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Spot and Contract Crude-Oil Markets in the Petroleum Industry

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INTRODUCTION

For over half a century, most crude oil was owned by or sold under contract to integrated oil companies. The dominance of integrated companies led to price stability, since it guaranteed markets for oil producers and provided security of supply for refiners.

In the last two decades the oil market has changed markedly. Today most crude oil in the international market is acquired by short-term contract and is often resold. The system of crude-oil pricing conceived by the major oil companies changed in the early 1970s, when OPEC asserted control over pricing and production. From 1974 to 1985 OPEC's official prices set the standard for other oil prices. Since the collapse of the oil market in 1986, however, crude oils traded in futures markets have replaced OPEC's official prices as the most commonly watched price indicators. The crude oil market, once dominated by contracts or outright ownership is now dominated by spot transactions.

The institutional shift in the world oil market is unprecedented. The industry appears to have been "turned on its head." The new structure has many advantages; for example, it offers far greater flexibility. But, the cost of flexibility may be price instability, at least in the short run.

It is interesting to note that, despite the radical shift in institutions, ownership, and control there has always been a spot and contract market for crude oil. The longevity and distinctness of the two types of transactions suggests that they may best be understood as two separate markets. Spot and contract prices are often similar, but almost never identical.

If spot and contract markets are separate, the distinction would not appear to be dependent on institutional arrangements. Since the industry is radically different and there are always two types of independent transactions, there must be deeper reasons for this economic behavior. One possible explanation lies with the lack of homogeneity in crude oil and refinery technology. The crude-oil market is not a simple market; it is complex and the price structure reflects imperfect information and uncertainty.

PRICING IN COMPLEX MARKETS

Many commodities and raw materials have a complex set of characteristics which affect their market value. For example, the price of diamonds depends on cut, clarity, weight, color, and the number and type of flaws. Agricultural products have a broad range of quality characteristics related to size, color, and spoilage factors. Crude oil, too, has a number of quality characteristics which are significant in determining the value of one crude oil as compared to another.

Most markets with complex commodities have a price structure containing quality adjustments, calculated against a "marker" price. The marker price is intended to capture general price movements in the value of the commodity, while the set of adjustments -- discounts or bonuses -- capture quality differentials. The marker in the diamond market is Diamond D, a perfect one carat diamond. In the crude-oil markets today there are two marker prices, West Texas Intermediate (WTI) and Brent; these are used by the New York Mercantile Exchange and London Commodities Market for futures contracting. WTI and Brent have replaced Arab Light as the most widely watched oil prices since the collapse of the crude oil market in 1986.

Markets for complex commodities have another distinguishing feature; they are usually divided into long-term contractual sales and short-term "spot" sales. The distinction between these two types of contractual arrangements are sometimes clear and distinct and other times fuzzy. Generally, the spot market and spot market prices for a commodity are easier to identify and describe than contract markets. Contract markets are, almost by definition, idiosyncratic. Contracts vary with respect to length-of-term, conditions of payment, performance standards, and a whole set of economic variables which impact the agreed upon commodity price. Commercial building rent for the same quality of office, for example, varies enormously depending on a wide array of terms and conditions and particularly the term of the lease.

The crude-oil market has a well established and visible pricing structure for both contract and spot sales. The extent to which these two pricing structures have evolved side-by-side in a clearly defined manner is rare, if not unique.

The principal reasons for the peculiar structure of the crude oil market are the needs for both supply security and flexibility that arise from the physical and chemical properties of crude oil and the technological constraints in refining. Producing petroleum products is a highly capital-intensive business, with large investments by both crude-oil producers and refiners, as well as transporters. Moreover, both the raw materials and the manufacturing processes for refining petroleum products are very heterogeneous. While the heterogeneity of crude oil implies that the available feedstocks are imperfect substitutes, refiners may still be able to use a less desirable crude oil, albeit with less than optimal results. It is this tension caused by imperfect substitution and the tradeoff between security and flexibility, that is the basis for the dual price structure.

IMPERFECT SUBSTITUTION

Crude-Oil Fungibility

Crude oil is fungible -- more or less. It is, however, the "more or less" that is interesting; it defines the degree of substitutability between crude oils and, to a large extent, their relative values.

No two crude oils are identical, but the characteristics are sufficiently similar that most crude oils can be refined by most refiners. The issue usually comes down to "economics;" one type of crude oil (given its quality, location, and price) may be more profitable than another type when run through a particular refinery. Refiners spend a great deal of money on highly specialized linear programs just to determine the optimum combination of crude oils, given their refinery facilities (production function), the expected demand and supply for refined products, the expected value of those refined products, and the cost of the crude oil.

Crude oils can be generally classified by the "field," or sometimes "pools" within a field, from which they are produced. However, some producing regions, such as Texas and most Middle East countries, produce crude oils from a number of fields that are almost identical in quality. In these instances the crude oils can be (and often are) lumped together for pricing. West Texas Sour, for example, is crude oil produced from a number of fields, in several producing districts, which exhibit nearly identical quality characteristics, and refiners typically quote (post) one price for this crude oil under the "generic" name West Texas Sour.

The principal determinants of crude oil quality are its "yield" (the percentage of gasoline, middle distillates, and heavy fuel oil derived from simple distillation) and sulfur content; while carbon, nitrogen, viscosity, etc. play a lesser role. In general, the heavier the crude oil the lower the yield of gasoline and other valuable products and the higher the percentage of sulfur. Thus, "light" crude oils are usually more valuable than "heavy" crude oils.

It is these distinguishing characteristics which determine the degree of substitutability between crude oil feedstocks. A refiner with facilities to run light, sweet crude oil is likely to experience significant capacity constraints if "forced" to run heavier and more sulfurous feedstocks. The more complex the refining facilities, the greater the feedstock flexibility; nevertheless, bottlenecks still may be experienced when "sub-optimal" feedstocks are substituted.

In the world oil market there are less than thirty dominant crude oils. Some of the better known are West Texas Intermediate, West Texas Sour, Alaska North Slope, Arab Light, Iranian Light, Bonny Light, and Brent. As mentioned earlier, the prices of WTI, Brent, and Arab Light are commonly used as marker prices. These crude oils are used as markers because of their volume of production and their generally desirable quality characteristics. In addition to the large-volume crude oils, there is a wide array of lesser-known crude oils produced all over the world. These hydrocarbons range in quality from tar-like heavy oils to light natural gasolines. In California, alone, there are 110 oil fields that are posted separately, and these posted prices reflect, in part,

adjustments for differences in quality and location.

Refinery Diversity

The heterogeneity in the crude oil market is matched by an equally complex refinery industry. Crude oil refining does not have a single dominant technology -- beyond simple distillation; there are many different ways to process crude oil, and they all have individual advantages and disadvantages which depend on the refinery's location, the product slate targeted, and the quality of crude oil available as feedstock.

Most refineries begin with simple atmospheric distillation; crude oil is separated into its basic hydrocarbon components -- gasoline, naphtha, kerosene, diesel, and heavy fuel oil. Some refineries, particularly small ones, stop at the first step. From the point of view of the market as a whole, however, simple distillation is not adequate. The bulk of product demand is for gasoline, diesel, and other light products. Given the average gravity of crude oil feedstocks, atmospheric distillation of most crude oils yields less than fifty percent light fuels.

Thus, it is necessary to upgrade heavy fuel oil (and residuum) into lighter products using catalytic- or hydro-cracking, coking, and similar processes. Refiners also have to deal with sulfur and other contaminants in crude oil which tend to concentrate in the heavy products. These contaminants must be removed because products with high sulfur content tend to be corrosive and to cause environmental problems. As a result, heavy fuel oil is less valuable when it contains a high proportion of sulfur.

A refiner seeking to produce more gasoline or diesel, and/or low sulfur fuel oils, has two choices: 1) the percentage of light, sweet crude oil used as a feedstock can be raised, or 2) investments can be made in the refinery to upgrade heavy fuel oil into lighter products, and/or reduce sulfur content. The optimum, or profit maximizing, choice depends on current and expected relative prices of heavy and light crude oil, the expected availability of specific-quality feedstocks, current and expected product prices, and the amortized cost of the proposed investment. In other words, refiners face a capital budgeting decision with both input and output value uncertainty. These uncertainties, combined with the financial strength of the individual refiners, lead to a range of complexity in refining facilities, even among the highly integrated majors.

Incentives for a Contract Market or Vertical Integration

Refineries are usually most profitable when they run the crude oils for which they were designed. General statements of this nature are bound to be pommelled with countless exceptions, but the crude-oil pricing structure can best be understood by beginning with just such a statement. Refiners talk about "security of supply," but they almost never run out of crude oil. What they mean by security of supply is access to a crude-oil feedstock at prices that allow them to make at least a normal margin of profit; in other words, they desire security of feedstock which does not vary significantly from the facility's optimal blend.

Refineries can operate in the red for a large number of reasons, but there

are primarily two with respect to the pricing and availability of crude oil. Occasionally petroleum product prices fall without a corresponding decrease in crude-oil prices. This was the market condition in 1983, when OPEC was forced to reduce official prices by \$5 per barrel. Other times, the price of particular crude oils will rise relative to other crude-oil prices, and this may adversely impact the refinery or refineries dependent on that quality of crude oil. During the British coal strike in 1984 and early 1985 heavy crude-oil prices rose relative to light crude-oil prices, and this reduced the profitability of sophisticated refineries.

Refinery profit margins are notoriously unstable. Profits are erratic principally because the differential between crude oil prices and petroleum product prices is unpredictable, particularly with respect to spot prices. Unstable profits are not, however, unique to crude-oil refining, and this market phenomenon, by itself, does not explain the structure of oil pricing.

Typically, refiners have made a number of investments that allow them to run crude oils with particular quality characteristics. Shortages in the availability of the desired crude oils can negatively impact the refiner's profit margin. For example, refineries designed for heavy, low-sulfur crude oils may not be able to efficiently switch to high-sulfur crude oil alternatives. They could run light crude oils, but these crudes are more expensive and some of the refiners upgrading capacity would be underutilized. Crude-oil producers also make investments in order to market their crude oil. They may have to invest in pipelines, tankers, and other facilities for delivering the oil. The key point is that the refiners and/or the producers often make specific investments that link buyer and seller but do not, by themselves, reduce risk.

In an attempt to reduce opportunistic behavior and associated risks, buyers and sellers that are linked together by specialized investments will either tighten contractual arrangements or integrate vertically¹. In their article on contracts and integration, Klein, Crawford, and Alchain use the example of a specialized printing press, designed to print exclusively for a single buyer. Very tight contracts or integration are required for mutually successful operation of buyer and seller, because, without it both parties may be tempted into price gouging; or what amounts to the same thing, they could be exposed to excessive uncertainty about price or volume.

These same incentives are clearly at play in the oil industry.

The Desirability of Flexibility

Refiners want assured supply, but they simultaneously desire some degree of flexibility. The printing press example is not completely analogous, because the press has no other use; flexibility is not an issue. Refineries do not want to contract for 100 percent of their capacity, because they may experience temporary equipment failure or petroleum product prices may change in unexpected ways.

Typically a refiner contracts or owns only a portion of its feedstock requirements. Remaining supplies are purchased on a spot basis. If, for example, gasoline prices go up, the refiner can shop around for light crude oil and increase its output of gasoline and light fuels. If heavy fuel oil prices

increase, the refiner can make its feedstock blend heavier by buying heavy crude oils. If there is a refinery accident, spot purchases could be terminated.

It is in this light that the spot market for crude oil has been described as a "balance wheel"². It is just this type of flexibility that gives refiners the opportunity to exploit unexpected, short-term changes in market conditions.

SEPARATE MARKETS

Spot and contract crude-oil sales are best understood as two markets, although the distinction is peculiar. It is peculiar, because physically identical commodities are traded in the two markets, often by the same buyers and sellers. It is easy to understand that the housing market in Seattle, Washington, is separate from the housing market in San Francisco, California; the commodity is not exactly mobile. Immobility is not the reason that spot and contract crude-oil markets are separate (the cargoes may often pass each other in the same harbor). Although crude oil sold spot may be physically identical and sold in the same place as that sold by contract, other terms and conditions of sale can be radically different.

Spot sales are, as the name implies, sales made on the spot. They are usually for a single cargo and an immediate cash payment. Buyer and seller need have no long-term relationship. Contract sales are more complex. In the United States and Canada contract sales are normally made using "posted prices."

Posted prices are usually prices posted by refiners or shippers, i.e., the buyer. These prices are an offer to buy crude oil in the field (or at specified delivery points) by the poster. The offer does not commit the poster to buy crude oil, only to negotiate in good faith. Crude oil is actually sold vis-a-vis long-term contracts. Many of these contracts have specific provisions related to the construction, ownership, and operation of gathering lines and other facilities required to move the crude oil. Payment terms are almost always standardized; the buyer must pay for all crude oil on the 20th day of the month following shipment. Because this amounts to a great deal of money, the seller usually requires that the buyer provide a letter of credit, bond, or reciprocal sale of crude oil. Oddly, the prices used in many long-term contracts are not those posted by the buyer. This phenomenon occurs because the seller usually wants the highest price posted or, at least, an average of prices posted by the buyer's competitors.

The arrangements for contract sales in the world oil market are similar to those in the United States and Canada but with several important differences. First and foremost, the exporting country, or seller, sets the price. Secondly, there is normally only one "official" price for each crude oil. Thirdly, credit conditions are not standardized and tend to vary with the market; a tight crude-oil market results in earlier payments and a soft market results in relaxed credit.

However, the dual nature of the crude oil market appears to hold for significant time periods for both internationally traded and U.S. domestic crude oils. Using the approach developed by Stigler and Sherwin³, spot and contract markets do indeed appear to constitute separate, distinct markets for identical

commodities.

Their test for defining markets is based upon the degree of correlation between price movements. Figure 1 shows the changes in the contract and spot prices for Arab Light from January 1978 to December 1984. The graph plots the first differences of the two price series. The correlation coefficient for these two series is 0.0054.

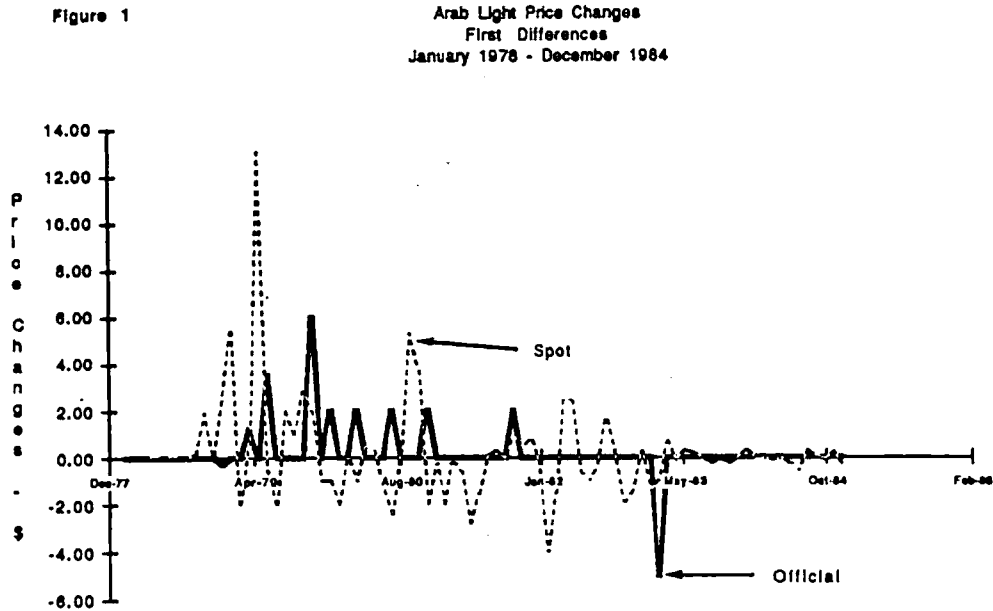


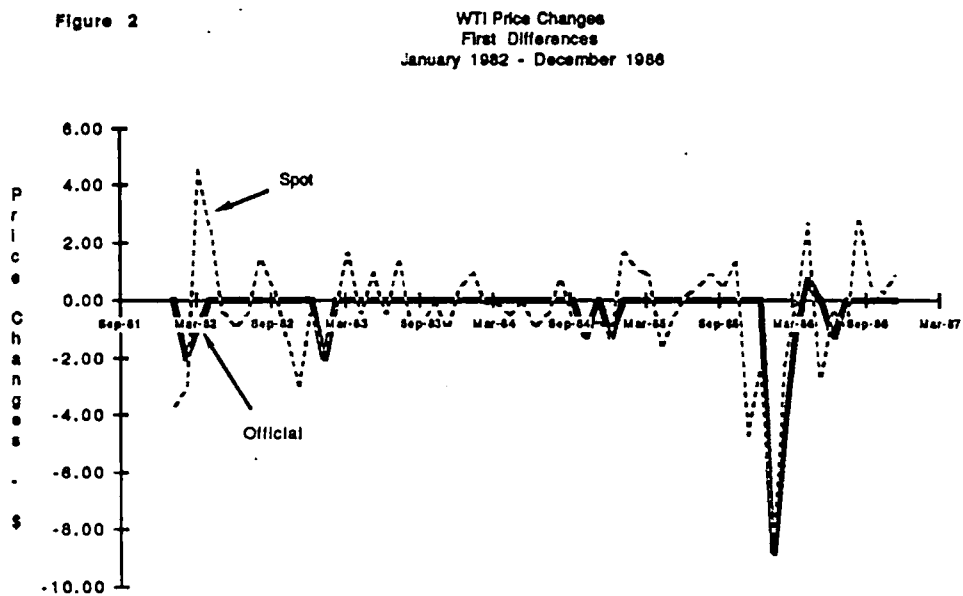
Figure 2 shows the changes in contract and spot prices for West Texas Intermediate from January 1982 to December 1986. The correlation coefficient for the first differences of these two series is 0.5738; the correlation is only 0.1781 for the period January 1982 to December 1984. While the relationship between WTI contract and spot prices is stronger than that for Arab Light, it is still weak enough to suggest the existence of two distinct markets.

The existence of separate markets for contract and spot crude oil is necessary to reduce risk. Refiners who are not fully integrated usually want to retain a degree of flexibility, yet they also desire some degree of insulation from market uncertainty. This suggests that their choice of the ratio of contract purchases to spot purchases is essentially a portfolio decision. Reduction of risk through diversification is accomplished by investing in, or in this case by purchasing from, markets which are not closely correlated.

The preceding analysis suggests that spot and contract markets are separate, but it does not indicate whether spot prices tend to be above or below contract prices. Generally, however, spot oil prices tend to be slightly below posted prices, although spot prices are leading indicators. When the oil market is poised for a price run-up, spot prices rise relative to postings. Likewise, in

the period preceding a price collapse spot oil prices drop well below posted prices.

Although spot prices tend to be below posted prices, this is not a universal rule. Whether they are above or below, depends mainly on who bears the risk. If the majority of the risk is borne by the refiner, spot prices will tend to be below contract prices, and vice versa if the producer bears the risk. In the mid-continent market, where crude oil is quite homogeneous and refineries are quite diverse, spot crude oil prices tend to be below postings. In California, where indigenous crude oil is very diverse and refineries are more sophisticated and homogeneous, spot prices tend to be above crude-oil postings.



CONCLUSION

The shift of oil pricing and production control from oil companies to OPEC and finally to the crude-oil futures markets is viewed by some as a permanent transition representing a transformation of the oil industry. The transformation which shifted the volume of oil allocated between the contract and spot market, on the other hand, does not appear to have disturbed the basic independence of the two markets. This suggests that the economic forces that shaped the oil industry are still at play. Events of the last two decades may not be a permanent transition, but instead could be a simple swing of the pendulum.

The price instability which is inherent in a spot-price dominated market could provoke another change -- a change that reintegrates the industry and reestablishes the dominance of the contract market.

FOOTNOTES

¹Benjamin Klein, Robert G. Crawford, and Armen A. Alchain, "Vertical Integration, Appropriable Rents and the Competitive Contract Process", *The Journal of Law and Economics*, October 1978.

²General Accounting Office, "The United States Exerts Limited Influence on the International Crude Oil Spot Market," August, 1980.

³George J. Stigler and Robert A. Sherwin, "The Extent of the Market," *The Journal of Law and Economics*, October 1985.