Course No. 101: Oil Market Basics

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Today's talk won't be about current oil markets, but about how oil markets work. I hope to give you some insight into what's behind the headlines, and perhaps more importantly, I hope to convey a sense of how dynamic oil markets are. The oil market is global, and communicates via price. There are constant signals resonating among different segments of the market and different regions, and those signals get supply and demand responses. This organic interaction thus brings an automatic corrective mechanism for imbalances.

Most of the time, the self-correction is seamless, and thus unnoticed outside of the industry. During times of severe imbalance, however, the adjustment process may include sharp price swings as the market's gyroscope rights itself. These price moves, attention-getting though they may be, are an essential part of the market's operation. Any interference with the price signal will also dampen the supply/demand response, ultimately undermining the market's efficiency.
The first series of charts takes a snapshot of regional patterns of world supply and demand for 1995. For each of the maps, "North America" includes Canada, the US and Mexico, the signatories to the North American Free Trade Agreement.

The first world map illustrates the dominance of the Middle East in oil reserves -- oil that has been discovered and is judged producible with current technology and economics. The region accounts for about 2/3 of the one trillion barrels of proved oil reserves. The richness of Middle Eastern reserves was an important motivator during the Cold War, when each side courted the region's favor and resisted its opponent's overtures in the area.

Oil reserves reflect geology, technology and economics. They are dynamic and change over time, as oil is withdrawn through production or added through exploration and development. Technological advances may increase proved reserves in hard-to-produce reservoirs without any drilling, but more commonly make it possible to produce oil (and thus prove oil reserves) at lower prices. Sharp and lasting changes in prices will also change a reasonable judgment of the amount of producible oil.

US reserves are quite low, accounting for 30 million barrels or just 3% of the world total. Is that a problem? No, because oil is traded in a global market. The owners of oil have an interest in selling it to users of oil. Even an extreme, expensive program to develop US resources will not change the geology. While low US production is not per se a problem, we should seek always to develop the most diverse sources of oil, including those in the US, to reduce the world market's dependence on any one supply region.
The US is the most densely explored oil region in the world, and one of the oldest producing regions. Unique to America is the private ownership of mineral rights. Landowners control -- broadly speaking at least -- the efforts to develop oil and other natural resources on their property, and participate in the economic benefit through a system of royalties. (Of course, landowners now face much stiffer regulation of their choices, especially environmental standards, than they once did.) In other countries, the government owns and controls development of natural resources. (Both state and federal governments are important landholders in the US as well, including offshore areas.) The critical benefit of home-grown production is regional: the spill-over activity and tax revenues are essential economic drivers in producing areas.

The US, at 8.3 million b/d, remains a major producing area, second only to Saudi Arabia (8.9), and about one million b/d higher than the Former Soviet Union.

This chart again illustrates the importance of the Middle East in oil supply, providing about 30% of the world’s total. Production from the Middle East would be higher if Iraq were fully re-integrated into world oil markets, and if the major producers of the Middle East used all of their productive capacity. Instead, they limit the free flow of their production under OPEC’s quota system.
✓ Contrast the picture of production with this picture of oil consumption. The US is by far the largest oil user, at about 17 million barrels per day. The next largest single country consumer is Japan, at less than 6 million barrels per day. None of the European countries individually approaches Japan's market, but taken all together, a reasonable aggregation in light of Europe's integrated infrastructure and markets, Europe uses about 15 million barrels per day.
The US has a special affinity for oil as a transportation fuel, an outgrowth of its vast spaces and suburban sprawl. Almost two-thirds of oil use in the United States is attributable to transportation, either in passenger cars, as with gasoline and some diesel, or moving people and goods, as with jet fuel and diesel trucks, trains and buses. The small arrows in the center of the circle reflect the split between transportation and other uses of oil, such as heating, electric generation or industrial production. (Middle distillates include some products that are used for transportation, such as jet fuel and diesel, and some that are used for heat and power such as heating oil in the US or its twin, gasoil, in international markets.)

For most of the rest of the world, the shares flip-flop: Almost two-thirds of the oil use goes to heating and power, leaving transportation’s share at less than 40%.

The importance of oil as a heating fuel in most of the world sets up a contrast in the seasonal consumption patterns. Worldwide, we use more oil in the cold months than in the warm months. The swing is about 4 million barrels per day more in the highest demand quarter, the fourth, than in the lowest demand quarter, the second. Therefore, prices tend to be strongest in the Autumn and weakest in the Spring. The US consumption and refinery operation pattern, however, is the opposite --higher in the warm months -- because of the increased use of gasoline during the driving season.
✓ Remembering the regional disparity between production and consumption sets us up to look at trade. Obviously, the high consuming regions such as North America, Europe and Asia are net importers, while the high production regions are exporters. Again, note the dominance of the Middle East as an exporter.

✓ The treatment of North America/NAFTA as one region changes the net import dependency markedly. Mexico and Canada are the two biggest suppliers to the United States, as we'll show in a few slides.
Logistics Dictate World Oil Trade

Each arrow equals 1 Mn. B/D

Excludes intra-regional trade and movements less than 0.5 Mn. B/D

✓ Generally, logistics drive the economics of moving oil, and thus world trade patterns. On this chart, each arrow represents inter-regional trade of one million barrels per day. The interdependency between the Middle East and Asia is founded on the fact that the voyage time is about 21 days, while Nigeria is 36 days from Japan. Meanwhile, the voyage from the Middle East to the US Gulf Coast is 42 days. Venezuela is 38 days from the refining centers of Singapore, but less than a week away from the US Gulf Coast.

✓ The only inter-regional pipeline movements represented on this chart are from the Former Soviet Union to Europe. Everything else shown on the map moves by tanker. (Not shown are Canada’s pipeline supplies to the US, an intra-regional move.)

✓ Again, the logistics drive the economics. Different tanker types are routinely used on different voyages. The long-haul trips out of the Middle East are perfectly suited to the Very Large Crude Carriers (VLCC’s) brought into service after the Suez Crisis in 1957. Avoiding the Suez meant longer voyages, but did away with the Suez size constraint, allowing shippers to take advantage of the economies of scale offered by these high capacity vessels. VLCC’s can comfortably unload at the important ports throughout Asia, but are far too large for US ports. Ships out of the Caribbean, or out of West Africa, in contrast, are routinely smaller, and do not encounter depth constraints in the US.
✓ Up to now, everything has been just a snapshot of oil supply and demand. The next few charts, in contrast, look at trends over time. Before we get to trends in production, however, I want to provide some background on OPEC, because the role of OPEC is crucial. We hear about OPEC -- the Organization of Petroleum Exporting Countries -- every time it meets. We also hear conflicting theories about its vital signs and whether it is being kept alive only by machines.

✓ Five countries established OPEC in 1960, to assert control over their natural resources. Note that OPEC is not synonymous with the Middle East or with Arab countries. Venezuela was a founding member, and OPEC's current membership of eleven countries now includes Indonesia as well as nations in Africa.

✓ OPEC really burst into the headlines in October 1973 when it unilaterally set prices for the first time, rather than by negotiation with the Western producing companies. At the same time, the Arab-Israeli War triggered the ARAB oil embargo, enforced with systematic production cutbacks -- a game of musical chairs in the oil market, where one chair is removed from the floor after each round.

✓ Prices soared, and along with them, the perception that OPEC was omnipotent and consumers were impotent. The perception has proven very wrong, to the benefit of consumers and the hard-learned lessons of producers.

✓ While there's more to the OPEC story, we'll come back to several times throughout my talk.
Oil Price Path:
Bumpy, Soon Downward Again

$barrel, ann. avg.

(11 mos.)

Refiners' Crude
Oil Cost

OPEC Vol.
Control

Non-OPEC
Pressure

Gulf
War

Tiger by
the Tail

Iran
Rev
++

Not alone,
say Saudis

Price Outlook
Cycle

Prices are as paid, unadjusted for inflation

✓ How successful has OPEC been? The Iranian Revolution and historic stock building allowed OPEC to increase prices in the late 1970's to $35/barrel (even higher for some transactions). The market reasserted itself in the early 1980's, with prices sliding until 1985. They plummeted in early 1986 when Saudi Arabia, until that time the sole arbiter of market volumes, said, "No more!" Saudi production had fallen to 2.5 million barrels per day. The price drop, from $26 at the beginning of the year to about $11 by mid-year, caught everyone's attention. It was the one time since OPEC asserted control over prices that oil prices approached their natural low point -- the cost of production. By this basic standard, OPEC's efforts in the past decades have been a success.

✓ OPEC came together to control volumes in the second half of 1986. Prices stabilized at a new lower level. Except for a brief time during the Gulf War, prices have never reached the old peak level, even in nominal terms. The low prices, however, also steeled the will of non-OPEC producers. With the advent of computer chips and computing power came impressive technological advances that have allowed producers to find and produce oil at lower and lower prices. Price pressure in the first half of the 1990's was generally downward.

✓ 1996's market has been a recurring cycle, with expectations of lower prices actually leading to higher prices. With the tease of Iraq's re-entry into markets always on the horizon, prices looked as though they would be lower in the future, discouraging stockpiling, but ironically, requiring the payment of premiums to get supplies of physical oil when purchasers could no longer hold out.
On this chart, I've specified the five most important producers (combining the North Sea), and divided the chart into OPEC and non-OPEC.

The price chart sets the stage for this graph of production trends. The high prices in the early 1980's reduced consumption, while non-OPEC producers had an awesome incentive to increase production. OPEC production fell, but it was Saudi Arabia that was left holding the bag, as pointed out previously.

The lower prices after 1986 brought room for volume growth, for OPEC and non-OPEC alike. The collapse of the Soviet Union resulted in a collapse in its production. The economy was a shambles, so demand plummeted. In addition, the production associations no longer had to meet the hard currency goals of Moscow, and their overworked fields could no longer be pushed to sustain volumes. Thus, while the non-OPEC total flattens out, the decline in Soviet production is largely responsible.

North Sea production has been a technological success story, with new fields brought on stream at lower and lower costs. North Sea production had been expected to peak in the early 1980's, and instead, we haven't seen the peak yet.

The US Gulf Coast is using the same deepwater technology in a new production boom. For the first time in more than a decade, US production will show increases in the coming years because of increased output from the Gulf Coast OCS.
Obviously, production and consumption follow the same patterns. For consumption, the logical split is between the OECD -- Organization for Economic Cooperation and Development, or the so-called "industrialized" countries -- and non-OECD nations.

A particularly interesting aspect of this slide is the demand growth in the populous and burgeoning Far East. "Non-OECD Asia" includes the giant China as well as newly industrialized countries such as Korea. Asia has been a key driver in world oil markets during the 1990's.

Again, note the Former Soviet Union. The communist collapse was accompanied by declining oil use, flattening the overall worldwide demand trend.
The next few slides focus on supply and demand patterns in the US.

As I pointed out, geography often dictates the best trading partners. Our closest neighbors are our most important sources of imported oil. More than half of our imported supplies come from areas that are less than one week away. Most of our supplies from Canada are a continuous pipeline stream.

The so-called Atlantic Basin -- West Africa and Europe -- provides more than one-quarter of our imports. Thus, almost 80% of our supplies come from so-called short-haul sources: close by and responsive, and a natural adjunct to lower inventory levels.

US dependence on the Middle East -- a long haul source -- is quite low. It is useful to bear in mind, however, that US reliance on one area versus another doesn't change price responses during a disruption in supplies. The importance of an export region in world supplies will determine the market's response to regional interruptions.
As shown in this slide, US regional balances are a kind of microcosm of global markets: we've got net "importers" short of supply and net "exporters" who refine more than they use.

The largest consuming areas are the East Coast and Midwest, while the largest supplier is the Gulf Coast.

The East Coast gets the largest share of its refined product supply from the Gulf Coast, but also imports crude oil and refined product directly.
Refineries turn crude oil into usable products, and the trick is to turn it into the highest value products with the greatest demand, such as gasoline.

Refineries, first, are stills, like a still to produce corn liquor. Crude oil is heated, and different hydrocarbons boil off at different temperatures. The vapors are captured and condensed. First to boil off are the light ends -- naphthas and gasoline components, then distillates like jet fuel, heating oil and diesel, and finally there remains a residue, a heavy, viscous substance that sells for less than the cost of crude oil. The sulfur hasn't boiled off, so it's concentrated in the residuum. So are the metals.

Refining technology and economics focus on getting more light ends and less residuum, by using heavier distillates and the residuum as feedstocks in additional process units.

As shown above, the natural characteristics of Arab Light crude oil will result in a residue of 45% and light ends of less than 20% when it is processed in a simple distillation column. A somewhat more sophisticated refinery such as those in Northwest Europe might lower the residuum to about 33% and increase the light ends to 30%. The most sophisticated refineries will process and re-process until the result is a 60% output of light ends, middle distillate output of about 30% and residual fuel oil output of 6% (the remaining output is coke).
While this chart looks complicated, if you follow it slowly you'll see how the refining process works. The thick lines are color-coded to represent the major product streams; feedstock lines are dotted; minor product lines are thin.

First, at the left, is the Crude Oil Distillation Unit -- the still -- and products boiling off, with the lightest products at the top.

Note how many processes feed the gasoline stream:
- The Light and Heavy Naphtha stream from Crude Distillation;
- Naphtha to the Refomer, back to Gasoline;
- Gasoil to the Cracker (either catalytic or thermal) to make more gasoline (and heating oil/diesel);
- Residuum to the Vacuum Distillation Unit, and then to the Cracker (more gasoline and heating oil/diesel);
- Output from the Vacuum Distillation Unit to a Coker to make more gasoline directly or to feed the Cracker (more gasoline and heating oil/diesel).

The purpose of the sophisticated processing units is clear: make more gasoline!
Different crude oils have different physical characteristics. They contain different amounts of the hydrocarbons that become petroleum products during the refining process. We assess a crude oil's value, in part, based on the ease with which it can be refined into the mix of products the market demands.

We've already looked at Arab Light, which has a relatively high share of low-value residue and a low share of high-value light ends. Compare Arab Light to the US "benchmark," the high quality West Texas Intermediate crude oil. The high naphtha yield from WTI makes it an ideal crude for making gasoline. Contrast these with Nigerian Bonny Light, an excellent crude oil for making middle distillates such as jet fuel, heating oil and diesel fuel.
The oil market communicates via price, in a kind of auction, or bid-and-ask system. Participants in the oil market have many sources of information, including a personal view of a tolerable price, published prices in trade publications, or even daily newspapers such as The Wall Street Journal or The Journal of Commerce, electronic information services (Reuters, Dow Jones/Telerate, Bloomberg) and futures prices (available, for instance, on the Internet, and published each day on commodity's pages across the country). Thus, even a consumer has access to a variety of sources of information to help assess the reasonableness of an offered price in the highly competitive oil market.

A seller may offer oil to a buyer at a price. But the buyer may have another source that will sell at a lower price. The seller must meet the lower price or keep shopping to place his volumes. Both the seller and the buyer can quickly determine whether the other is reasonable in assessing the alternatives -- a few phone calls, a check of the Internet.

The market also constantly resonates with information between market segments -- producers and refiners, refiners and marketers, marketers and consumers.
The oil market is global. At the same time different segments of the market are communicating via the bid-and-ask auction, different regions are also vying for supply, providing opportunity for arbitrage, or profitable trade among regions based on different regional prices.

The major producing and refining regions become the centers of the global auction. The US Gulf Coast, with its huge refining capacity and indigenous production, is both a crude oil and a product pricing center. Northwest Europe, with refining and storage in Amsterdam, Rotterdam and Antwerp, as well as North Sea crudes, is also a pricing center for both crude oil and product. The Middle East, source of so much crude oil, is a crucial crude oil pricing center. The US East Coast is designated a product pricing center because it is a distribution and consuming center; refining areas such as Singapore and the Mediterranean are also product pricing centers.

We saw a recent example of regional interaction in pricing, when Europe's low heating oil inventories and move to low sulfur diesel fuel pushed up prices there, beckoning supplies from all over the world. US Gulf Coast supplies responded, as did other areas. Again, the higher regional price is a signal, a request for additional supply. Soaring prices are analogous to shouting for supply. And the shout gets a prompt response, satisfying the need, and quieting the call.
Buying and Selling Oil

• **SPOT TRANSACTIONS**
  - One-time
  - Fixed price or Futures +/-
  - Market maker

• **TERM CONTRACTS**
  - Based on Market-based indicator +/- "Adjustment":
  - Marker crude; or Avg.; or Basket; or Futures +/-
  - Quality / quality differentials; location differentials
  - Credit terms

✓ Decades ago, a contract not only assured supply, it also fixed a price, usually with a relatively infrequent re-opening schedule. Spot transactions, the one-time agreement between buyer and seller, represented a small share of the volume, and while they were made at market-clearing prices, they were sometimes significantly above or below contract prices, depending on the market.

✓ At the same time that markets were weakening in the early 1980's as a reaction to the unsustainably high prices of 1979-81, they were also becoming more transparent. More, better, faster price information, combined with ready supply, emboldened buyers to move away from contracts and toward a greater reliance on spot markets for routine supply.

✓ We now have a kind of hybrid system. Contracts are again important, but their pricing clause is usually based on a market-based indicator. For crude oil, the market-based indicator might be the published spot price of a marker such as WTI or Brent Blend, or an average of several crude's spot prices. For product, the indicator might be a published spot price in a given market: New York Harbor, for instance. The price for the next month's futures contract might also serve as a base. Thus, spot prices move quickly through all segments of the industry. Contracts would also usually include an adjustment to account for lower or higher quality, or location differentials. Finally, credit terms also affect the final price of contract supplies.
The most important component of petroleum product prices is crude oil. As shown above, the retail price for gasoline (excluding tax) and for heating oil -- two highly visible examples -- have followed crude's path closely. (The crude oil price shown is the same as the one shown earlier. None of these prices is adjusted for inflation.) In the short-term we sometimes see more independence in product prices, but in the longer term, the tie to crude oil is clear.

It is interesting to note that the relationship between average unleaded retail gasoline prices and crude oil has been broadly unchanged during the early 1990's, even in the face of environmental mandates that have increased the cost of refining, distributing and storing new discrete products. Thus, refineries and marketers have had to absorb these costs, reducing their profitability.
Recent increases in product prices have been headline-grabbers. Looking at product price increases alone, however, tells only part of the story. As shown, crude oil constitutes about two-thirds of the current pre-tax price of gasoline at the pump. For heating oil, crude oil currently accounts for about 50% of the retail price. Thus, movements in world crude oil markets cannot be ignored in assessing product markets.

Policymakers and others point to low petroleum product inventories and imagine that they are the cause of oil price increases at the consumer level. In fact, the increases in crude oil prices, up some 15-16 cents over year-ago levels, account for about 80% of the total year-on-year increases in the retail prices for gasoline and heating oil.
Further Reading

- Petroleum: An Energy Profile, Energy Information Administration, DOE/EIA-0545 (91). Oil basics from reservoir to gasoline tank. (Free)
- International Crude Oil Market Handbook, Petroleum Intelligence Weekly. How the market works, crude oil quality, price formation, price formulas. ($$$, from PIW in New York)

✔️ In the time allotted, we obviously cannot talk about every aspect of oil markets. Each of the topics I mentioned could get a fuller treatment, and there are some I didn’t even touch, such as the vast distribution infrastructure to get products from refiners to consumers. My aim, however, was to provide the survey or overview course in oil markets. Those who are interested can explore further.

✔️ In summary, geology has distributed oil resources around the world, often in areas that are sparsely populated, hostile environments. In contrast, oil is used in industrialized, or industrializing, populous regions. The regional supply and demand mismatch has encouraged the development of a truly global market in oil, by now mature. The market moves volumes from supply-long to supply-short areas. Prices are the signals that call forth supply and dictate oil flow, correcting regional imbalances. As electronic communication and commodity futures markets have matured, prices have become more and more transparent -- readily knowable by all. Thus, the global oil market has become increasingly competitive, responsive, and finally, increasingly efficient.