Structure Matters:
Oil Markets Enter the Adelman Era

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The 2014/2015 oil price collapse surprised the many economists who have published brilliant econometric explanations of oil price behavior. The sharp decline would not have caught Morris Adelman unawares. Professor Adelman's lifelong research focused on the link between market structure and price behavior. His seminal work on industry structure, beginning with grocery retailer A&P, has provided a framework that can be used to explain oil price fluctuations that have occurred over the past four decades. His approach may not be as accurate as the elegant econometric models that dominate today's literature but it does have one clear advantage: it provides far greater clarity on the way forward.

Professor Adelman would have been aware of the very complicated, brilliant attempts to model oil market behavior by Hamilton, Kilian, and others. Some of us who knew him can well imagine him remarking that such efforts are excellent and exquisite and worthy of academic recognition but useless for policymaking, planning, or predicting. At the same time, he would likely have recognized that economic practice had long since moved beyond his research approach. Today, central banks and international organizations regularly rely on elaborate, relatively rigid modeling approaches to project oil prices, often with disastrous results. To their credit, International Monetary Fund researchers Beidas-Strom and Buitron (2015) make a valiant but ultimately futile effort to explain why modern econometric models failed so badly at the end of 2014 (pp. 36-38). After examining various econometric analysis techniques in detail, they conclude

simply that "demand and supply factors played a role in the oil price collapse of 2014." The authors do not, however, mention Saudi Arabia anywhere in their paper.

Professor Adelman would have had a different explanation for the 2014 decline. The phrase "economic expectations of Saudi Arabian leaders" would have been part of it. He also would have described how the Saudis' perception of the global energy market's changing structure prompted them to act as they have. He most likely would have shunned statistical methods entirely. Consequently, his analysis probably would have received little traction among the major central banks or multinational organizations such as the IMF, where econometric models are now the "WORD." As Wolf (2014) puts it, economists such as Adelman and Kindleberger "were far below the salt where the princes of academic economics sat" (p. 195). Wolf writes of macroeconomists such as Bernanke who relied on dynamic computable general equilibrium models to project the path of economic growth. He adds that these models failed to predict the 2008/2009 economic collapse. Yet, despite such deficiencies, academics, central banks, and influential global organizations such as the IMF continue to use the techniques.

Indeed, oil market analysis is also dominated by the "princes of academic economics" and their elegant econometric models. The literature is full of complicated explanations for the present oil price collapse. These studies have attempted to modify existing models to account for current events and failed. In my view, the academic economists might do better if they step away from their computers and take a close look at the importance of market structure and the actions and motives of market participants.

The organization of this paper is simple. I first discuss Professor Adelman's "structural approach" to economic problems, beginning with his writing on the Great Atlantic & Pacific Com-

pany (A&P). That work focuses on the economic structure of retail grocery marketing. I then note that many of his writings on oil markets followed the global oil industry's evolution from oligopoly to cartel to quasi-competitive markets, then back to a cartel, and finally to a competitive structure where producers with the lowest costs produce at maximum rates. The market's path forward today may be shaped by impending limits on fossil fuel use, limits dictated not by markets but by governments. Adelman seems to have anticipated this "final" outcome in his work.

Why Structure Matters

Hamilton (2014) published a paper on the world oil market structure just nine months ago that concluded "hundred-dollar oil is here to stay." Ironically, the prevailing crude oil price fell below $50 per barrel within weeks of its publication. Hamilton reached his conclusion by concentrating on five factors he considers to be the exclusive determinants of oil prices:

- Economic growth in emerging economies
- Increased production of low-quality hydrocarbons
- Stagnation of crude output
- Geopolitical disturbances holding back investments
- Resource limitations

What did Hamilton and the many other economists (such as the IMF forecasters) who espoused the "hundred dollar" view fail to see? Ironically, Professor Adelman could have answered this question because he made a similar forecasting error following the 1973 oil shock:

> In March 1971, I said, "the genie is out of the bottle. The oil producing countries had a great success using the weapon of a threatened concerted stoppage and they cannot be expected to put it away." [NYT 3-29-71:49] A year later: "I would expect prices to describe a parabola in the 1970s—first rising, then falling" [NYT 4-10-72:53]. The parabola took much longer than I expected. The world price of oil, inflation-adjusted, rose to fourteen times the 1970 level, then declined by 1993 to somewhat lower three times. (1995, p. xxi)

Hamilton and Adelman's errors differ in one fundamental way. Hamilton did not allow for a change in market structure in preparing his 2014 paper or in any of his earlier studies. Adelman, on the other hand, saw the price rise following the 1973 embargo as resulting from a change in structure, a shift he expected would be reversed quickly. His forecast, as he humbly admitted, was wrong.

Industry Structure and Market Prices

Industry structure affects how prices are determined in a market. Adelman recognized this from the start of his career. His thesis on the A&P antitrust suit is a classic study of how structure affects market prices. Indeed, his analysis was awarded the Wells Prize by Harvard's Economics Department, an honor bestowed on the best thesis each year. Other winners include Nobel Laureates Paul Samuelson, Robert M. Solow, and Michael Spence.

Adelman's 1959 study examines the antitrust suit brought against A&P by the US Justice Department. The case has been described by Levinson (2011) as the climax of "decades of effort to cripple chain stores in order to protect mom-and-pop retailers and the companies that supplied them." A&P was the largest retailer in the world at the time of the suit. The issue being argued

reflected competing visions of society: one favored corporate efficiency, the other autonomous farmers, craftsmen, and merchants. It is a debate that continues today.

A&P had been attacked by antitrust regulators for its size. The company was the first to introduce the supermarket model. Because of its integrated structure, which included bakeries, large warehouses, and manufacturing plants, A&P could achieve lower costs than any competitor. Adelman showed that the firm's aggressive approach and unified structure allowed it to achieve an expense rate for sales that was one third lower than that of any other store (1959, p. 98). The company passed its cost savings on to consumers, seeking a twenty-five percent share of any market in which it competed.

A&P's efforts to build market share and pass benefits to consumers were frustrated, though, by antitrust officials. The Justice Department

> …complained that A&P had an unfair competitive advantage because its vertical integration, including manufacturing, warehousing, and retailing, allowed it to charge lower prices. Prosecutors also complained that A&P refused to buy from food companies that insisted on selling through brokers or refused to give A&P advertising allowances.[1]

The Justice Department filed its suit against A&P during the Franklin Delano Roosevelt administration, a time when large companies were not favored by politicians. The government prevailed and the company was ordered to sell its manufacturing divisions. President Eisenhower reversed the ruling. By that time, though, other companies had caught up and the momentary advantage achieved through opening supermarkets had been lost.

[1] Wikipedia, "The Great Atlantic & Pacific Company" [http://goo.gl/yVJZrx], accessed April 22, 2015.

Adelman shows that the grocery business in which A&P competed was highly fragmented, often with large sellers offering products to smaller buyers at prices that exceeded marginal costs. Established suppliers were also allowed to set retail prices. Professor Adelman also demonstrates that A&P was a relatively small participant in every regional market where it had a presence. The firm enjoyed larger profits, though, because it circumvented the price maintenance schemes imposed by large suppliers such as Lever Brothers by investing in its own manufacturing facilities or hiring third parties to produce equivalent goods. A&P was an "integrated manufacturer-wholesaler-retailer" (1959, p. 405). The gains from this approach, though, were limited.

In a telling comment that would weave through all his later research on the energy industry, Adelman wrote that the benefits of diversification into various business lines were vastly overrated:

> The greater number of profit centers, the greater the insurance. But even an infinite number of profit centers would do nothing to raise the *average* profit over any particular time period; all this kind of insurance does is protect again crippling loss in any one short time period (1959, p. 407).

Forty years later, the importance of this message was heard by the world's integrated oil companies. Over the first fifteen years of the twenty-first century, integrated oil companies divested refining and retail assets to focus on fossil fuel production.

Adelman was also harshly critical of public policies adopted to "to strengthen the local monopoly position of the retailer" and effectively preserve oligopoly (1959, p. 424). His comments on the effects of energy policy written over the following decades echo this thought.

Ultimately, the young Adelman focused on policies that widen markets and promote competition. With regard to the European Common Market, which was just forming, he wrote that the "treaty of six nations will, if successful, greatly widen the market and thereby *exclude* inefficient business concerns which are today sheltered from competition; their resources will be put to better use" (1959, p. 425).

Adelman examined the impact of measures that narrowed markets and protected producers throughout his life. Of equal importance were the policies of large firms enjoying some market power that discouraged the entry of new firms by holding prices above marginal production costs.

Oil Market Structure and Oil Prices

Adelman (1972) examines the effect of such measures in depth in *The World Petroleum Market*, his masterful study of oil production costs by world region and the steps taken by multinational companies to stifle competition by charging independent crude oil buyers prices above costs while processing the crude at cost in their own refineries and marketing the product. Again and again, he writes of the anticompetitive consequences, often unintentional, resulting from the industry's integrated structure and the very low cost at which Middle Eastern oil could be produced. For example, he comments that an integrated producer-refiner will be cautious about cutting product prices for fear that the price decline will spread and thus penalize it for the action, which would not happen to an independent refiner with one location (p. 99). Prior to nationalization, the large multinationals forestalled excess production through joint arrangements in oil-exporting countries, whereby a company seeking to take more than its contractual share paid a higher penalty price for incremental supply (p. 93). His analysis showed that the integrated inter-

national structure of the oil industry raised prices charged to consumers just as the restrictive retail franchise system for marketing automobiles protected by state legislatures and the US Congress raised auto prices for consumers.

Changes in market structure have contributed to all significant oil price increases or decreases experienced since 1970. The path of prices would have been far different in their absence. Obviously market behavior would also have been very different had we experienced certain structural changes that did not occur (such as competent management of strategic stocks by consuming governments). The structural changes that did happen introduced significant noise into markets, noise that must detract from the forecasting accuracy of models recently created to project prices. Future structural changes will cause further distortions.

Here I analyze the major price shifts in the oil market since 1973 and note the key structural changes, "Adelman moments" if you will, associated with each. Table 1 summarizes the eleven episodes of note, listing the price change associated with each along with changes in demand, inventories, and supply. Finally, in the right-hand column, I show the structural change that contributed to the price episode.

The 1973/74 Oil Price Shock

Crude oil prices tripled following the 1973 Arab oil embargo and the subsequent confiscation of assets initially developed by multinationals in producing countries. Adelman wrote frequently on the fragility of high oil prices, explaining again and again that oil resources were not finite, that the cost of resource development was not rising despite the claims of others, and that high prices were being sustained by the OPEC cartel that had replaced the international oil oligopoly. He warned that prices would drop "sharply" should the cartel lose control (1990, p. 233).

One Adelman student published a fascinating analysis of the success of various resource cartels, also called restrictive commodity agreements. Eckbo (1976) assessed the performance of the various agreements and concluded that the ones that worked best tended to last three to four years, fail, and then reestablish themselves. The prices of commodities governed by these pacts rose when the agreements were adhered to and fell when they were not. Eckbo predicted that OPEC had the characteristics of a successful cartel and that OPEC's failure would be followed by the rise of other cartel-like organizations. It was a prescient expectation of developments that have occurred in the oil market over the last forty years.

Uncharacteristically, though, Adelman and his students missed two important structural changes that happened around the time of the 1973 embargo: the peaking of US production three years earlier and the end of the US oil import quota program. The quota, combined with state-imposed limits on production volumes, allowed US oil producers to receive a substantial premium to prices paid to producers in other countries for more than two decades. A Cabinet Task Force chaired by George Shultz concluded that, in 1970, US prices would decline from $3.30 to $2 per barrel if the restrictions were lifted (Cabinet Task Force 1979, p. 19). In any event, restrictions on domestic production were lifted in 1973 and the quota replaced by a fee. US imports surged, adding to global demand because domestic productive capacity had peaked (Bohi and Russell 1978).

The removal of import controls, the peaking of US production, and the replacement of the multinational oil companies by OPEC nations as managers of the global oil market can be seen as three almost unrelated structural changes that occurred nearly simultaneously. The price increases that surprised so many at the time are understandable in light of these factors.

Few attempts were made back then to develop econometric models that predicted the equilibrium price based on the simultaneous solution of supply and demand. There were, though, many models created that tried to predict or assess OPEC's optimal strategy (see Al-Qahtani, Balistreri, and Dahl 2008).

Structural Breakdown: The 1979-1981 Price Increase

Eckbo's prediction that effective cartels would last ten years at most was confirmed by OPEC's loss of control following the overthrow of the Shah of Iran and collapse of Iranian production. Prices rose sharply, almost tripling between 1978 and 1981. Once again, market structure played an important role. The loss of Iran's oil led to a four million barrel per day reduction in OPEC output. Initially, the cutback created the impression of a tight market, although Adelman suggested that supplies were ample (1996, p. 172). The pressure continued despite a sharp global slowdown into 1982 following the outbreak of war between Iran and Iraq.

A key factor was the cancelation of third-party sales. Kuwait, for instance, terminated long-term supply contracts to key multinational companies. The latter had supplied crude from Kuwait to Japan under related long-term agreements. The oil companies in turn terminated their deals on relatively short notice. Exxon, for example, told customers their contracts would expire in twelve months.

Fearing their crude oil supplies would be inadequate, the Japanese turned to a very small spot market. Prices rose rapidly, led by product markets where customers who worried about shortages or future price increases bid up current prices. Rising product prices created an incentive for traders and firms to add to inventories because crude oil prices charged by exporting nations had a well-established pattern of following spot product prices. The statistical relationship was doc-

umented by Verleger (1982). Earlier, Verleger shows a direct relationship between inventory accumulation and the price spread (difference between spot product prices and prices set by oil-exporting countries) (1982, pp. 89-121).

The chaos created by the unexpected, rapid annulment of term contracts sustained high prices at a time of high inventories that would otherwise have caused prices to fall. This is a market behavior that is hard to capture in even the most elegant time-series models built to explain price cycles. Kilian notes that unanticipated market-specific demand increases have an "immediate, large, and persistent impact on prices," while supply disruptions have only a modest effect (2009, p. 1062). The data on oil consumption in the 1979 to 1981 period do not show a significant surge in use. To the contrary, consumption declined. But the structural changes associated with the contract cancellations created a very large increase in demand for precautionary inventories (Verleger 1983), which in turn created the unanticipated rise in aggregate demand.

The Learning Experience: 1982-1986

The oil cycle from 1982 to 1986 might best be described as a learning experience. Prices declined modestly from 1981 to 1985 and then collapsed more than fifty percent. Through the period, oil-exporting countries attempted to do the impossible: set price *and* quantity. The experiment failed. Horsnell and Mabro (1993) are particularly critical of the OPEC's efforts (pp. 291-292).

Prices remained high only because Saudi Arabia was willing to reduce its export volumes to maintain market balance. Two figures tell the story. Figure 1 shows production by Saudi Arabia from 1965 to 2013 and by the other OPEC members except Iran and Iraq. (The two countries were at war at the time.) Saudi output fell seventy-eight percent between the end of 1981 and the

end of 1985. Production of the other OPEC nations declined only ten percent. Figure 2 shows the reduction in indicated Saudi oil exports, which are calculated by subtracting consumption from output. The data presented in Figures 1 and 2 emphasize Saudi Arabia's role as swing producer.

Prices collapsed in 1986 when Saudi Arabia concluded it could no longer shoulder all the falloff in demand. The 1986 price drop was instigated by a Saudi decision to offer oil volumes *at any price*. Adopting a practice known as "netback pricing," Saudi Aramco took on all risk of price decreases while buyers were guaranteed a margin on their purchase. Netback pricing tied the crude price to the crude value derived by the refiner purchaser. In addition, crude prices were determined *on arrival*, a practice followed in other commodity markets that removes any risk of price decline while oil is in transit to the refinery. The strategy helped Saudi Arabia double its sales. In economic terms the Saudi supply curve shifted from being perfectly horizontal at an uncompetitive price to being vertical at a quantity of four million barrels per day. Under the Saudi strategy, purchasers could buy as much as they desired, knowing they would pay the market price when the oil was delivered. This was a clear change in structure. The Saudis threatened to move the supply curve to the right (see Figure 3) unless other producers cooperated and reduced output.

Kilian (2009) attributes the 1986 price decrease more to a "decline in oil market-specific demand than the direct effect of an increase in Saudi oil production" (p. 1063), making the point that demand for oil as opposed to consumption decreased when buyers realized prices were going to fall. The drop in precautionary demand is the opposite of the 1979 increase in precautionary demand for stocks.

There are two problems with this explanation. First, stocks did not fall in 1986, suggesting the precautionary demand for inventories proposed by Kilian did not change (see Figure 4). Second, Saudi output rose fifty percent over the six months while the output of other countries remained flat or dropped, as Figure 5 illustrates. This graph shows an index of Saudi export volumes (with January 1985 set equal to 100) compared to an index of exports from other OPEC countries by month (again with January 1985 set equal to 100) for 1985 and 1986. Saudi export volumes (computed as production less consumption) doubled by July 1986 while the export volumes of the rest of OPEC barely changed.

Thus Saudi Arabia experienced a much smaller income loss on a monthly basis than the other producers, who saw earnings plummet seventy to eighty percent. The loss in income forced other OPEC nations to adjust at least partly to the Saudi ultimatum that sales reductions be shared by all members. OPEC became a cartel again.

A Cartel for a While: 1987-1990

Adelman describes the years after 1986 as a period of stagnation (1995, p. 243), noting that OPEC's excess production capacity essentially vanished but prices did not rise. In a telling analysis reproduced here as Figure 6, he showed that, contrary to claims of DOE analysts and others, there was no relationship between OPEC capacity utilization and oil price changes.

(From the time of the 1973 embargo to perhaps 1995, many analysts linked the change in global oil prices to changes in the percentage of OPEC capacity being used despite the best dissuasive efforts of Adelman and others. A full explanation of this faulty approach can be found in Al-Qahtani Balistreri, and Dahl (2008).)

One explanation for the price stability may lie in the efforts of some OPEC members to integrate downstream. Two of the countries that pushed hard to expand production, Kuwait and Venezuela, purchased refining assets. By 1987, Kuwait owned more than eight hundred thousand barrels per day of refining capacity in Europe. By 1990, Venezuela had more than 1.9 million barrels per day of refining capacity.[2]

Economists had long argued that vertical integration was not the panacea that most businessmen claim. (Indeed, Adelman's A&P study demonstrated that the synergies in grocery marketing were negligible absent government policies favoring small businesses.) In the case of oil, though, the price stability reported during Adelman's stagnation period may have been sustained by Kuwait and Venezuela moving into refining. The impact of this structural change has never been investigated. Apparently, an oil-exporting country seeking to sell additional volumes and increase its market share can "disguise" or "moderate" the impact of its action with regard to other members by acquiring refining capacity and moving additional volume through these facilities. Venezuela was particularly successful in following such a strategy.

[2] An anonymous referee was puzzled by this view, suggesting that whether it refined at home or sold downstream a country would have sold the same volume and apparently earned the same income. This argument overlooks three considerations. First, quotas were adjusted infrequently. Second, some countries produced in excess of their quotas. Third, at times of falling demand, some countries could not find buyers for all the oil they were allowed to produce. Nigeria suffered, for example, in 1985 when it was forced to cut output. During this time, refining margins rose. Kuwait was able to place its oil in its own refineries and thus was not forced to cut production. Furthermore, Kuwait, unlike other producers, was able to maintain income per barrel because margin increases offset discounts. See, for example, John Wood-Collins and Nordine Ait Laousine, "Downstream Integration: Myths and Realities," *Petroleum Intelligence Weekly*, October 3, 1988.

The Gulf War

Iraq's invasion of Kuwait temporarily altered oil market behavior. The loss of Kuwaiti and Iraqi supplies caused the price of Dated Brent, the industry benchmark, to rise from $17.10 per barrel on August 1, 1990, the day before the invasion, to a peak of $36.95 on October 1, 1990. (Dated Brent had traded as low as $13.10 per barrel in June.) The invasion itself can be described as the most violent possible reaction to an attempt to change industry structure. Kuwait and the UAE had moved sharply to boost production. OPEC meetings took place and promises were made but not kept. Consequently, Saddam Hussein, Iraq's president, became the ultimate enforcer of cartel discipline (Adelman 1995, pp. 284-290).

Kilian attributes the 1990 increase associated with Iraq's invasion of Kuwait to an increase in precautionary demand (2011, p. 1063). The argument is convincing. Prices rose after the 1990 attack due to suppliers becoming concerned about supply availability.

Verleger (1993) offered a similar explanation for the 1990 price rise but with an added emphasis on structural change. As Kilian found in his research eighteen years later, a boost in demand contributed to the price climb. The demand increase was attributed to growing uncertainty regarding future supply. Verleger quantified the demand using the supply-of-storage function, a stylized representation of the link between inventories and price spreads introduced by Working (1949). Verleger attributed the greater precautionary demand to a structural change in government policy regarding strategic stocks, not the invasion of Kuwait. Days prior to the invasion, the US Secretary of Energy and the president of the United States assured the world that strategic stocks

would be released during a disruption. Private sector companies had relied on these promises in making plans. Precautionary demand for stocks rose when governments refused to act.[3]

OPEC's Breakdown and Resurrection

Prices collapsed with Iraq's defeat. Eckbo's assessment of a cartel's lifespan was again confirmed. Prices traded in a terribly boring range between $11 and $22 per barrel. OPEC members met frequently but did little. UN sanctions imposed on Iraq following the end of the Gulf War removed Adelman's "policeman" Saddam Hussein from the scene. The market approached but did not achieve the economist's ideal of perfect competition.

The Asian financial crisis brought the organization back into action. Interest rates charged to Asian oil firms rose rapidly while global consumption fell well below projected levels. The Asian refiners liquidated oil inventories, adding to global supplies just as use dropped. Global consumption had been projected to average 74.9 million barrels per day in the third quarter of 1998 and 77.2 million barrels per day in the fourth quarter.[4]Actual consumption averaged 73.6 million barrels per day in the third quarter, a shortfall of 1.3 million barrels per day, and 74.9 million barrels per day in the fourth quarter, a reduction of 2.1 million barrels per day.[5] Oil-

[3] An anonymous referee offered several helpful comments noting that US stocks were released, but the release did not take place until the war began. The invasion started August 3, 1989. In testimony given only three months earlier, the Assistant Secretary for Fossil Energy had testified that stocks would be drawn rapidly. The policy was changed the day after Iraq's attack. See Robert H. Gentile's Senate testimony, "Energy Policy and Conservation Act Amendments of 1990," S. HRG. 101-602, March 20, 1990.

[4] "Even Optimistic Scenario Shows Fundamentals Weak until Autumn," *Petroleum Intelligence Weekly*, April 6, 1998.

[5] "Global Oil Demand Climbs an Uneasy Slow Growth Path," *Petroleum Intelligence Weekly*, March 8, 1999, p. 6.

exporting countries, led by Saudi Arabia, allowed prices to fall until three non-OPEC oil-exporting nations—Mexico, Norway, and Russia—agreed to join OPEC in a production cut.[6]

OPEC's Salad Days: 2002 to 2006

Price tripled between the beginning of 2002 and early 2007. During the same period, OPEC crude production rose as much as forty-five percent from January 2003 (see Figure 7). OPEC members and other oil producers enjoyed the financial gains and left well enough alone. Hamilton (2009) attributes the price increase to the failure of supply to rise (p. 235). The numbers support his conclusion. Global consumption went up 8.5 million barrels per day according to the IEA, while non-OPEC production increased only 1.2 million barrels per day. Rising OPEC supply (production climbed twenty percent) made up the difference. The consequence was a steady unsurprising boost in prices.

Market stability was enhanced by developments in Iraq. The battle there between the new government and opposition forces sapped the nation's ability to restore its output, removing a key destabilizing factor from the market.

(One can argue that Iraq's invasion of Kuwait, the subsequent sanctions imposed by the United Nations, and the chaos that followed the second Gulf War caused the ultimate structural change in the global oil market. The path of global supply and investment from 1991 to 2015 would have been entirely different had Iraq never acted.)

[6] Steve Liesman and John J. Fialka, "Why Oil Price Tripled Even as Nations Strove to Limit its Gyrations," *The Wall Street Journal*, March 26, 2000, p. a1.

Not surprisingly, Adelman anticipated the market behavior that occurred in his writings on cartels. In 1978, he predicted prices would "gravitate" slowly to the monopoly level, especially when global economic conditions were strong. In a paper written two years later (Adelman 1980), he anticipated OPEC's actions twenty years beyond, noting that world short-run supply elasticities were close to zero and adding that members would be unlikely to take destabilizing steps as long as their economic situations were good.

The Oil Spike and Collapse: Beginning of the End or End of the Beginning?

Historians may mark the period from mid-2007 to the end of 2009 as the beginning of a new area for oil or as the beginning of the end of the oil era. Only time will tell.

Most economists—Hamilton (2009) and Kilian (2009) for instance—believe that strong demand at a time of low growth in supply caused the 2007 price increase. Some economists even anticipated the event. For instance, Verleger (2005) warned as early as 2004 of the approach of $160 per barrel oil:

> Crude prices could climb from the present average in the $40s to perhaps $55 by mid-2005 and as high as $70 in 2006 should "shortage conditions" occur in those years. Even higher prices might be seen later in the decade. *In theory, crude prices might reach $160 per barrel if history follows the 1973 script precisely* [emphasis added] (p. 224).

Speculation in oil commodity markets—institutions that had been very small or nonexistent in prior crisis—magnified the surge. Demand clearly played a part but not exactly as described by conventional models. It was not robust demand for crude that instigated the increase but demand for a single product: distillate fuel oil. This demand occurred at a time when new environmental

regulations (a subject absent from all articles on oil market behavior) actually constrained supply.

Using Kilian's term, the demand shock happened in distillate fuel as did the supply shock. An earthquake in China, which increased Chinese distillate demand, and the country hosting the 2008 Summer Olympics added pressure on the market. As can be seen from Figure 8, global distillate demand jumped a full percentage point in that summer. Chinese distillate use at that time could have increased as the country shut down coal-fired power plants to minimize its notorious pollution. The distillate consumed was produced in the spring. Refiners pushed output up in advance of the demand.

Data on global distillate production by sulfur content are not available.[7] One can get an indication of the demand shock, though, from US statistics (see Figure 9), which show that exports from the US jumped in June and July of 2008.

A significant portion of the exports went to Europe, not China. IEA data show that US exports to Europe rose more than one hundred fifty percent to two hundred sixty-four thousand barrels per day in the third quarter.

The increase in US exports to Europe was tied to the environmental "supply shock." EU environmental officials mandated a shift to low-sulfur diesel (ten parts per million) in 2009 and demanded that stocks be turned. EU refiners were not prepared to meet the demand. EU oil companies had long protested that their refineries were ill suited to meet the organization's push to

[7] The IEA publishes consumption by country, which allows one to approximate production for some countries. However, production data are not available by sulfur quality. Furthermore, consumption data are not available for all countries.

dieselize. Christophe de Margerie, then CEO of Total, complained frequently to French government officials that the country's refineries were designed to produce gasoline while its energy policy was pushing consumers to buy diesel autos. His appeals for sanity fell on deaf ears.

The supply shock occurred because the world refining industry lacked the desulfurization and hydrocracking capacity required to produce low-sulfur diesel from the high-sulfur medium and heavy grade crudes produced by Middle East nations, Venezuela, and Mexico. Without this capacity, refineries required light sweet crude such as the oil produced in Nigeria. The global supply of this crude at best was around ten million barrels per day (see Figure 10). Unfortunately, a low-scale civil war significantly reduced Nigeria's output. At the same time, with exquisitely bad timing, the US government elected to remove fifty million barrels per day barrels of light sweet crude from the market to fill the Strategic Petroleum Reserve. Nigeria's troubles and the US government action cut global distillate supply two hundred fifty thousand barrels per day, a ten-percent supply reduction at a time when global consumers wanted to boost use by perhaps five hundred thousand barrels per day.

Diesel prices rose as a result, along with all other prices. The increase in distillate prices was much larger, however. In the US, spot diesel rose eighty-five percent as gasoline climbed fifty-two percent from June 2007 to June 2008. Europe and Asia experienced a similar effect. In Europe, spot gasoline rose fifty-three percent and spot diesel ninety percent. In Asia, spot gasoline rose sixty-six percent and diesel an astonishing two hundred three percent. Values of light crudes such as those produced in Nigeria jumped $80 per barrel. Values of crude oils produced in the Middle East rose far less, just $66 per barrel.

The problem caused by the environmental regulations can be seen by comparing the netbacks from Nigerian Bonny Light, a light, low-sulfur crude ideal for producing low-sulfur diesel with the netback for Arab Heavy, a crude that produces little low-sulfur diesel without intensive additional refinement in facilities that were at capacity in 2008. As can be seen from Figure 11, the differential was five times the historical norm computed from 1980 to 2008 and more than double the difference observed in the three years since low-sulfur diesel was first introduced in the US.

OPEC members even attempted to sell additional volumes of high-sulfur crude into the market. They could not find takers, though, because refiners lacked the capacity to convert the sour crude into distillate or diesel that met environmental standards. OPEC lost control over the market. Verleger (2011) shows how the lack of adequate refining capacity to upgrade heavy crude oil can cause all crude prices to rise when sweet crude supplies crude are lost. Some OPEC nations could have added oil to the market, but at the time no refineries existed that could convert the incremental supply of sour crude to the diesel product in demand. It was a market subtlety not even Adelman had contemplated.

The link between product and crude prices that led to the light sweet crude price surge in 2008 had been described many years earlier by Adelman, who showed that product prices in a competitive European refining market from 1960 on explained the price movement of crude bought through arm's-length transactions (1972, pp. 182-191). Since then, the linkage between product and crude prices has been further quantified by this author, who showed that the prices set by OPEC during the 1970s closely followed product price movements (Verleger 1982).

Crude oil prices declined seventy percent after Lehman Brothers failed. The decline would have been greater had oil-exporting countries not jointly cut production 2.3 million barrels per day between October 2008 and February 2009. The declines can be seen in Figure 12.

With the cuts, OPEC reestablished control over the market after 2009 with the onset of the Great Recession. Unilateral production cutbacks by members in the fall of 2008 and in early 2009, as well as banks aggressively acquiring oil for inventories, helped stabilize and then restore crude prices from $40 to $70 per barrel by the end of 2009.

The price restoration, supported by bank acquisition of inventories[8], may have laid the foundation for OPEC's ultimate collapse and possibly the introduction of a competitive market for crude oil for the first time in over eighty years. The contributors to this dramatic change were the breakthrough fracking technology, the mandated introduction of renewable fuels into the petroleum supply, the acceptance of financial innovation in oil, the IEA's failure to respond to the loss of Libyan supply, and the central bankers' strategy of quantitative easing (QE). Of these, the central bank action was by far the most important.

Following the collapse of Lehman Brothers, the United States Federal Reserve embarked on a QE program that drove interest rates to zero, where they have remained since (see Figure 13). The Federal Reserve acted because the US Congress could not agree on a course to stimulate the economy despite calls to do so from Fed chairman Ben Bernanke and others.

[8] See Footnote 5 on JPMorgan's acquisition of oil. Argus Media also noted the chartering of tankers by Morgan Stanley's commodity group and the JPMorgan transaction.

This was not the first experiment with this type of monetary program. Eichengreen (2015) describes the approach taken by the Federal Reserve in the late 1920s as the United States attempted to accommodate Britain's return to gold. US interest rates were kept very low. As Eichengreen explains, the low interest rate policy boosted speculation in housing, banks, and equities that ultimately led to the Great Depression.

Whether QE will bring on another depression in fewer than eighty years, as Eichengreen believes (p. 387), is irrelevant. What is important is the effect of QE on the oil sector. Fracking by independent oil companies is widely credited for the surge in US oil production. As Figure 14 shows, in 2008 EIA projected output in 2014 of 7.7 million barrels per day. Output actually averaged 11.2 million barrels per day due to the fracking surge.

Hydraulic fracking, of course, has been used in the oil sector for decades. However, the successful fracking of horizontal shale oil wells in tight sands only began in late 2008, days after Lehman Brothers failed. Gold (2014) reports that the first successful petroleum well fracture occurred in North Dakota in October 2008 (p. 55). Adelman's remark, "the genie is out of the bottle," is apt here.

The smaller independent firms that developed US shale benefited from the willingness of investors seeking better returns than those offered in credit markets to put billions in their hands. The output surge followed. Ironically, the increase echoed the boost that took place in 1929 when independent drillers, fueled by the cheap money described, raised production well beyond global needs. The headline "Big Excess of Crude Oil Seen" appeared in *The New York Times* in August 1929. On November 10, 1929, the paper published another article on the topic, this one titled "World Still Produces More Oil than Needed." In it, the author explained that the head of Royal

Dutch Shell would be traveling from the Netherlands to address the American Petroleum Institute in an effort to curb production. His effort failed, however, because the international companies had no leverage on US wildcatters.

History could be repeating. Attempts to reduce supplies may be frustrated by the very large and liquid financial markets that permit the disruptive independent producers to hedge and expand output even as prices fall. These markets only began to appear in the mid-1980s and were not available to producers at the time of the 1986 or 1998/1999 price collapses. Verleger (1987) describes their development.

Figure 15 tracks the oil market's expansion. This graph shows total open interest in the three major crude futures contracts: the WTI contract inaugurated by the New York Mercantile Exchange, the equivalent contract for WTI traded on the InterContinental Exchange, and the Brent futures contract created by the International Petroleum Exchange. As can be seen from the graph, open interest totaled two hundred fifty thousand contracts at the beginning of 2001. At the end of April 2015, total open interest had increased to more than four million contracts. This suggests that up to four billion barrels of oil could be hedged by producers, or ten million barrels per day. For many reasons, the amount hedged is far less. Still, it is clear that a very large volume of incremental production has been hedged.[9] The producers of the hedged oil are much less vulnerable to having to cut production due to their cash flows being reduced as they were in earlier price

[9] There are several ways to quantify hedging, none very precise. The Commodity Futures Trading Commission has published data for decades that distinguish commercial traders from noncommercials. However, the CFTC only began to distinguish "merchant use" of futures in 2006, and the Intercontinental Exchange (which hosts the Brent futures contract) began to report the data in 2009. These data show that merchant short positions rose from five hundred million barrels in 2006 to 1.6 billion barrels in 2015. Data on hedge positions for individual companies seems to indicate increases as well, although every company follows a different approach.

cycles. In effect, the supply curve has been flattened as Turnovsky (1983) predicted.[10] New financial markets have increased the price elasticity of oil supply.

Renewable fuel programs will also deserve credit for moving crude oil markets back to a competitive footing, should that occur. In the United States, the renewables movement began in 2006 with President George W. Bush's State of the Union speech. In it, he called for a new energy policy after remarking that the United States was "addicted to oil."[11] The US Renewable Fuel Standard (RFS) was inaugurated shortly after in an effort to reduce America's dependence on foreign oil.

The supply-and-demand presentation prepared monthly by economists at the IEA documents the consequences of President Bush's plea. Global biofuel production rose from one million barrels per day in 2007 to 2.2 million barrels a day in 2014, according to IEA data. US blending of such fuels reached one million barrels per day in 2014 according to the DOE. These volumes, although not published then by EIA, were miniscule in 2007. On a global basis, production of renewable fuels, labeled biofuels by the IEA, rose from three hundred thousand barrels per day in 2000 to one million barrels per day in 2007 and then jumped to two million barrels per day by 2013. Current projections show them flattening through the end of the decade. Still, the increase in biofuels reduced the market for conventional crude.

[10] Wright and Williams (1991) provide further detail here, showing that price volatility declines as storage increases. Obviously, the introduction of successful futures markets can promote storage and thus lead to greater price stability. The introduction of a disruptive technology, as described by Christensen (1997), such as hydraulic fracking tends to move the supply curve down because the smaller firms practicing fracking tend to be large hedgers.

[11] George W. Bush, State of the Union Address, January 31, 2006.

Finally, energy policymakers may have inadvertently accelerated the transition of oil to a competitive market when they failed to release strategic stocks following the collapse of Libyan production in 2011. The country's output plunged to fewer than two hundred thousand barrels per day in May of that year after President Kaddafi was deposed. The price of Brent, which had traded around $70 per barrel in September 2010, jumped as high as $125 in April 2011. It then remained above $100 until the fall of 2014 despite efforts by Saudi Arabia and other countries to boost production. One factor sustaining high prices may have been additional supply losses. As Figure 16 illustrates, the US Department of Energy's calculation of unplanned outages rose from one million barrels per day in 2011 to three million barrels per day by the end of 2014 as Iranian supplies were limited by sanctions, civil war in Syria disrupted output, and other nations experienced minor interruptions.

The more than 1.6 billion barrels held in strategic storage by IEA members could have been drawn down to meet these reductions. Many would assert, however, that each incident was too small to justify using reserves. In addition, no mechanism was in place to justify using strategic inventories to offset a number of independent disruptions that collectively reduced supply more than three million barrels per day. Adelman's dissenting view on this topic was clear: "Price explosions are rooted in individuals' fears of shortages. Their fright is rational and can be prevented. The SPR needs to be a seller of last resort, to assure buyers of constant ready supply" (1991b, pp. 1-9).

Strategic stocks were not used to offset any of these supply disruptions.[12] Instead prices were allowed to remain high. The high prices provided further incentives for those seeking high returns to pour additional cash into businesses seeking to develop shale oil in the United States. US production surged ever upward, accelerating the United States' move toward energy independence. The increase also created a serious problem that led to the oil price collapse that came after the three previous years of sustained high prices.

The Adelman Era: A Competitive Market for Crude

Baumeister and Kilian (2015) have written that the price decline that began in mid-2014 and gathered momentum after OPEC's November 2014 meeting can be explained entirely by shocks to supply and demand. Their data support this conclusion. As statisticians, they are correct. Their economic analysis, though, is wrong. Oil prices plummeted in 2014 and 2015 because of the changes in market structure noted above. The key change was the successful introduction of hydraulic fracking of horizontal wells, a disruptive technology that gave smaller firms entry and pulled down the cost curve. Financial markets protected the new entrants against attempts by the large entrenched suppliers to drive them out of business. These changes ultimately left Saudi Arabia no choice but to alter course and act as a conventional supplier that adjusts output until the prices received equal its marginal costs. The consequences of this development are just beginning to be realized.

OPEC's ability to sustain high prices depended primarily on the willingness of one nation, Saudi Arabia, to adjust output such that prices stayed well above the incremental production cost. In

[12] As noted in Footnote 7, there was a brief release of strategic stocks in 2011. It was announced on June 24 of that year. Prices initially fell. Within two weeks, though, prices were higher. The release was insignificant in its effect.

November 2014, the Kingdom's leaders concluded it was not in the best interest of their country to maintain this charade, confirming Adelman's research forty years earlier that high prices would bring on incremental supply that would eventually cause prices to decline and exhaust the patience of the large low-cost producers (1972, p. 77). Adelman updated this research several times over the following forty years. Without providing numbers, Saudi Arabia's oil minister Ali Naimi reinforced Adelman's 1972 conclusions regarding the production cost in Saudi Arabia when commenting on the surge of new oil production from the United States from fracking:

> Saudi Arabia, blessed with a massive hydrocarbon resource base and some of the world's largest conventional oilfields, enjoys very low production costs. And we are more efficient than other producers. It is an advantage which we will use, as any producer would, to help supply dependent global customers (2015a, p. 4).

Naimi explained that Saudi Arabia was now disinclined to reduce output on its own to preserve higher prices so high-cost producers could continue to expand production. Naimi reiterated this view in a paper presented to the Saudi Economic Association on April 4, 2014. In his formal address, he noted that Saudi Arabia had been willing to cut production unilaterally in the early 1980s to support prices:

> The experience of the first half of the 1980s was still in our minds. At the time, we cut our production several times. Some OPEC countries followed our lead, and the aim was to reach a specific price that we thought was achievable. It didn't work. In the end, we lost our customers and the price. The Kingdom's production dwindled from over 10 MMBD in 1980 to less than 3 MMBD in 1985. The price

> fell from over $40 per barrel to less than $10. We are not willing to make the same mistake again. (2015b)

The effects of the actions recalled by Naimi were clear at the time they were happening. A January 1983 article published in *The Economist* put the Saudi hard currency reserves at over $150 billion, adding that the country had no debt.[13] Two years later, *Petroleum Intelligence Weekly* put these reserves at "over $100 billion," explaining that they had been drawn down at a rate of as much as $1.3 billon per month.[14] By the end of 1987, the reserves fell to $50 billion (Rabinovich 1988, p. 16).

Economists correctly understand that "revenue needs" do not determine price, although many oil market analysts do not. On the other hand, economists, especially Professor Adelman, also recognize that financial considerations likely motivate the actions of oil-exporting countries that have sufficient hydrocarbon reserves to boost production. Adelman correctly anticipated that Saudi Arabia would cut production for a while. He warned, though, that "nobody can predict how much the Saudis would be willing to reduce their output. Nobody in OPEC wants to find out" (1993, p. 435). At the time this comment was first written, 1982, Saudi Arabia enjoyed strong revenues and large financial reserves. Four years later in 1986, Adelman's warning that Saudi Arabia did not have unlimited patience was validated. It was validated again in 2014.

[13] "Saudi Arabia's Four Sisters Turn Ugly," *The Economist*, January 8, 1983, p. 57.

[14] "Financial Pressure Building on OPEC's Poorer Members," *Petroleum Intelligence Weekly*, January 14, 1985, p. 7.

Saudi Arabia has the financial resources to stay the course in any price war. Specifically, OPEC's leading member has sufficient foreign exchange reserves to withstand a prolonged price decline of as much as seventy-five percent, a decrease that would take prices to $25 per barrel.

Table 2 provides the data to support this conclusion. The table lists OPEC members and other leading exporters in the first column. The second column presents the most recent estimates of foreign exchange reserves for each country (in millions of dollars). The third and fourth columns list the volume and dollar value of exports. These were calculated from recent production and consumption data, while the export values come from OPEC's *Annual Statistical Bulletin*. For non-OPEC countries such as Russia, I estimated the oil and natural gas export volumes.

The fifth column of Table 2 is the critical one. It shows estimates of the "breakeven price" required by each country to balance its budget. The source for this price for OPEC nations was an October 10, 2014 *Wall Street Journal* article.[15] For the non-OPEC exporters, I inserted my own estimate. For Russia, for example, I relied on my work earlier this year on the implications of lower oil prices for Russia's economy.[16] In Mexico's case, I allowed for the fact that oil plays a vastly diminished role in that nation's economy, specifically sixteen percent of its exports now compared to sixty percent in 1998. For the remaining countries, I made rough estimates of their breakeven prices.

The table's last three columns show the number of days these nations could draw from foreign reserves to meet their budgets if prices fell to $75, $50, or $25 per barrel. For example, Saudi

[15] Benoît Faucon, "Oil Price Slump Strains Budgets of Some OPEC Members," *The Wall Street Journal*, October 10, 2014.

[16] "A Meaningful Response to Russian Aggression," *Notes at the Margin*, March 3, 2014.

Arabia's reserves would cover its expenses for five thousand four hundred days with oil at $75 per barrel, assuming no changes to the country's expenditures and no increase in its oil output. The table also includes a row showing how many days Saudi Arabia could cover its budget if it raised exports one million barrels per day. In this case, I calculate that reserves would last more than twelve thousand days rather than five thousand four hundred.

Even if prices fell to $25 per barrel, Saudi financial reserves would last over one thousand days at 2015 output levels and more than six thousand days if production were increased. In short, the concerns expressed by *PIW* can be dismissed regarding Saudi Arabia.

Venezuela, though, has a problem, as does Iraq. The former's financial reserves will last only three hundred days at a price of $75 and fewer than one hundred sixty days if they fell to $25.

Saudi officials understood, though, that prices could be well below $100 per barrel for a very long time and their reserves could decline. Ali Naimi may have been thinking of the previous decrease in the country's reserves that lasted thirteen years. According to IMF data, Saudi reserves fell from $34 billion in 1981 to $7.5 billion in 1992. (Figure 17 shows the rise from 1960 to 1981, followed by the fall between that year and 1992.[17]) The data reveal that Saudi Arabia, however, has very large financial reserves that can be used to cover expenses for many years.

In addition to its monetary reserves, Saudi Arabia possesses large crude oil reserves. The 2014 edition of BP's *Statistical Review of World Energy* puts the Kingdom's year-end 2013 reserves at 265.9 billion barrels, which represents 15.8 percent of the world total. This figure is likely an un-

[17] Figure 17 terminates at 2000 because Saudi reserves rose to a point after that year that makes the variations from 1960 to 2000 insignificant and indistinguishable.

derestimate. Adelman (1972) continually reminded readers that "reserves are not found; only oil in place is found; reserves are developed (p. 25).

Over his career, Adelman would note that a country that thought at one point in time it had limited reserves could wake to discover it had produced its entire inventory of oil and yet had even greater reserves than before. This comment should be labeled Adelman's Theory. Regarding US reserves, he wrote that "proved reserves in 1930 were 13 billion; in 1998 about 20. In the interim, 120 billion were added and used" (1990, p. 223).

The history of Saudi Arabian production illustrates this. Between 1981 and 2013, the country produced 104 billion barrels of crude while its published reserves increased from 168 to 265 billion barrels (see Figure 18). Simple addition reveals the country added more than two hundred billion barrels to proven reserves, proving Adelman's point.

Concerns regarding global warming have given Adelman's Theory far greater significance. Saudi oil minister Ali Naimi made a telling remark at a conference, a comment that received almost no attention. After explaining that he had attended every major international meeting on global warming, he offered this observation and query:

> There are many things happening in the energy sphere—technology on the one hand and efficient [sic] on the other, there are politics. All of these are good for humanity, but they will definitely be a threat to oil demand in the future. My

> question to the panel—is there a black swan that we don't know about which will come by 2050 and we will have no demand?[18]

His question is obviously critical for a country that relies on hydrocarbon sales for more than ninety percent of its foreign exchange income. The mandated end of demand—or perhaps the discovery of new technologies that make oil obsolete—would have very troubling implications for Saudi Arabia.

This threat is real, not imagined. The December meeting of the International Panel on Climate Change in Lima, Peru, emphasized the need to end or at least drastically limit fossil fuel combustion. *Financial Times*' award-winning reporter on environmental issues, Pilita Clark, wrote that oil and gas production would be phased out by 2050 under one proposal advanced at the meeting.[19]

Many are skeptical that any reductions will be achieved. However, it is clear that concerns regarding global warming are increasing. Furthermore, serious suggestions have been advanced proposing that countries that move to reduce their emissions adopt economic sanctions against those that do not (free riders) (Nordhaus, 2015).

The discussion of possible agreements that allow sanctions to be imposed on free-rider nations combined with steps taken by China and other large emitters seem to have pushed Saudi Arabia

[18] Remarks made during panel discussion "Current Developments in the Oil and Natural Gas Markets and their Implications for Energy Sector in the Arab World," Tenth Arab Energy Conference, Organization of the Arab Petroleum Exporting Countries, Abu Dhabi, UAE, December 21, 2014.

[19] Pilita Clark, "UN Climate Talks Call Future of Energy Majors into Question," *Financial Times*, December 7, 2014 [http://goo.gl/EHpSrD].

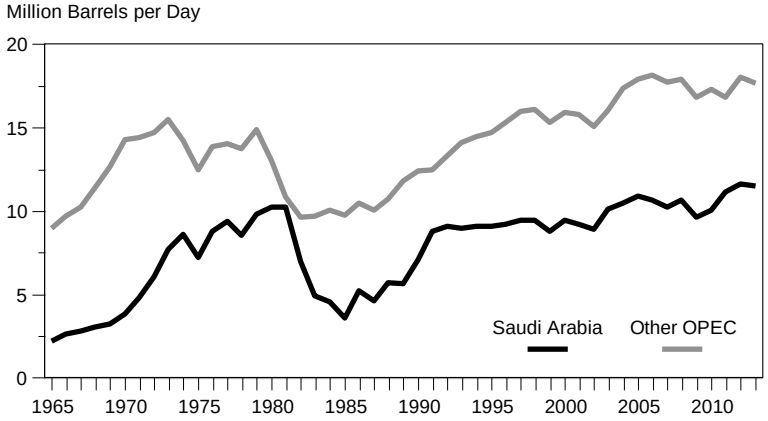
to act. While only time will tell with certainty, it appears that Saudi Arabia believes it needs to protect is primary market. In doing so, it has changed the oil market's structure.

Describing resource extraction, Adelman (1990) wrote that "over time, new lower-cost fields expand more rapidly than older higher-cost fields. *Therefore, when high cost areas expand and low cost areas contract—a glaring anomaly in oil since 1973—it is a sure sign of a noncompetitive market*" (p. 223) [emphasis added].

The noncompetitive crude oil market may have ended on November 28, 2014, when OPEC announced that producers would no longer limit production. If it did, the transformation will be consistent with the alteration of retail grocery marketing described by Adelman in 1959. The oil industry has been remade by innovation, changes in demand structure, and the introduction of new fuels as well as the decline in global energy consumption, just as food marketing shifted from small corner stores to larger markets to supermarkets and finally to the mega markets seen across the world today. Adelman chronicled the role of structural change brought about by competitive forces in grocery marketing and then petroleum. He also chronicled the efforts of governments to frustrate the benefits increased competition would bring to both industries. Ultimately, the efforts to regulate and block competitive forces failed.

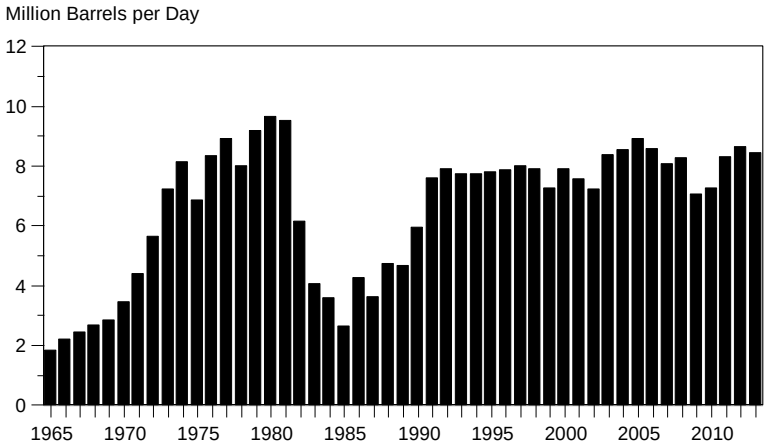
Figures and Tables

Figure 1
Crude Oil Production by Saudi Arabia vs. Crude Oil Production of Other OPEC Nations (excluding Iran and Iraq), 1965 to 2013



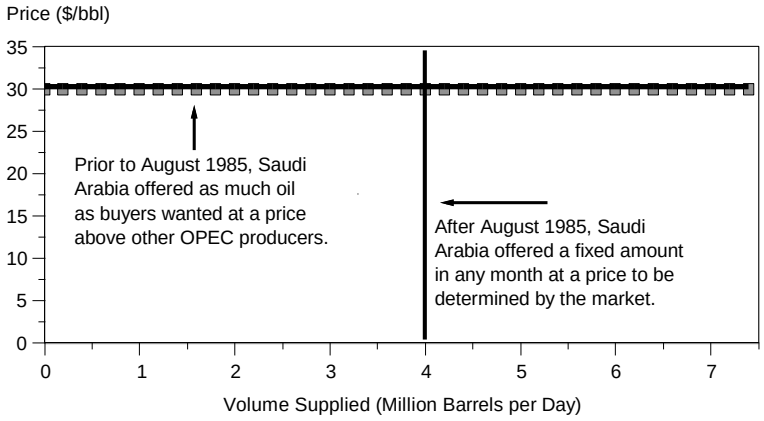
Source: BP Statistical Review of World Energy.

Figure 2
Saudi Arabian Crude Oil Exports, 1965 to 2013



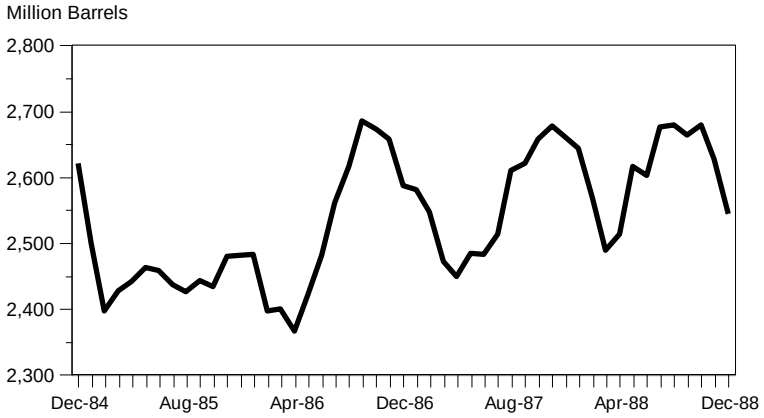
Source: PKVerleger LLC.

Figure 3
Hypothetical Saudi Crude Oil Supply Curve
Before and After 1985



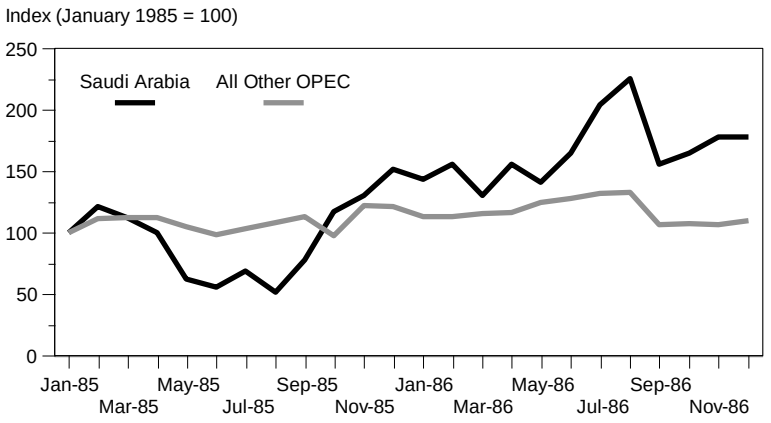
Source: PKVerleger LLC.

Figure 4
OECD Crude Oil Inventories,
December 1984 to December 1988



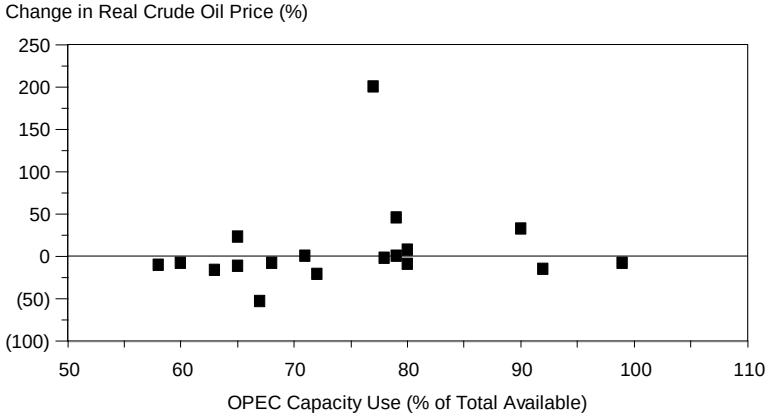
Source: Energy Intelligence Group.

Figure 5
Index of Saudi Crude Oil Output vs. Index of Crude Oil Output of All Other OPEC Members, 1985 to 1986



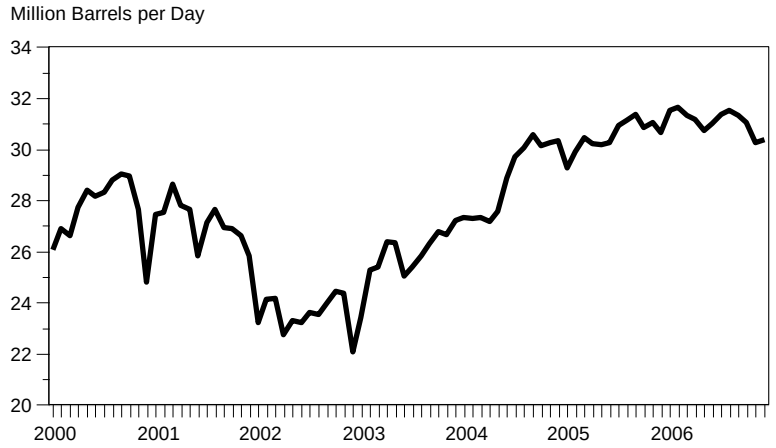
Source: PKVerleger LLC.

Figure 6
OPEC Crude Oil Capacity Use vs. Real Crude Oil Price Change, 1974 to 1993 Observations



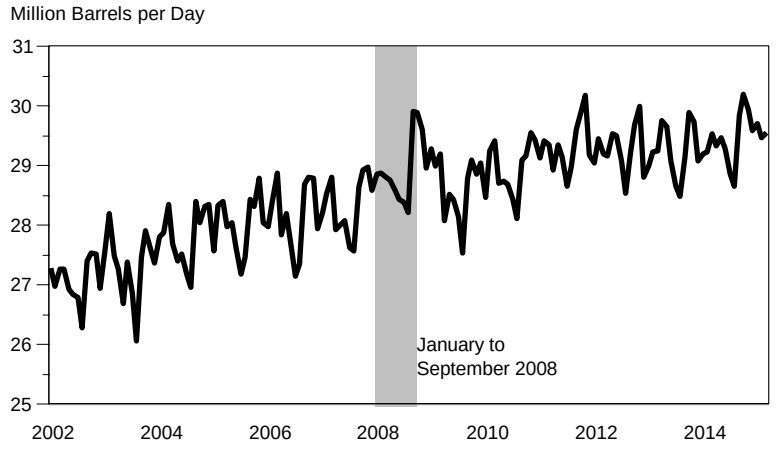
Source: Adelman (1995, p.245).

Figure 7
OPEC Monthly Crude Oil Output, 2000 to 2006



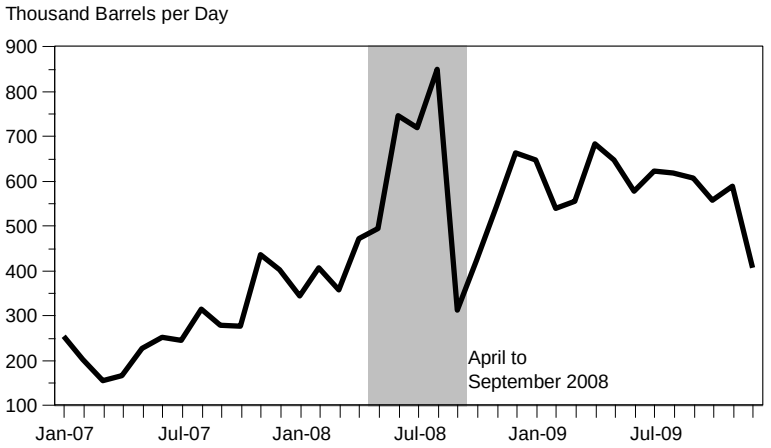
Source: Energy Intelligence Group.

Figure 8
Monthly Global Distillate Demand, 2002 to 2015



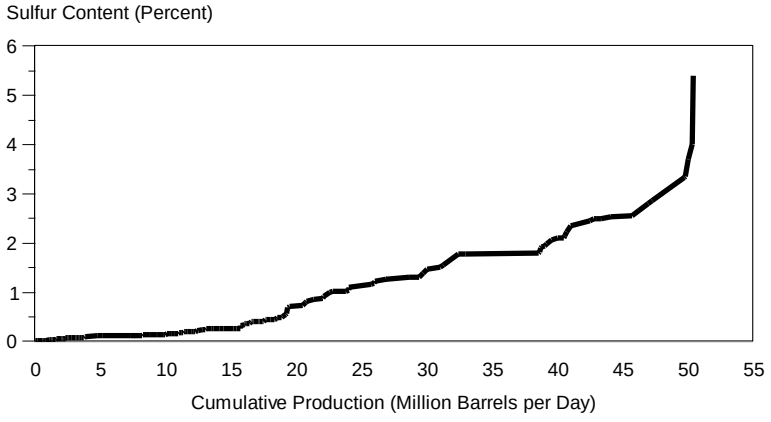
Source: Energy Intelligence Group.

Figure 9
Monthly US Distillate Exports, 2007 to 2009



Source: US DOE.

Figure 10
Distribution of Sulfur Content in Global Crude Supplies, 2005



Source: PKVerleger LLC based on EIG data.

Figure 11
Spread between Light Sweet Crude and Heavy High-Sulfur Crude at Rotterdam, January 1980 to September 2013

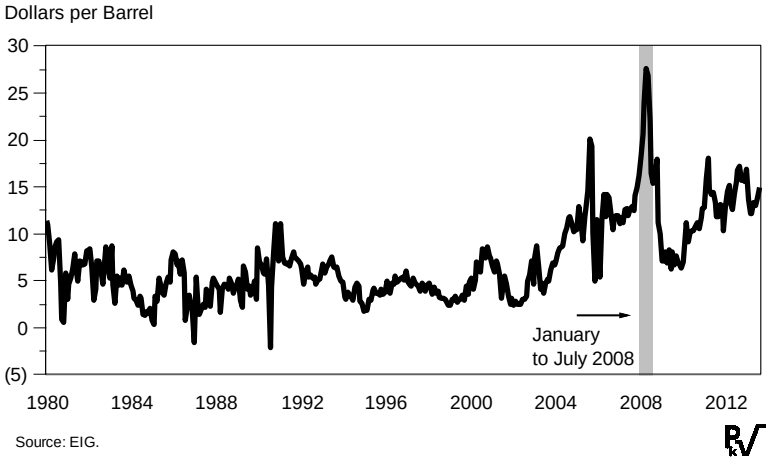


Figure 12
Monthly OPEC and Non-OPEC Crude Oil Production, January 2007 to December 2008

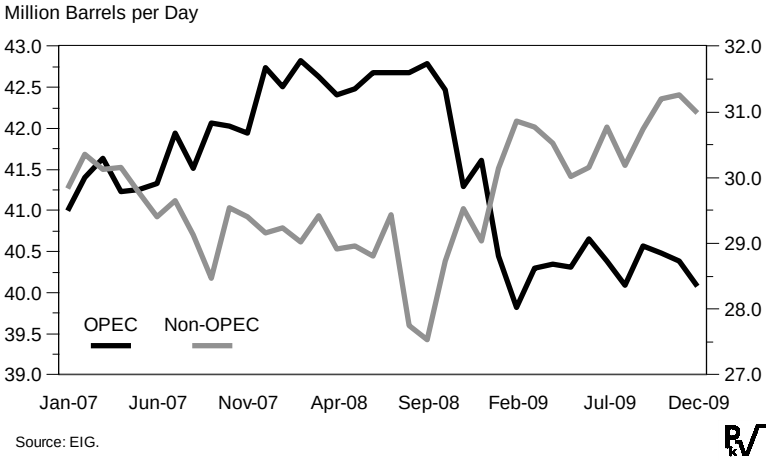


Figure 13
Three-Month LIBOR Rate, Weekly Data, 1986 to 2015

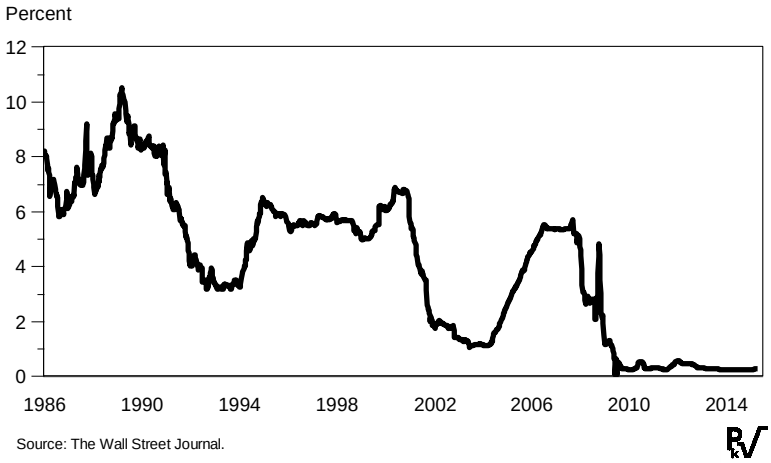


Figure 14
US Crude Oil and Natural Gas Liquids Production, History vs. EIA 2008 Forecast

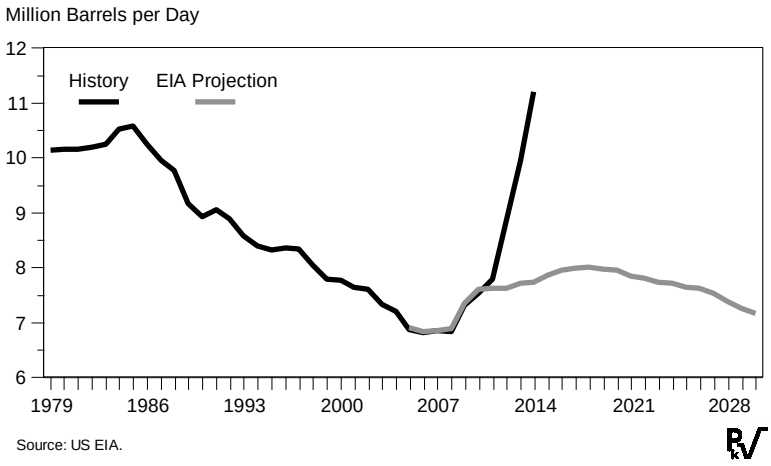


Figure 15
Total Open Interest in Three Major Crude Oil Contracts, 1991 to 2015

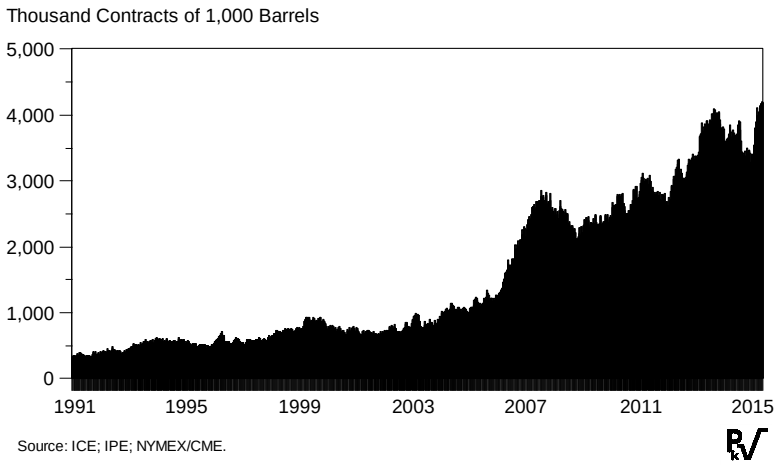


Figure 16
Estimated Global Crude Oil Supply Loss from Unplanned Production Outages, January 2010 to March 2015

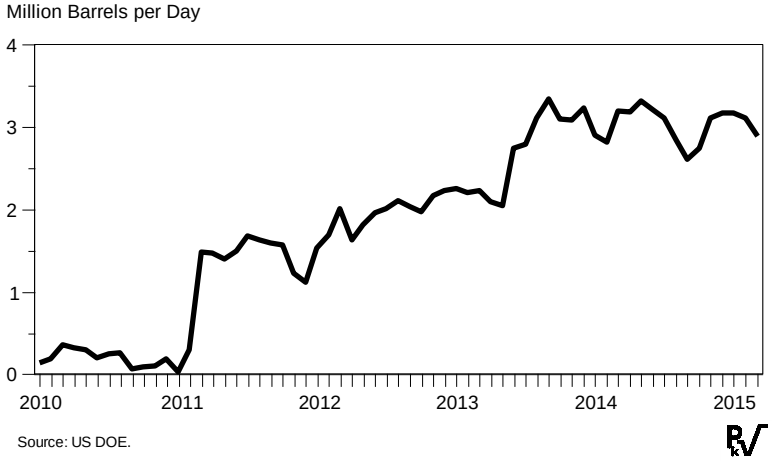
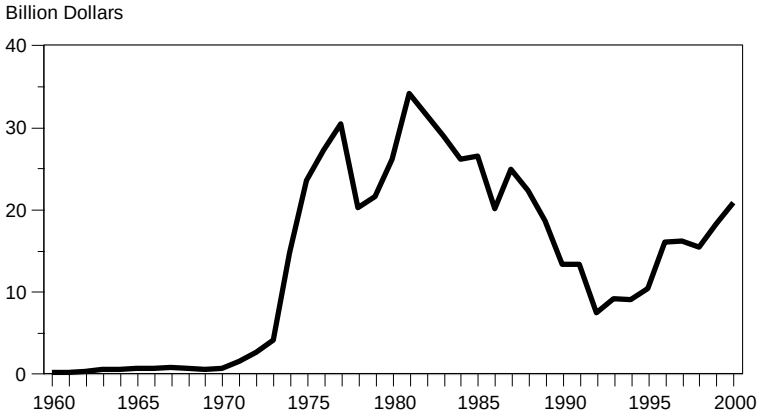
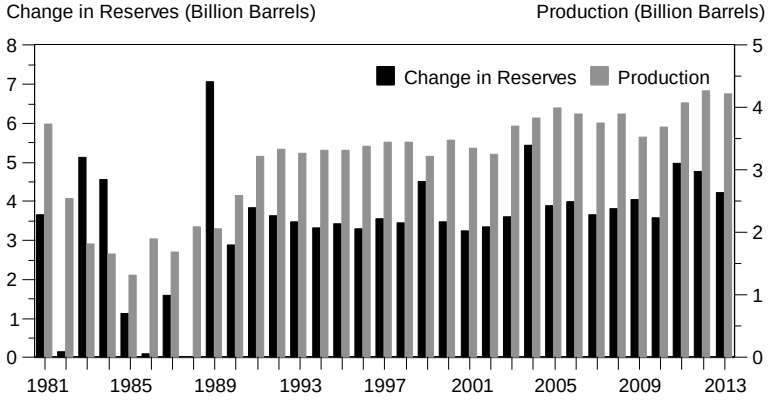


Figure 17
Saudi Arabian Foreign Exchange Reserves, 1960 to 2000



Source: IMF.

Figure 18
Change in Reported Saudi Crude Oil Reserves vs. Annual Crude Oil Production, 1981 to 2013



Note: For presentation purposes, the 1988 reserve increase of 88 billion barrels has been omitted.
Source: BP Statistical Reveiw of World Energy.

Table 1. Explaining Large Movements in Oil Prices

Episode	Price Change (%)	Demand Factor	Inventory Factor	Supply Factor	Structural Issues
1973/1974	300	Strong continued global growth	Acquisition of precautionary stocks	Peaking of US production	End of US import controls; end of US prorationing; nationalization of multinational oil companies
1979/1980	200	Falling consumption	Acquisition of precautionary stocks	Fall of Shah of Iran; outbreak of Iran/Iraq War; decline in exports from the two countries	End of multinational third-party crude sales
1985/1986	(50)	Strong increase in consumption	Liquidation of stocks	Tripling of Saudi exports	Introduction of netback pricing by Saudi Arabia
1990/1991	200	None	Increased demand for precautionary stocks	Loss of Kuwaiti and Iranian production	Unexpected change in regulations that led the US to not release strategic stocks as had been promised[20]
1998/1999	(50)	Decline in demand due to Asian debt crisis	Sale of inventories by Asian refiners to raise cash	None	OPEC did not change output[21]
1999/2000	120	Economic recovery		OPEC and non-OPEC supply cut	Coordinated effort by OPEC and non-OPEC countries to drain global stocks
2002/2007	150	Emergence of Chinese demand			
2007/mid-2008	100	Global surge in distillate demand	Increased demand for light sweet crude; European firms ordered by EU to stockpile low-sulfur diesel	Disruption of Nigerian production; US government removal of light sweet crude from the market[22]	Imposition of new rules limiting sulfur content to fifteen parts per million

[20] See Philip K. Verleger, Jr., "Understanding the 1990 Oil Crisis," *Energy Journal* 11, No. 4 (October 1, 1990), pp. 15-34. One month before the invasion, the Department of Energy had assured the public that stocks would be used in a disruption. Two days after the invasion, the DOE announced that stocks would not be released. See also Philip K. Verleger, Jr., "Verleger: US Oil Crisis Management Falters," *Petroleum Intelligence Weekly*, August 13, 1990, p. 7.

[21] An anonymous referee notes that OPEC production did decline, citing data in the *BP Statistical Review of World Energy*. However, BP presents annual data. In the last half of 1998, OPEC countries pushed production up. See Peter Fritsch, "OPEC Accord to Lift Cap on Output May Cut Prices," *The Wall Street Journal*, December 1, 1997, or "OPEC's Agreement Only to Disagree Leaves a Vacuum," *Petroleum Intelligence Weekly*, December 7, 1998.

[22] An anonymous reviewer asserted he or she was not aware of such activity. In testimony to the US Senate, the head of the Energy Information Administration acknowledged that the DOE was putting light crude into the Strategic Petroleum Reserve. See testimony of Guy Caruso, EIA Administrator, "Speculation in the Crude Market," S. HRG. 110-382 [http://goo.gl/nBhnWk], December 11, 2007, p. 38.

Table 1. Explaining Large Movements in Oil Prices

Episode	Price Change (%)	Demand Factor	Inventory Factor	Supply Factor	Structural Issues
Mid-2008/2009	(65)	Great Recession; increased inventory demand from financial institutions[23]	Monetization of inventories by stock liquidation	None	OPEC production cuts; new financial instruments that facilitated hedging; larger financial markets that facilitated hedging[24]
2011/2012	65	None		Loss of Libyan supply	Failure to use strategic stocks; increased supply of biofuels[25]
2014/2015	(55)	None	Acquisition of low-priced crude for strategic stocks; acquisition of oil for private stocks through hedging	Increased US supply from fracking	OPEC abandonment of production controls; increased use of financial markets

Source: PKVerleger LLC.

[23] An anonymous referee questions whether financial institutions held inventories. JPMorgan in fact accumulated several million barrels of oil. See Alaric Nightingale, "JPMorgan Hires Supertanker for Storage, Brokers Say," Bloomberg, June 3, 2009 [http://goo.gl/BkvxNj].

[24] Total open interest in the three primary crude futures contracts stood at 2.4 billion barrels excluding options. At the time, this represented a fivefold increase from the time of the previous price decline in 1999.

[25] There was one miniscule release of strategic stocks in June 2011 following the Libyan disruption. Clayton (2012) notes "the immediate collapse in prices [from the release] was short lived. By the first week of July 2011 prices had reclaimed all their lost ground, closing four dollars per barrel higher than the day of the announcement" (p. 2). The announcement occurred on June 24, seven days earlier. No further sales were made. This author's judgment was and is that the release was a failure.

Table 2. Coverage of Government Budget Deficits from Foreign Exchange Reserves for OPEC Countries and Certain Key Non-OPEC Nations as of January 6, 2015

	Foreign Exchange Reserves (Million Dollars)	Oil Exports (Thousand Barrels per Day)	Estimated Oil Export Revenue (Million Dollars)	Breakeven Price (Dollars per Barrel)	Coverage Days at $75 per Barrel	Coverage Days at $50 per Barrel	Coverage Days at $25 per Barrel
Saudi Arabia	714,285	7,325	377,013	93	5,417	2,268	1,434
Iran	68,060	598	98,870	140	1,751	1,265	990
Iraq	77,747	2,450	89,765	106	1,024	567	392
Kuwait	32,410	2,356	115,015	75		550	275
UAE	58,040	2,127	379,490	70		1,364	606
Qatar	43,486	433	136,840	65		6,695	2,511
Venezuela	24,241	1,623	89,175	121	325	210	156
Nigeria	32,386	1,430	95,118	119	515	328	241
Libya	119,714	430	40,723	90	18,560	6,960	4,283
Algeria	201,437	814	65,644	121	5,380	3,485	2,578
Angola	32,780	1,600	68,191	98	891	427	281
Ecuador	4,346	348	25,700	117	297	186	136
Saudi Arabia Higher Exports	714,285	8,325	377,013	93	12,564	8,727	6,685
Russia	376,208	11,165	407,526	100	1,348	674	449
Mexico	198,222	480	17,520	10			
Norway	66,683	1,359	118,904	50			1,963
Kazakhstan	29,125	1,150	41,975	100	1,013	507	338
Oman	17,700	850	38,615	70		1,041	463

Note: Russian exports include natural gas volumes in million barrels per day of oil equivalents.

Source: Reserves – IMF; Export Volumes – OPEC, BP Statistical Review of World Energy, PKVerleger LLC; Export Revenues – OPEC, PKVerleger LLC; Breakeven Price – *WSJ*, October 10, 2014.

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