC supply as responding symmetrically to both price rises and price falls.

Perhaps a more serious weakness is to be found in their differences about what the competitive price level would be. Given that their basic assumptions and approach are fairly similar, such divergence is a cause of concern and probably illustrates how very sensitive these models are to the set of parameter values adopted.

The real weakness however, is their common assumption that OPEC is a homogenous group pursuing similar objectives. A more realistic study was conducted by Hnyilicza and Pindyck (1976) who examined the cartel in two parts, a group of savers, like Saudi Arabia, Libya and Kuwait, who have little immediate need for cash and would thus use a low rate of discount, and a group of spenders (Nigeria, Iran etc.) with large cash needs and a higher discount rate.

This model determines the cartel's optimal price path and quota allocation using game theory but the optimisation rule arrived at is a very unrealistic one: saver countries should only start extracting their oil after spenders have exhausted their resources.

Furthermore, dividing the cartel in two parts is not very realistic because within each group there are clear differences in philosophy. So grouping Saudi Arabia with Libya would hardly reflect a uniformity of outlook. A variant of the cartel hypothesis views Saudi Arabia or a subgroup of OPEC members as the Dominant producer, who sets the price and absorbs demand/supply fluctuations in order to support price.

Such models can be said to represent accepted dogma amongst most energy economists. Certainly, characterisation of the oil producers is a prerequisite to explaining and predicting their behaviour. This is not an excuse, however, for ignoring the fact that OPEC up to March 1983 had never behaved as a cartel administering prices.

2. THE HYPOTHESES

A cartel is formed in order to protect and maximise profits by discouraging entry and suppressing competition between its members. To do so it relies upon output quotas, common price and market sharing arrangements, none of which is to be found in OPEC's behaviour in the 1970's and early 1980's.

On the question of an output regulating mechanism, this did not exist for various reasons. First, the prevailing opinion until 1981 was that a shortage of oil would develop in the future and output regulation can only make sense under conditions of threatening excess capacity. Secondly, the conviction that state sovereignty is the factor determining decisions about oil, meant that the sharing with others of national decision making was not acceptable. Furthermore, given the Saudi's dominant position in terms of reserves, any plan to regulate output must be endorsed by them and must simultaneously serve the political and economic objectives of all members. Given their often conflicting national interests, it would seem that any such plan is bound to fail, as it is very hard to imagine a way of reconciling such diverse interests.

According to economic theory, a market sharing cartel can use either of two methods for sharing;

(1) Determination of quotas; until March 1983 OPEC had never attempted to do this (at least not successfully) probably feeling that there was no need to.

(2) Non price competition; this requires agreement on a common price level and structure taking into account

quality differences between the various crudes.

To examine whether OPEC did set the price, one has to take into account the physical nature of crude oil, which by itself is not valuable. Its value derives from the sale of refined products obtained from it, so the economic value is attached to products, irrespective of their crude oil origin.

Therefore, the economic performance of all crudes is measured by the same criterion, namely market valorisation corresponding to a given demand pattern at prevailing product prices. Checked against this common criterion, the relative values of all crudes ought to be set according to their relative economic performance.

Each OPEC member country produces one or more crudes whose products are highly substitutable. This may create competition among members, resulting in price undercutting in an effort to increase sales. To avoid this a cohesive pricing system ought to be established, incorporating quality and location differentials, so that price differentials are in a state of equilibrium.

In theory, therefore, the price administrator ought to define a reference crude oil, with well known characteristics on the basis of which the relative values of other crudes will be set depending on their product yield and transport costs.

One method that can be used to develop such an overall pricing pattern is the netback formula concept. According to this the cif prices of all crudes of similar gravity are equalised in a given market irrespective of their geographical origin.

Following the majors, OPEC chose Arabian Light 34 degrees API as the market crude, a choice justified by the amount of knowledge about this specific crude and by the importance of Saudi Arabia as a producer. Also following the majors, OPEC in 1973 established a constant basic gravity differential (BGD) of 6 cents per degree API for crudes above 34 degrees and 3 cents per degree for crudes below the reference gravity.

The use of such a constant BGD simply meant that OPEC failed to establish the overall pricing pattern. The reason is that since the cost of transport varies between areas, the netback formula i.e. the equalisation of the cif prices of similar crudes will only apply if the BGD applicable to the fob prices of crudes in one export area has a value different from that in any other export area.

Therefore, the overall pricing structure was never established. Instead, the task of setting the differentials was left to each member's discretion and thus became a function of actual or perceived demand pressures; in other words, price differentials have been market determined.

This hypothesis is further supported if one considers the significance of gravity in the pricing of crude oil. The physical significance of gravity is, simply, that higher gravity crudes give rise to a higher percentage yield of light products. Given that lighter products are the least substitutable and thus most valuable, higher gravity crudes have a greater economic value. In fact, investigation of the relationship between crude gravity and product yields reveals that for a simple refinery, yields are linear functions of gravity.

Furthermore, the use by OPEC of a constant BGD has meant the preservation of a linear relationship between the fob price of crude and gravity. Since both crude prices and product yields are linearly related to gravity clearly they are themselves related and this relationship is crucial to understanding the price formulation mechanism.

Crude oil and product prices are obviously the two factors determining the economic balance of a refiner's operations. A quantitative model developed by Rifai (1975) and based on these two factors proves a very important relationship: that the stability of crude oil pricing patterns is governed by the stability of the products' pricing patterns.

This implies that if the change in product prices is simply a cumulative move, say an overall decline, so that the level of all product prices falls but their relative distribution around a reference product – say gasoline – remains unchanged, then the level of all crude prices will fall, but relative crude oil prices, i.e. differentials, will remain unaltered. If however, the relative distribution of products' prices changes e.g. there is a widening of the differential between light and heavy products, then the differential between crude oil prices will change in the same direction.

Clearly, faced with changes in demand patterns and product prices, the major oil companies would have to change their lifting programmes. They would have to change the composition of the blend in an attempt to compensate for the changing product prices. Thus liftings of certain gravity crudes would increase while for others they would fall, since the majors' contractual arrangements with OPEC did allow for such changes. Therefore, eventually producing countries would have to change the price of their crude to reflect the new stucture of product prices.

It would seem that the only way to achieve control over the structure of crude prices is through control of product prices given the derived nature of the demand for crude,and this was something that OPEC could never achieve. Thus it seems reasonable to argue that differentials have been market determined, with the oil companies playing a significant role in the formulation of prices, since they had the power of disposal of OPEC's oil.

Indeed, there were examples in the 1970's to support this argument e.g. cases where a particular crude such as that of Abu Dhabi was unrealistically priced by the producer and the companies completely refused to lift any oil until a price change was agreed. Presumably this hypothesis can explain the observed relationship between crude oil prices. The question still remains as to whether the actual level of the marker's price was administered by OPEC.

Studying closely OPEC's behaviour confirms that even at times of crisis the group was following market trends, as indicated by the spot market for both crude and products. The spot price of crude can be taken to be a true market price, since this is a true market in the sense that any distortion creating an imbalance generates an equilibrium restoring price adjustment. The spot market for crude in the 1970's was a very marginal market, handling an estimated 5–15% of world oil volumes; even so the prices at which these marginal barrels were traded were indicative of the state of the market. For example a rising spot price would indicate a shortage of oil – actual or perceived.

An interesting and important aspect of the relationship existing between offical and spot prices is that spot prices have always led official prices. This happened in 1973, in 1979 and again in 1983. The reason for this relationship is not hard to find.

Clearly OPEC leaders will not tolerate spot prices greatly exceeding contract prices indefinitely because a company buying at official prices (Government Selling Prices) can immediately resell on the spot market and reap the profits. These revenues could be accruing to OPEC nations. In the opposite direction, declining spot prices indicate a surplus, and given the existence of non–OPEC suppliers, OPEC member countries will eventually follow as they can not afford to lose market share.

Therefore, spot prices do influence Government Selling Prices (GSPs) and thus the variability of world oil prices and the price level itself have been affected by this relationship which literally explains the observed price trends. So it would seem that the spot market is of far greater importance in price determination than the volume of trading in the 1970's would indicate. Its importance in recent years has been overwhelming given that the volume of trade passing though it, at spot or spot related prices, is estimated at between 45–75% of the world total.

Clearly, if the level of the reference crude price has been affected by market trends so that a change in demand has not been met by a cartel quantity adjustment but by a price adjustment, and if at the same time differentials have been market determined, then the hypothesis that it was the cartelisation of the oil market by OPEC that caused the events of the 1970's has to be rejected.

Instead one has to accept that the importance of market forces has grown over time from a position of non-existence back in the 1950's to a dominant role today. The transition has not been smooth neither is it yet complete. This transitional period has witnessed the appearance of new actors and changes in the distribution of power among these actors.

The majors' power was declining as OPEC was taking over the upstream phases but not disappearing. The seven sisters were still playing an important role in price formulation, as argued earlier, by virtue of their power of disposal. OPEC itself was unable to assume the majors' dominant position probably due to lack of expertise, political friction and the de-integration of the industry which has meant the lack of any checks and constraints previously available to the companies for the detection and prevention of cheating. Nevertheless, OPEC did play a role especially in the two crises not because of the taking of cartel action to raise oil prices, but rather by virtue of people's perceptions that this was the case, and of course by virtue of their "power of denial" i.e. determination of maximum production levels.

The 1973 embargo certainly represents action taken by the Arab members of OPEC but that was probably the only such case as most OPEC conferences since then and up to 1983 have ended, more often than not, in disagreement. Furthermore, the timing of both crises can be explained by political events – the Arab-Israeli war and the Iranian revolution. These would have occurred independently of OPEC's presence or absence. Of course in a competitive market system such disturbances would only last for a short period and prices ought to fall back soon afterwards. This has not happened because the market was not perfect but subject to long adjustment lags and because it was subject to certain structural changes occurring concurrently which helped to keep prices high.

After 1973 prices did not return to their pre-intervention level probably because of the change in property rights, i.e. the transfer of ownership and control of the upstream from the majors to the OPEC governments. The nationalisation of crude oil deposits by the producers has resulted in prices being higher than otherwise, because governments usually work with longer time horizons than companies, i.e. use a lower discount rate resulting in slower depletion. This would have occurred in any case as the trend for nationalisation was in existence before the creation of OPEC; and this seems a more satisfactory explanation than the one based on oligopolistic behaviour on behalf of the cartel. For exactly the same reasons, i.e. the majors' uncertainty over property rights, prices in the late 1960's were lower than otherwise as companies tended to maximise production. This explanation, due to Johany (1979) seems adequate for the first oil crisis though it is not clear how the same argument applies to the 1979 crisis, given that by that time the transfer of ownership had already occurred.

The unexpected political events of 1979 and 1980 caused expectations of further disruptions and hence panic buying. The effect of this on perceptions can explain prices remaining high. At the same time further structural changes were taking place. OPEC countries entered into direct marketing of their crude for the first time and there was a shift from long to short term contracts, with many national oil companies going to the spot market and being willing to pay a premium to secure supplies, thus prolonging the shortage.

With the high price levels of the 1970's, production from higher cost non–OPEC countries has been encouraged and with demand finally responding and starting to decline in 1982 the market saw prices falling for the first time in the face of excess capacity.

It would, therefore, seem that the transitional period scenario offers a plausible explanation of oil price movements. OPEC and non–OPEC, the majors' and buyers' perceptions, unexpected political events and structural changes all combined to determine prices, within a framework in which the market's importance has been increasing.

Nowadays, many experts agree on the importance of the market forces. Although the hypothesis is well supported by theoretical arguments there has been no attempt to validate it empirically. This provides a justification for a quantitative study which was undertaken in the hope that it would fill at least part of the gap which clearly exists between numerous unsatisfactory models of the OPEC cartel on the one hand, and only a qualitative argument on the other.

To incoporate all the factors that proved to be important to the price trend would have been an impossible task. At the same time, any empirical testing ought to take place in such a manner that the basic behavioural hypothesis used to explain the phenomenon under study will be retained. Given the complexity and diversity of the factors shaping oil prices, all that could be hoped for was that the empirical investigation of certain aspects of the system may provide support for trends which would only exist under the qualitative explanation advanced.

This investigation has focussed on two relationships which, as argued earlier on, are believed to be a key to understanding the oil market:

(1) <u>The interaction between spot and administered prices</u>,

i.e. between market prices and the OPEC price and the extent to which one affects the other. This would enable us to deduce whether the market or the administrating body exert more influence on prices.

(2) The relationship between crude oil and product prices, i.e. between the two sides of the market (demand/ supply).

Having decided to focus on these relationships, the next step was to determine the appropriate methodology.

3. METHODOLOGY AND DATA

The concept of cause and effect is fundamental in any science and the elucidation of causal relationships among a set of variables is one of the major goals of empirical research. However, when it is not possible to conduct a controlled experiment it becomes very difficult to produce convincing evidence that a cause and effect relationship actually exists. This is almost invariably the case in economics and as a result the traditional approach in econometrics has been to set up a model on the basis of prior economic theory. Not only is a cause and effect relationship assumed to hold, but furthermore the direction of causality is also taken to known.

Suppose for simplicity that a system contains only 2 variables X and Y. Given that a cause and effect relationship can only be in one direction say from X to Y, the only question that remains is whether such a relationship actually exists. The usual approach is to regress Y on X and test the coefficient for significance. However, a high correlation between two sets of non–experimental data does not constitute evidence of a causal relationship. Thus fitting a regression model is primarily an exercise in measurement. That a relationship exists is not actually questioned, but is taken for granted on the basis of economic theory.

This approach underlies the econometric model building but it suffers from a disadvantage: although specification of a hypothesis derives from economic theory, and thus faith is placed in prior knowledge from that theory, an empirical investigation should not rely on untestable features and premises as this violates an important principle of scientific research.

Thus the danger exists that an econometric model may specify that 2 variables are causally related even when they are not and perhaps even worse, it may specify the wrong causality directions. Acceptance of the cartel hypothesis in the oil market would necessitate the specification of causality running from variables representing the OPEC administered system to variables representing the marginal spot market. If the assumption is incorrect, clearly the results will be misleading.

So the prerequisite of any empirical work that aims to test a particular hypothesis is to discover the mechanism of causality. Movement through time can answer questions about the existence and direction of causality, and thus the empirical identification of lead and lag relationships between variables is crucial in providing support for any hypothesis.

Clearly the appropriate lags are not known on the basis of theory. This coupled with the lack of any investigation of the characteristics of the data in econometrics means that there is no method of identifying the lag structures. The approach typically taken is to specify, a priori, some arbitrary conditions about the form of the distributed lag and, as there are no rules of thumb available,to keep experimenting until a good fit – as indicated by a high R^2 – is obtained. The result may be a very poor predicting equation.

Prior to any testing or estimation of structural parameters it is necessary to investigate and understand the statistical properties of the data. This is a necessary precondition to identifying the mechanism of causality through a discovery of leads and lags. The methodology that enables one to do so is that pioneered by Box and Jenkins (1976), which aims at discovering the statistical features of a series and modelling its behaviour and its relationship to other time series.

To employ the Box–Jenkins methods, data were collected on four crude oils: Arabian light, the marker or reference crude; Nigerian light, a representative of African light crudes; Kuwait export crude, a representative of Middle Eastern heavier crudes; and Iranian light, a crude of comparable quality to the marker.

For each crude, data were collected on official selling prices, spot prices and netbacks in various markets. The official price data were collected from the Petroleum Economist (monthly figures). The spot price data were available from 3 sources; the Petroleum Economist since 1979, the OPEC bulletin since 1979 and the Middle East Petroleum and Economic Publications (MEPEP) since 1976.

One ambiguity of the spot price data is that since there is no central register – due to the absence of a centralised dealing system – the data are collected by a survey approach. Thus it is not known whether a trader reports a price offered for a transaction or a price at which the transaction has actually taken place. Since there is usually no clear statement of the principles on which the series are calculated by each source, it is nearly impossible to judge which series is more appropriate for empirical work.

Given that the MEPEP and the Petroleum Economist data were fairly close and both were lower than the OPEC data and since the aim was to cover as long a period as possible, the MEPEP data was finally selected. That covers the longest period (since January 1976) and it was expected to yield results similar to what would have been obtained had the Petroleum Economist data been used.

With reference to the netbacks data, construction of netbacks requires information on four elements:

(1) Spot product prices in a particular market.
(2) Refinery yields in that market.
(3) Transport and insurance costs between the refinery and the export port of the crude considered.
(4) The running costs per barrel of the refinery considered.

So the netback summarises the value of a barrel of crude in terms of products for the average or typical refinery in a particular market.

Data on spot product prices at Rotterdam has been collected from Platt's Oilgram, the aim being initially to construct the netback series. However, the complexity of the calculations proved overwhelming: data on refinery yields was not available on a consistent basis while figures on running costs were non-existent. Thus construction of the netbacks would have to rely on simplistic assumptions and a high degree of extrapolation of the limited data available. The final product would be very suspect. Therefore, it was decided to rely on figures published by PIW.

This source publishes netbacks on the four crudes considered as from Rotterdam on a monthly basis from the beginning of the period (January 1976). Five other centres – The Middle East, Singapore, Italy, the Carribean and the US Gulf were added on later. All PIW data, with the exception of the US netbacks, assume a basic topping/reforming type refinery with the yield patterns being varied between winter and summer. For the US Gulf a refinery with conversion possibilities is assumed throughout the period.

Clearly if there is a unified worldwide spot market for products – as is often argued in the trade press – then the netback series ought to follow similar trends. Therefore, repetition of the tests for all the 6 markets is not necessary. Instead, 3 main centres have been used: Rotterdam (as the most important in terms of volume), the US Gulf (as a representative of complex refining) and the Middle East, this choice being based on the potential importance of the area as an export port for products, given that OPEC countries have moved downstream in recent years.

With the Box–Jenkins framework the data themselves are permitted insofar as possible to suggest the pattern of interrelationships. The way that series are related is closely connected with the concept of causality between variables advanced by Granger (1969).

Granger's definition of causality is essentially in terms of predictability: a variable X causes Y, if present Y can be better predicted by using past values of X than by not doing so. Intuitively X causes Y if after explaining whatever of Y that can be explained on the basis of its own past, some more remains to be explained by X. This suggests relating X to that part of Y which cannot be explained by Y's own past.

To derive these so–called prewhitened or filtered series one has to investigate the statistical behaviour of the series – typically through the autocorrelation and partial autocorrelation functions. On the basis of this behaviour one then has to identify, estimate and diagnostically check for adequacy univariate ARIMA (integrated autoregressive moving average) models for each series individually. This is the first step in the research.

These models essentially "explain" a time series in terms of its own past so they are atheoretical in that they have nothing to say about the structure of the system. Nevertheless, ceteris paribus, i.e. in the absence of any changes in that structure, they provide the most powerful tool for very short term forecasting superior to the most complex econometric model. Furthermore, the exercise is not a purely mechanistic one as there is a lot of interpretation involved when choosing the appropriate model. Box and Jenkins have theoretically derived the statistical behaviour of a general class of models; what the researcher has to do is to compare the observed series behaviour to the theoretical patterns and try to "match" them and specify the appropriate class of models (whether AR or pure MA or a mixed ARIMA). These univariate models can then be used to investigate causality and lead/lag relationships between 2 or more series.

4. RESULTS

Such models have been built for the 5 series available on each of the four crudes for various sub–periods between important OPEC conferences. For example the data on Arabian light have been divided into 6 sub–periods.

(1) January 1976 – December 1978
A period of stability ending with the Abu Dhabi meeting.
(2) January 1979 – June 1980
Abu Dhabi to Algiers.
(3) January 1979 – May 1981
Abu Dhabi to Geneva.
(4) June 1981 – March 1983
Geneva to London.
(5) June 1981 – March 1985
Geneva onwards.
(6) April 1983 – March 1985
London onwards.

When it came to modelling the period as a whole (January 1976 – March 1985) the standard Box–Jenkins models could not be used. Despite numerous attempts it was impossible to come up with anything acceptable. The reason was that these models require a time series either to be or to be transformed into a homogeneous series in mean and variance, i.e. into a stationary series which has a constant average value and constant variance around this mean value, both independent of time.

The 1979 crisis had such a large impact on prices, producing a step jump, that statistical properties of the series have been overwhelmed and grossly distorted by that event. Simple techniques such as differencing or logarithmic transformations which are normally employed did not achieve stationarity.

Therefore, an extention of the basic ARIMA models had to be used namely, intervention analysis or impact assessment. This analysis is aimed at modelling the precise nature and magnitude of a change in a series caused by a known intervention. The analysis enables one to examine whether the change was of the kind actually expected.

Typically, each series is modelled in terms of two components:

(1) An intervention component describing the deterministic relationship between a known event and the series. The intervention has to be characterised in terms of its onset (whether abrupt or gradual) and its duration (whether permanent or temporary).

(2) A noise component, describing the stochastic behaviour of the series which is identified on the basis of the pre–intervention section (1976–78) and modelled according to a standard Box–Jenkins model.

Typically the data on spot crude prices and netbacks in the various markets have been modelled in terms of two interventions or events: the 1979 Iranian revolution and the 1980 Iran–Iraq war, both of which had a very similar supply effect but each caused a different reaction. So the 1979 event has been modelled as a permanent change while the 1980 one as a very temporary disruption. Both have been found significant.

The official price data has also been modelled in terms of two events: the 1979 one and the March 1983 conference decision to cut prices in line with the spot market trend. This latter was considered as an important turning point in OPEC's history, as for the very first time the members lowered their prices – explicitly admitting the dominance of the spot market in the current industry environment and contrary to one of the main objectives of OPEC's formation in 1960 – to prevent any further price reductions. Both events were found to be significant. By contrast, the 1980 disruption was found insignificant which is not surprising, given that its effect on the spot market was very short–lived and given the inertia characterising the OPEC conference system. Presumably there was not enough time for official prices to respond as the spot price started its downward movement very soon after 1980.

Figure 1 presents the performance of one of these models for Nigerian light. There is a very good fit between the actual series and the series simulated on the basis of the estimated model. Furthermore, one can see how the series has been decomposed into a part due to the combined interventions of 1979–80 and into a noise part. Looking at the intervention component it is clear that one is dealing with a true market, which after the disruption tends to return to its preintervention level i.e. tends to restore itself to equilibrium in an oscillatory manner. Though the lags of the response to the excitation are long, nevertheless the system is stable. Table 1 presents a sample of the intervention models.

Having filtered all the data in this way, one is then able to perform the causality test. As mentioned earlier, Granger's definition of causality is the only empirically testable one. A few methods exist enabling one to test the existence and directions of causality and we have employed two such methods: Sim's regressions relying on the F statistic and the Pierce S statistic (Pierce, 1977) which relies on the cross correlation function.

Sim's method involved performing a number of regressions of each variable on past and future lags of the other and testing their significance. The test is based on the obvious idea that "the past can cause the future but the future cannot cause the past". Thus, we expect that if the spot price causes the official then regressing the OPEC price on past and future lags of the spot, the overall regression will be significant but the coefficients on

FIG. 1. NIGERIAN BONNY LIGHT : SPOT PRICE , 1976-1985

$/bbl

ACTUAL SERIES, SIMULATED SERIES, PARTS DUE TO INTERVENTION AND NOISE.

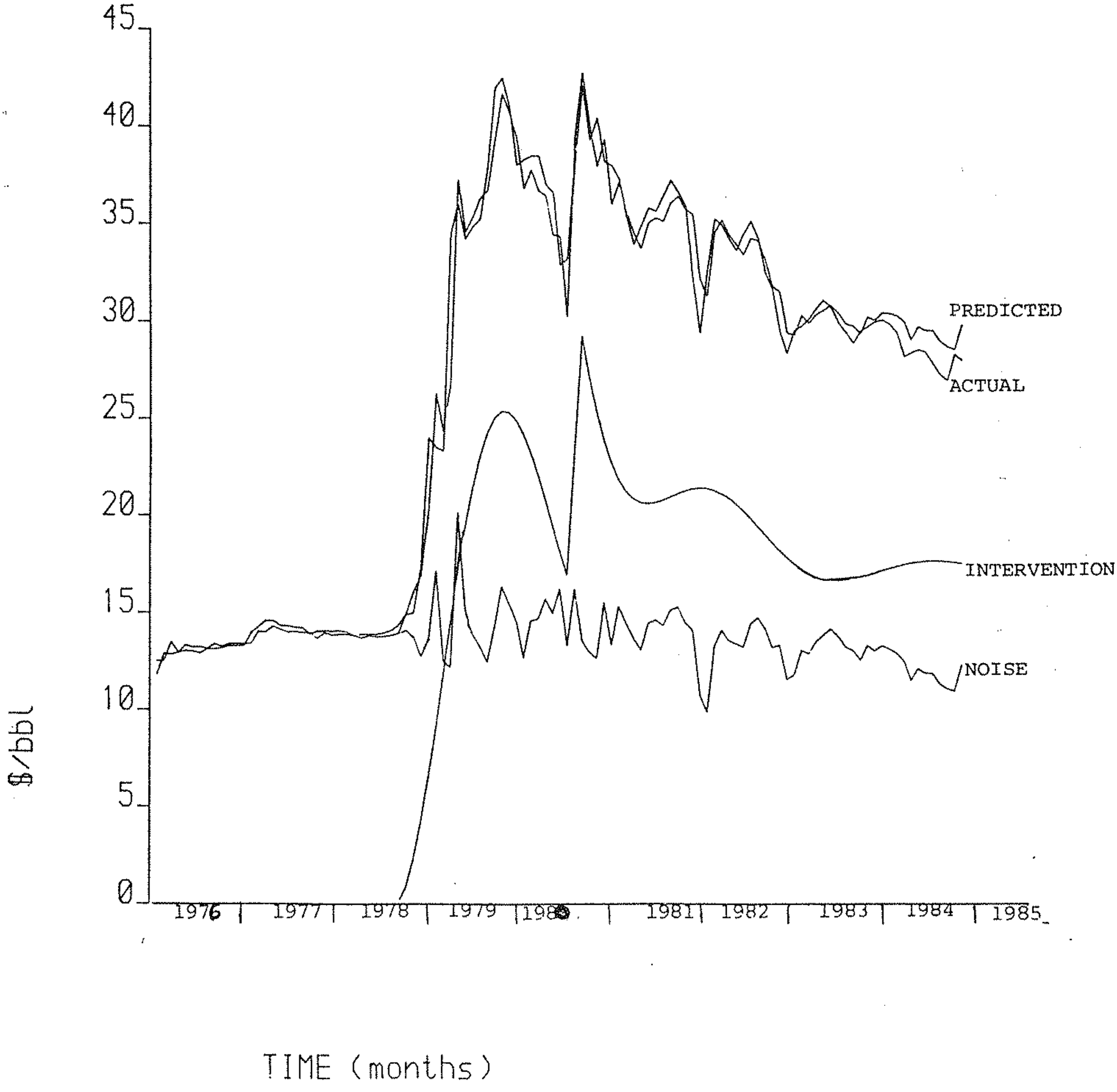

TABLE 1 INTERVENTION MODELS, 1976−85

A. ARABIAN LIGHT − OFFICIAL PRICE

$$Y_t = \frac{w_o}{(1-\delta_1 B-\delta_2 B^2)} I_{1979} + w_o^* I_{1983} + (1-\theta_1 B-\theta_2 B^2-\theta_4 B^4)a_t$$

w_o = 0.211 (0.018)	δ_1 = 1.85 (0.016)	δ_2 = −0.86 (0.01)	w_o^* = −4.1 (0.568)
θ_o = 12.16 (0.191)	θ_1 = −0.811 (0.092)	θ_2 = −0.361 (−0.12)	θ_4 = 0.287 (0.093)

Q_{20}= 22.4 RSS = 40 D.F = 100

B. IRANIAN LIGHT − SPOT PRICE

$$Y_t = \frac{w_o}{(1-\delta_1 B-\delta_2 B^2)} I_{1979} + \frac{w_o^*}{(1-\delta_1 B)} (1-B)I_{1980} + \theta_o + \frac{(1-\theta_1 B)a_t}{(1-\varphi_1 B)}$$

w_o = 0.72 (0.07)	δ_1 = 1.854 (0.02)	δ_2 = −0.898 (0.018)	w_o^* = 7.2 (1.06)
δ_1^* = 0.888 (0.024)	θ_o = 12.14 (0.56)	θ_1 = −0.405 (0.123)	φ_1 = 0.465 (0.12)

Q_{23} = 18 RSS = 190 D.F = 103

C. NIGERIAN BONNY − ROTTERDAM NETBACK

$$Y_t = \frac{w_o}{(1-\delta_1 B-\delta_2 B^2)} I_{1979} + \frac{w_o^*}{(1-\delta_1^* B)} (I-B)I_{1980} + \theta_o + \frac{1}{(1-\theta_1 B)} a_t$$

w_o = 0.752 (0.101)	δ_1 = 1.84 (0.02)	δ_2 = −0.89 (0.02)	w_o^* = 5.13 (1.106)

$\delta_1^* = 0.91$ (0.03)	$\theta_o = 13.48$ (0.76)	$\varphi_1 = 0.668$ (0.077)
$Q_{24} = 28$	RSS = 260	D.F. = 104

(Table 1 – continued)

<u>D KUWAIT EXPORT CRUDE – MIDDLE EAST NETBACK</u>

$$Y_t = \frac{w_o}{(1-\delta_1 B - \delta_2 B^2)} I_{1979} + \frac{w_o^*}{(1-\delta_1^* B)} (1-B) I_{1980} + \theta_o$$

$$+ (1 - \theta_1 B - \theta_2{}^2 B) a_t$$

$w_o = 0.707$ (0.068)	$\delta_1 = 1.78$ (0.02)	$\delta_2 = -0.83$ (0.02)	$w_o^* = 4.97$ (0.51)
$\delta_1^* = 0.91$ (0.015)	$\theta_o = 11.64$ (0.31)	$\theta_1 = -0.816$ (0.099)	$\theta_2 = -0.269$ (0.09)
$Q_{23} = 27$	RSS = 64	D.F = 95	

NOTE: Figures in parentheses denote standard errors.
RSS = residual sum of squares.
D.F. = degrees of freedom.
Q = test of model adequacy in terms of the residual autocorrelation function.

future lags will not be. In the opposite direction, regression of the spot price on past and future lags of the OPEC price will yield significant future coefficients.

The second test statistic is derived from the significant lags of the cross correlation function between two series. Clearly if the netbacks are leading and causing official prices we expect the positive half of the CCF to include all the significant lags, while the negative half should not include any.

To perform both tests it is essential that each series is free from autocorrelation, since both the F statistic and the cross correlation function become "contaminated" by it. Hence, the filtering stage is necessary.

Clearly if both tests give rise to the same conclusions, then confidence in the results is increased. These tests have been performed for the various subperiods and a sample of the results is presented in Tables 2 and 3. As expected the only insignificant regressions are those of the spot price and the netbacks on past lags of the official price.

In all cases the hypothesis of independence is rejected. The results indicate that it is a strong and statistically significant relationship between spot and official prices for all the crudes in all the periods examined. However, whereas spot prices are a significant leading indicator for official prices for all crudes, there is no evidence of a lead indicator role from official to spot prices. Thus the evidence is consistent with unidirectional Granger causality from spot to OPEC administered prices.

The exception to this general conclusion is the case of Arabian light between 1981–83, when the above mentioned causality direction is not confirmed. This is not surprising given that in this period, when the spot market was declining, the marker's price was unrealistically raised from $32 to $34/bbl in the Geneva meeting – when with the rest of OPEC prices falling to new price levels around the $34 marker, price reunification was claimed. Of course, looking at the longer period 1981–85 the trend is confirmed since OPEC did follow in 1983 with a $5/bbl reduction.

With reference to the relationship between official prices and netbacks, the hypothesis of independence is rejected in all cases as there is a statistically significant relationship between the two series. As regards the direction of causality, the overwhelming conclusion is that netbacks appear to "cause" official prices whilst the oppposite does not hold. This pattern is violated in the case of Kuwait export crude between 1976 and 1978, when although a statistically significant relationship is confirmed between the two variables, the direction of causality is not clear as neither variable appears to be a leading indicator. This could be interpreted as evidence that the series

TABLE 2 ARABIAN LIGHT: SIM'S CAUSALITY TEST
1976–1985 (Monthly Data) – FILTERED SERIES

REGRESSION		F	DW
Official Price	= F (Spot Price A)	2.27	2.03
Official Price	= F (Spot Price B)	1.9	1.93
Official Price	= F (Rotterdam Netback A)	2.44	2.14
Official Price	= F (Rotterdam Netback B)	1.82	2.18
Official Price	= F (Middle East Netback A)	2.9	2.03
Official Price	= F (Middle East Netback B)	1.9	2.05
Official Price	= F (US Netback A)	6.35	1.93
Official Price	= F (US Netback B)	3.36	1.92
Spot Price	= F (Official Price A)	0.49*	1.98
Spot Price	= F (Official Price B)	1.88	1.95
Spot Price	= F (Rotterdam Netback A)	14.5	1.85
Spot Price	= F (Rotterdam Netback B)	10.57	1.87
Spot Price	= F (Middle East Netback A)	3.29	2.14
Spot Price	= F (Middle East Netback B)	4.16	2.08
Spot Price	= F (US Netback A)	7.13	1.82
Spot Price	= F (US Netback B)	7.55	1.75
Rotterdam Netback	= F (Official Price A)	1.3*	2.15
Rotterdam Netback	= F (Official Price B)	2.44	2.19
Rotterdam Netback	= F (Spot Price A)	13.19	2.3
Rotterdam Netback	= F (Spot Price B)	8.84	2.28
Middle East Netback	= F (Official Price A)	1.7*	2.07
Middle East Netback	= F (Official Price B)	2.3	2.05
Middle East Netback	= F (Spot Price A)	6.35	2.4
Middle East Netback	= F (Spot Price B)	4.01	2.32
US Netback	= F (Official Price A)	0.44*	1.95
US Netback	= F (Official Price B)	3.4	1.7
US Netback	= F (Spot Price A)	12.2	1.8
US Netback	= F (Spot Price B)	7.29	1.85

NOTE: A = 6 past lags, B = 6 past and 6 future lags
* Denotes insignificance at the 5% level.

TABLE 3. THE PIERCE S - STATISTIC CAUSALITY TEST

1. ARABIAN LIGHT 1976-85: OFFICIAL PRICE, SPOT PRICE, ROTTERDAM NETBACK

Official versus Spot Price			Official Price versus Netback			Spot Price versus Netback		
Independence	Causality from->to GSP->Spot	Spot->GSP	Independence	Causality from->to GSP->N/b	N/b->GSP	Independence	Causality from->to Spot->N/b	N/b->Spot
48.45*	9.39	39.43*	56.16*	16.65	39.88*	97.9*	68.56*	73.2*

2. ARABIAN LIGHT 1976-85: OFFICIAL PRICE(GSP), SPOT PRICE, MIDDLE EAST NETBACK

Offical Price versus Netback			Spot Price versus Netback		
Independence	Causality from->to GSP->N/b	N/b GSP	Independence	Causality from->to Spot->N/b	N/b->Spot
56.05*	25.3	31.4*	80.98*	59.2*	33.8*

3. KUWAIT EXPORT CRUDE 1976-78: OFFICIAL PRICE, SPOT PRICE, ROTTERDAM NETBACK

Official Price versus Spot Price			Official price versus Netback			Spot Price versus Netback		
Independence	Causality from->to GSP->Spot	Spot->GSP	Independence	Causality from->to GSP->N/b	N/b->GSP	Independence	Causality->to Spot->N/b	N/b->Spot
17.86*	2.16	25.7*	11.17*	5.5	3.8	23.33*	6.8	5.6

TABLE 3 (Contd.).

THE PIERCE S-STATISTIC CAUSALITY TEST

4. IRANIAN LIGHT 1979-81: OFFICIAL PRICE, SPOT PRICE, US NETBACK.

Official Price versus Spot Price			Official Price versus Netback			Spot Price versus Netback		
Independence	Causality from->to GSP->Spot	Spot-'GSP	Independence	Causality from->to GSP->N/b	N/b->GSP	Independence	Causality from->to Spot->N/b	N/b->Spot
13.2*	4.4	9.13*	12.66*	2.05	10.6*	16.03*	5.05	8.8

5. NIGERIAN BONNY LIGHT 1981-83: SPOT PRICE, ROTTERDAM NETBACK.

Official Price versus Spot Price			Official Price versus Netbacks			Spot Price versus Netbacks		
Independence	Causality from->to GSP->Spot	Spot->GSP	Independence	Causality from->to GSP->N/b	N/b->GSP	Independence	Causality from->to Spot->N/b	N/b->Spot
15.91*	3.4	12*	17.7*	2.93	14.76*	24.4*	6.8	2.67

6. KUWAIT EXPORT CRUDE 1981-85: OFFICIAL PRICE, SPOT PRICE, MIDDLE EAST NETBACK

Official Price versus Spot Price			Official Price versus Netback			Spot Price versus Netback		
Independence	Causality from->to GSP->Spot	Spot->GSP	Independence	Causality from->to GSP->N/b	N/b->GSP	Independence	Causality from->to Spot->N/b	N/b->Spot
40.1*	11.63	28.35*	33.83*	14.15	19.6*	34.25*	24.32	7.0

Note: * denotes significance at the 95% level and hence rejection of hypothesis of e.g. independence.
GSP = Government Selling Price.

exhibit a relationship of simultaneity and the question arises as to the reasons for and meaning of this trend.

The spot market for crude between 1976 and 1978 has been fairly small and if we take official prices to be the supply side and netbacks the representation of demand, then interaction is the expected structure. The question then arises as to why this was not the pattern found for the other crudes since the size of the spot market was a general phenomenon, not specific to Kuwait crude.

The answer appears to be the fact that differentials even in this period have been market determined, with adjustments to official prices left to individual producers to undertake in response to changing market conditions. The fact that Kuwait was quick enough to respond to a changing market in 1977 by cutting its official price by 10 cents when the rest of the OPEC price structure was unchanged can account for the interactive relationship. For clearly, the longer OPEC takes to respond to a change, the longer the lead of a netback change over an official price alteration and hence the clearer the confirmation of the pattern of unidirectional causality. On the other hand, a fast reaction by Kuwait, coupled with

the continually changing spot market for products may appear to be a feedback relationship when all it reflects is a closer adjustment by the producer to the market.

The third relationship examined is that between spot prices and netbacks and again the hypothesis of independence is always rejected by both tests. However, in contrast to the previous cases, neither variable appears to be causing the other i.e. no lead indicator is found, reflecting that the relationship is one of feedback i.e. each variable is "causing" the other simultaneously which is indeed the structure expected.

With reference to the lag structures, looking first at the relationships of the official price to spot and netbacks – i.e. administered versus market prices – if we take as our bench mark the stable period 1976–78, we find a significant lag of the official price behind spot of 6 months. This is perfectly explained by the regular biannual OPEC conferences, when the price was adjusted to reflect the spot market situation. Compared to this period one can conclude that over time the lags are getting shorter.

In theory OPEC sets the price at a meeting and that price remains fixed between any two conferences. In practice the "real" official prices include premia or discounts given in response to a situation of scarcity or surplus in the market. The fact that the lags are getting shorter indicates that OPEC pricing is becoming more responsive to the market, following more closely after 1979. A typical structure can be seen in Table 4.

TABLE 4 ARABIAN LIGHT – OFFICIAL PRICE VS ROTTERDAM NETBACK

1976 (Jan.) – 1985 (March)

ESTIMATED LAG DISTRIBUTIONS

Coefficient on Lag of:	Official P. on Netback Past Only	Official P. on Netback with Future	Netback on Official P.
6	0.04	0.031	0.119
5	−0.056	−0.08	0.216
4	−0.05	−0.062	0.488
3	−0.028	−0.049	0.044
2	0.154*	0.137*	0.108
1	0.007	0.000	−0.296
0	−0.023	−0.034	−0.136
−1		−0.013	0.058
−2		0.059	0.726*
−3		0.022	−0.047
−4		0.1	−0.206
−5		0.03	−0.369*
−6		0.03	0.145
SUM OF COEFFICIENTS:	0.038	0.053	0.85

* Denotes significance at the 5% level.

Lagged netbacks have a significant effect on the official price while the opposite does not hold. Furthermore future netback lags are insignificant and very small which is what a believer in unidirectional causality would expect. The very small sum of the coefficients indicates that OPEC does respond but not fully (i.e. it is not a dollar–to–dollar response).

Turning next to the relationship between spot crude prices and netbacks, the lagged response of one side to the other is longer for the crisis period

1979–81. A supply side shock, leading to an increase in the spot price, typically causes an immediate increase in product prices in the current month as refiners obviously attempt to pass on the cost increase to consumers. So netbacks respond in the same direction now and up to one month after the crude price change.

From then on the lags become negative. Clearly, as product prices are increased there is a demand response – i.e. decline – which leads to reduced crude purchases hence reduced spot crude prices and in turn product prices and thus netbacks.

For the surplus period 1981–85 the lags are very short. The data on Arabian Light suggest that there is no lagged effect from netbacks to spot crude prices. So a fall in demand translated into product price declines is immediately reflected in reduced crude purchases and thus a declining spot price. In the opposite direction one finds that the one month lagged spot price affects netbacks positively.

5. TRANSFER FUNCTIONS

Having determined the causality directions and explored the lag structures, the next step was to actually model the interrelationships between the series using transfer function models. These models express the output from a system (e.g. the official OPEC price) as a weighted sum of lagged input values (the inputs being the spot crude price and/or netbacks). The weights estimated indicate how the input (or exogenous) series is transferred to or reflected in the output (dependent) series.

These models look very much like the conventional regression models. However, the advantages are that:

(1) The transfer functions are based on the empirical specification of the significant lead/lag effects and not simply on a theory.

(2) The error term itself is modelled according to a Box–Jenkins model. So the autocorrelation of the noise which is typically a serious "problem" in regression analysis is considered here an inherent feature of the data and it is modelled thereby reducing the area of "uncertainty" and enabling more powerful forecasts to be made.

At this stage it was also possible to test whether an assumption made at the filtering stage was valid. When looking at the period 1976–85 as a whole, as mentioned earlier, intervention models were built. Essentially we got rid of that part of the series which was due to the intervention and then tested causality and lag structures working with the residual i.e. filtered series. On the basis of the lags identified between the filtered series. inclusive of the intervention.

The implicit assumption was, therefore, that the 1979–80 events did not have an independent effect on each series individually. Rather we assumed that the effect on the OPEC price came through the spot market. Hence the assumption was made that the lags found between the filtered series are identical to those between the original data. If this is not the case, then the transfer function models will have a very poor fit. In fact it has been found that the transfer functions estimated with the original time series are the same as those with the filtered series. Hence the assumption is valid and the approach of prewhitening via impact assessment models is correct. Table 5 presents a sample of these models.

TABLE 5 TRANSFER FUNCTION MODELS – A SAMPLE, 1976–85

A. ARABIAN LIGHT

1. [Output = Official OPEC price]
   [Input = Spot Crude Oil Price]

$$Y_t = \frac{(w_0 - w_1 B) X_{t-1}}{(1-\delta_1 B)} + \frac{1}{(1-\varphi_1 B)} a_t + \theta_o$$

$w_o = -0.07$ (-0.03) $w_1 = -0.13$ (-0.04) $\delta_1 = 0.89$ (0.03)

$\varphi_1 = 0.96$ (0.02) $\theta_o = 8.17$ (2.24) $Q_{24} = 20$

2. [Output = Rotterdam Netback]
   [Input = Spot Crude Oil Price]

$$Y_t = (w_o - w_1 B - w_2 B^2 - w_3 B^3) X_t + (1 - \theta_1 B - \theta_2 B^2 - \theta_3 B^3 - \theta_4 B^4 - \theta_5 B^5) a_t$$

$w_o = 0.808$ (0.052) $w_1 = -0.117$ (-0.055) $w_2 = -0.099$ (-0.052) $w_3 = 0.084$ (0.049)

$\theta_1 = -0.592$ (-0.093) $\theta_2 = -0.242$ (-0.107) $\theta_3 = -0.135$ (-0.112) $\theta_4 = -0.261$ (-0.112)

$\theta_5 = -0.4$ (-0.097) $Q_{20} = 26$

B. IRANIAN LIGHT

1. [Output = Official OPEC Price]
   [Input = Middle East Netbacks]

$$Y_t = \frac{w_0}{(1-\delta_1 B)} X_{t-1} + \frac{1}{(1-\varphi_1 B)} a_t$$

w_o = 0.105 (0.026) $\quad \sigma_1$ = 0.901 (0.032) $\quad \varphi_1$ = 0.9 (0.03) $\quad Q_{24}$ = 3.4

2. [Output = US Netback]
   [Input = Spot Crude Oil Price]

$$Y_t = (w_o - w_1 B)X_t + \frac{1}{(1-\varphi_1 B)} a_t + \theta_o$$

w_o = 0.724 (0.07) $\quad w_1$ = −0.131 (0.062) $\quad \varphi_1$ = 0.614 (0.084) $\quad \theta_o$ = 3.93 (1.07) $\quad Q_{24}$ = 13

(Table 5 continued)

C. NIGERIAN LIGHT

1. [Output = Official OPEC Price]
   [Input = US Netback]

$$Y_t = \frac{(w_0 - w_1 B - w_2 B^2 - w_3 B^3)}{(1-\delta_1 B)} X_{t-4} + \frac{1}{(1-\varphi_1 B)} a_t + \theta_o$$

w_o = 0.109 (0.053) $\quad w_1$ = 0.105 (0.071) $\quad w_2$ = 0.028 (0.07) $\quad w_3$ = −0.192 (−0.057)

δ_1 = 0.697 (0.106) $\quad \varphi_1$ = 0.95 (0.03) $\quad \theta_o$ = 13.07 (4.09) $\quad Q_{24}$ = 24

2. [Output = Spot Crude Oil Price]
   [Input = Rotterdam Netback]

$$Y_t = (w_o - w_1 B - w_2 B^2 - w_3 B^3)\ X_{t-3} + \frac{1}{(1-\varphi_1 B)} a_t$$

w_o = 0.734 (0.054) $\quad w_1$ = −0.146 (0.06) $\quad w_2$ = 0.056 (0.058) $\quad w_3$ = −0.202 (−0.052)

$\varphi_1 = 0.556$ (0.084) $\quad Q_{24} = 17$

D. KUWAIT CRUDE

1. [Output = Spot Crude Oil Price]
   [Input = Middle East Netback]

$$Y_t = w_o X_{t-1} + \frac{1}{(1-\varphi_1 B)} a_t$$

$w_o = 1.04$ (0.026) $\quad \varphi_1 = 0.67$ (0.09) $\quad Q_{24} = 18$

2. [Output = Rotterdam Netback]
   [Input = Spot Crude Oil Price]

$$Y_t = (w_o - w_1 B) X_t + \frac{1}{(1-\varphi_1 B - \varphi_2 B^2)} a_t$$

$w_o = 0.57$ (0.054) $\quad w_1 = -0.36$ (0.05) $\quad \varphi_1 = 0.62$ (0.10) $\quad \varphi_2 = 0.16$ (0.10) $\quad Q_{23} = 16$

6. EXPECTATIONS

As mentioned earlier, expectations have played an important role in oil price formulation and searching for the mechanism of formulating such expectations has been another aspect of the research.

There are various hypotheses as to the way people form expections but nowadays the dominant is the rational expectations hypothesis (REH). This states that in a competitive world, economic agents will exploit all available information to take advantage of any perceived profit opportunities. The implication is that economic agents do not make systematic mistakes when forecasting the future and that the drive for profit will tend to eliminate any obvious opportunities for abnormal gain.

The basic assumption of REH is that people act as if they knew the exact structure and operation of the market. On a priori grounds we expect that this does not apply to the oil market. The panic and over–reaction of 1979 when it was feared that the OPEC cartel might cause further price increases, when in fact Saudi Arabia was raising its production to the maximum sustainable (10 mbd) in order to compensate for the Iranian loss and prevent any further price escalation, would seem to contradict that assumption, as would the general perception of the OPEC cartel administering price.

Thus we would expect that the market is characterised by inefficiency caused by lack of information and by destabilising speculation. We cannot, therefore assume that the market incorporates all new information in the spot price in a rapid and unbiased manner, hence we expect it to be an inefficient market.

The term efficiency refers to 2 aspects of price adjustment to new information:

(1) The speed and
(2) The quality i.e. the direction and magnitude of the adjustment.

An efficient spot market for crude oil and products would be one where current prices do correctly reflect all information contained in past prices. In an efficient market there are no opportunities for making speculative profits by exploiting information contained in past price changes. Traders are therefore precluded from systematically outperforming an efficient market.

The issue is not whether a skilled speculator can outperform the market. This is certainly possible; the real issue is whether a skilled speculator can outperform the market by virtue of his/her skill or by chance. By casual observation it is impossible to resolve this question as it is impossible to distinguish between chance results and systematic skill. The matter can only be resolved by statistical testing.

If the spot market for crude and products is found to be an efficient market then we would have indirectly confirmed the REH. The efficient market hypothesis – i.e. that price changes are unsystematic – can be examined by a very simple test: regression of today's price change (as a percent) on the price changes of 3 to 4 more periods (days or months) ago should yield insignificant coefficients and no autocorrelation in the error term, if indeed the market is efficient.

This regression has been run using both daily and monthly data from Platt's Oilgram on gasoline and gasoil prices at Rotterdam between 1967 and 1984 and for subperiods. As expected coefficients on past price changes were significant thus confirming that the market is inefficient and hence rejecting REH.

This confirms that expectations are backwards looking i.e. formed by some sort of adaptive mechanism. The problem is to choose a variable that will reflect such adaptive expectations.

A typical approach would be to argue in the Keynesian tradition that there is some "normal" level of oil prices in people's minds towards which they expect actual prices to move. Thus when the current price is above that normal level, people expect it to fall or converge towards it. The reason could be that as price keeps rising people envisage a point at which demand will respond and start declining; eventually, an excess supply situation might be viewed as the factor forcing price to converge to its normal level.

Similarly if current price is below its normal and falling, people think that a continuous fall will at some point act on demand, which will therefore have to start rising. Such demand pressures will cause prices to start rising towards their normal level.

Thus on the convergent hypothesis, expected price is inversely related to the difference between current actual price and some moving average of past prices, intended to capture the notion of the long run normal level. A variable capturing such convergent expectations would be the difference of current price from a long run average of prices (intended to represent the normal level). The coefficient of this variable is expected to be negative.

On the other hand, the argument can be turned just the other way round. On a priori grounds there is no reason why simple trend extrapolation might not be the dominant influence on perceptions. So it would not be surprising if it turned out that a rise in prices leads to expectations of further increases and vice versa. This seems to be have happened recently when there was talk of a $5/bbl price, and it certainly did happen back in 1979–80 – when forecasts of even $100/bbl were made for 1990. Given the "panic" factor, expectations may become extrapolative, at least in the short run.

Therefore, there are 2 candidates for consideration as the expectational variable:

(1) The difference of current price from a long run normal price level.
(2) The difference of current price and very recent prices, corresponding to extrapolative expectations.

Expected price should be inversely related to the first and proportionally related to the second. Clearly the convergent hypothesis is a long run view of the mechanism and it seems plausible to assume that both types will be in operation, though with a different timing. Thus, once a significant change in the price occurs e.g. the recent decline, people expect prices to go on falling for a short period; as time goes by and the price does fall they realise that there is a limit to how far it will fall and at that point expectations become convergent i.e. price is expected to start rising again towards its normal level – which is nothing more than a subjective view of what the oil price "ought to be".

Both expectational variables were constructed and used in the transfer functions, and both were found with the correct sign and improving the fit of the models, although multicollinearity has caused a low significance.

7. CONCLUSION AND PROSPECTS

The natural extension of this research would be the development of a model of the world oil market, describing both the demand and supply sides. The empirically identified transfer functions on prices would then be incorporated within this model enabling simulation and quantitative prediction.

Given the time constraint, this is a suggestion for further research rather than an objective of this study. Nevertheless, we can attempt to gaze into the crystal ball and assess the prospects for the market in qualititative terms.

1986 proved to be the year of the third of price crisis. With Saudi Arabian production shrinking to levels not seen before (around 2.5 mbd in the summer) and the consequent sharp fall in revenues, the role of the saving producer proved very expensive. The conscious decision by the Saudis to abandon that role in favour of increasing their market share by flooding the market led to the oil price collapse. This dramatic development will perhaps prove to be more significant than the two previous crises, as it resulted from cartel action rather than unanticipated political crises and it thus demonstrated clearly that OPEC does have the power.

The functions arrived at in this paper could not predict such a supply side development, as they are essentially demand determined. Nevertheless, the extension of the functions by inclusion of a third "intervention" would easily reflect the price decline.

The market share policy pursued by OPEC proved to be a very costly exercise, with revenues shrinking to politically unacceptable levels. Hence the October and December 1986 agreements to introduce output quotas and return to the fixed price system by abandoning netback deals. The extent to which this development represented a further structural change for the industry depends on OPEC's determination to maintain low output. Certainly the economic and political strain caused by the dramatic revenue losses created enough determination for OPEC members to want to control the market, and as long as the memory of the price fall remains vivid, low output is the only possible policy course.

Following the December 1986 agreement on quotas and fixed prices, changing perceptions caused a price jump from $15 to $18/bbl on average, despite the excessive stockbuild of 1986 – the result of the market share pursuit by OPEC. With the group currently maintaining output at or even below the quota ceiling, a stock draft is well underway. This is bound to cause increased reliance on OPEC oil, with the residual demand for OPEC crude rising substantially in the second half of the year and hence leading to upwards pressure on prices.

The conclusions of this research remain unchanged, namely, that OPEC has essentially been a market follower, exhibiting none of the cartel characteristics up to 1985 when the system started cracking. From now onwards, it may well be the case that OPEC maintains the leader's role.

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