Several observers have argued that the recent sharp decline in oil prices is unlikely to last, largely because pricing strategy by Saudi Arabia can be described as "dynamic profit maximization" designed to drive overseas competitors out of business in the short run, and to erode investment in new competitive production capacity over the longer term. Punishment of overseas competitors unquestionably is a component of Saudi strategy, but the ensuing conclusion that sharp price increases are to be expected does not follow. That model falls short as economic analysis because it asks the wrong question: Will future oil prices remain low? The correct question is much more difficult: Why are current prices not far higher already?

A sensible model of oil price patterns over time predicts that expectations of higher future prices should be reflected in current prices. Current prices do not suggest sharply higher price trends, and recent data on futures prices and consumption and production paths are consistent with that inference. Although recent movements in crude-oil inventories support an inference of prospective price increases, a simple analysis of spot prices and rates of return to arbitrage activities does not support that conclusion.

Observed Saudi production and pricing strategy is consistent with a different hypothesis: the House of Saud’s increased fears of internal and external threats to its rule, and an increased possibility of some sort of overthrow. In addition, the more recent partial recovery of international oil prices is consistent with an observed increase in global supply disruptions, so that a longer-term price recovery might reflect that factor rather than the effects of dynamic profit maximization by the Saudis. At the same time, a simple simulation of a severe supply disruption suggests that market prices would decline quickly from an initial sharp increase, an inference supported by the long-run history of movements in oil prices.

Some common dimensions of conventional wisdom on international oil markets—in particular, the description of OPEC as a cartel and the assumed effects of the 1973 Arab OPEC oil embargo—are incorrect. But the optimization problem faced by the House of Saud is complex...
and fascinating, an observation that supports the larger truth that specialists in economics and in the international politics and the defense dynamics of the Middle East have much to learn from each other.

I. Background

My colleague Kevin A. Hassett offered recently a short and informal analysis of prospective oil prices, arguing that Saudi pricing policy is intended in substantial part to make competitors’ investments in production capacity unprofitable over the longer term. That is consistent with a related dimension of Saudi production policy, intended ostensibly to preserve “market share,” which actually is designed to allow greater volatility in oil prices so as to increase investment risks perceived by competitors. Over the longer term, both impacts would reduce worldwide production capacity and increase prices below and above the respective levels that would prevail otherwise. Thus the Saudis maximize profits dynamically by driving prices down to levels at which it is unprofitable for others to invest, for example, in new hydraulic fracturing production facilities.

It is correct to note as well that Arab OPEC producers enjoy marginal production costs lower than those in the US and elsewhere; accordingly, the Saudis and the other Persian Gulf producers can continue production profitably during periods of low prices while other producers cannot, as illustrated by the current wave of bankruptcies in the US oil patch.

The additional argument made by some that Saudi cash reserves of about $600 billion allow them to “ride out” periods of low prices more easily than others is, however, problematic: Unlike a typical US oil producer, the House of Saud confronts threats to its rule—large, growing, long-term, and both domestic and foreign, about which more below. Accordingly, vast spending to ameliorate them is necessary but may not be sustainable. The International Monetary Fund, for example, estimated in 2015 the Saudi “fiscal gap” at about 20 percent of “non-oil GDP,” a parameter that analytically is questionable (an issue for another day), but likely to be correlated with the fiscal ability of the ruling family to maintain social spending deemed necessary. Note the recent news reports that the House of Saud now is issuing bonds as vehicles for borrowing in international capital markets.

What is important here is the political reality that the large nominal size of Saudi cash reserves is less impressive than may seem to be the case in the context of low oil prices. From the perspective of straightforward economic analysis, low marginal production costs

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3 Recent news reports suggest that this effect is being observed among non-OPEC producers of crude oil. For example, see Benoit Faucon, “OPEC Sees Sharper-Than-Expected Fall in Non-Cartel Output,” Wall Street Journal, April 13, 2016, http://www.wsj.com/articles/opec-sees-sharper-than-expected-fall-in-oil-output-outside-the-cartel-1460543249.
mean that maximization of sales revenues is a useful approximation of maximization of profits as a rough guideline for predicting Saudi output and pricing policy.\textsuperscript{11} It is axiomatic that any given producer, including the Saudis, faces “elastic” demand (a reduction in price yields an increase in total sales revenue), particularly in a global commodity market such as that for crude oil.

Therefore, if maximization of sales revenues is a useful approximation of Saudi objectives, then prices lower rather than higher—a bigger market share—are consistent with that goal. Such lower prices certainly are consistent with the goal of driving competitors out of business, and thus with higher prices over the longer term, but all producers with low marginal production costs will have incentives to compete those higher prices downward. This includes producers with low costs of ceasing production when prices are low and of resuming operations when prices rise. Moreover, the higher long-term prices inexorably will engender investments in technological advances—the US revolution in hydraulic fracturing and horizontal drilling is the most obvious recent example—so that a prediction of prices substantially higher than those observed recently is not obviously correct, a point discussed in Section II.\textsuperscript{12} Section III presents observations on the growing internal and external threats faced by the House of Saud. Section IV presents a simulation of the price effects of a severe oil supply disruption over a 10-year horizon. Section V offers a brief criticism of two central components of conventional wisdom on the history of the international oil market, and Section VI presents concluding observations.

\textsuperscript{11} In the conceptual case in which marginal production cost is zero, a profit-maximizing producer would choose an output level at which total sales revenues are maximized, that is, where marginal revenue (which normally declines more rapidly than price as the latter falls) is zero. When marginal cost is low (but still greater than zero), maximization of total sales revenue is a useful approximation of profit maximization at the point where marginal revenue equals marginal cost. It is useful because measurement of marginal cost often is difficult.


II. Some Data

In brief, Hassett concludes that the low prices\textsuperscript{13} of about $30 per barrel observed at the time that he wrote his article are unlikely to last because dynamic profit maximization by the Saudis—allowing low prices to drive production by current competitors downward and to discourage investment by future competitors—means that the current price is lower than the long-run equilibrium price, perhaps by a substantial amount: “Today’s low prices probably mean higher long-run profits for OPEC, higher prices at the pump, and a share of world production for OPEC that is for the most part steady. Sorry.”\textsuperscript{14}

Prices indeed have increased substantially this year since the January/February period, from $27.88 per barrel (for Brent crude oil) on January 20 to $45.93 on April 21, or 65 percent. Figure 1 shows this recent trend with the daily data for Brent spot prices, for January 4 through April 21.\textsuperscript{15} (The gaps are days when the markets were closed.) Notwithstanding the volatility in given weeks, the upward trend from mid-January through mid-April is clear, with hiatuses in parts of February and March.

Whether this is part of the longer-run price increase that Hassett and others predict\textsuperscript{16} or simply a manifestation of familiar short-run volatility in crude prices remains to be seen, but some basic analytics can be applied to this question. First, the production and consumption of oil are substitutable over time; a given barrel can be produced and/or consumed during either the current time period or some future one. This means—under a complex set of simplifying assumptions—that the profitability of (i.e., the total expected economic return to) producing and selling a barrel of oil today must equal the expected profitability of producing and selling it in the future.\textsuperscript{17}

\textsuperscript{13} See Oil-price.net, “Crude Oil and Commodity Prices,” http://www.oil-price.net/.

\textsuperscript{14} Hassett, “Don’t Stop Worrying About Oil.”

\textsuperscript{15} See Investing.com, “Brent Oil Historical Data.”


\textsuperscript{17} If it were more profitable to sell a barrel of oil today than to hold it for sale tomorrow, more oil would be sold today, reducing its price and thus the profitability of selling it in the current time period. The analysis is identical for the case in which the expected profitability of selling in the next time
For our purposes here, the current and expected future prices of oil are reasonable first approximations of the parameters yielding those “total economic returns,” or profitability. Suppose that the risk-adjusted market rate of interest in the private sector is 4 percent. An oil producer can produce a barrel today, put the proceeds in, say, corporate bonds, and expect to earn 4 percent. If oil prices are expected to rise at a rate higher than 4 percent, then there is created an incentive to keep oil in the ground, selling when prices are expected to have increased by more than 4 percent, thus earning a return greater than the market rate of interest. Accordingly, if prices are expected to rise at a rate higher than the interest rate, less oil will be produced today, raising the current price, and more oil will (be expected to) be produced in the future, reducing the expected future price. This adjustment continues until the profitability of producing and selling oil today equals the expected profitability of doing so tomorrow.

As an aside, one implication of such standard analysis is as follows: Expectations that the Federal Reserve will increase US interest rates should put downward pressure on current oil prices in dollars because whatever the expected future price of oil, the current price must be lower in order to rise at that higher rate of interest. It is interesting, therefore, that the Fed statement on March 16, 2016, softening its earlier stance on a gradual increase in the federal funds rate, coincided with an increase in oil prices of more than 7 percent over March 16–17. See Board of Governors of the Federal Reserve System, press releases, March 16, 2016, https://www.federalreserve.gov/newsevents/press/monetary/20160316a.htm, and December 16, 2015, https://www.federalreserve.gov/newsevents/press/monetary/20151216a.htm, respectively. Has the market anticipated this Fed softening since mid-January? It is hard to measure expectations or to discern the factors that drive them.
restoring the slope of the expected price path to the market rate of interest. The same analysis applies if oil prices are expected to fall: Producers will increase output today in order to take advantage of current prices higher than expected future ones, thus reducing prices today and increasing expected ones in the future. The expected price—not necessarily the actual price, as new information emerges constantly—rises at the market rate of interest.

As an aside, this standard analysis is inconsistent with the commonly asserted “peak oil” hypothesis: Because global oil reserves are (by assumption) finite physically, a maximum extraction rate for oil will be reached at some point, after which that rate must decline permanently. Apart from the future effects of new discoveries and technological advances, the problem with this hypothesis is that it ignores the effect of expected cost and price paths on the intertemporal choices among alternative oil-production decisions. If future production really were to decline inexorably, expected future prices ought to rise, other things held constant, yielding incentives to conserve oil (and other depletable resources) for future periods. Accordingly, there is a fundamental analytic flaw in the widely asserted admonition that (additional) resource “conservation” is necessary to maintain “sustainability.”

If we define “conservation” as a shift of some resource consumption from the current time period—such as this year or this decade or some longer period—into some future one, no resource will be “depleted” during the current time period, in substantial part because of the effect of price expectations on incentives to allocate resource use over time, as just described. Therefore, oil (and other resource) markets are “conserving” in the sense that no depletable resource is being depleted in the current time period; the “conservation for sustainability” argument boils down to an assertion that market forces yield too little “conservation” in some undefined sense, the basis for which remains entirely unclear.

Returning to the dynamic profit-maximization ("punishment of competitors") argument: One would think that the market ought to be able to predict the approximate effects on investment and future prices attendant upon Saudi pricing strategy. Accordingly, current prices would reflect expectations of the higher future prices predicted by that analysis. Figure 2 illustrates recent paths for crude oil prices (in nominal dollars) and global production and consumption, using monthly (not daily) data from January 2014 through March 2016. Production has increased over this period from about 92 million barrels per day (mmbd) to about 96 mmbd, with most of the increase observed in 2014. Consumption increased beginning around the middle of 2014 as prices fell, and then again in the summer of 2015 as prices fell further, by a total of about 3 mmbd. The visible increase in the gap between production and consumption beginning in the summer of 2014 in part may explain the decline in prices from about $109 to about $40 per barrel. Whatever the source of the declines in prices in the summers of 2014 and 2015, they yielded consumption increases visible in the data beginning around the same time periods, of approximately 1–2 mmbd each time.

While we should be very careful with respect to drawing conclusions from aggregate production and consumption data—they may obscure underlying shifts in fundamental supply and demand conditions—these data show no obvious shift in those market conditions that would explain so large a decline in prices. The consumption increase over the entire time period was about 3 mmbd, or about 3.3 percent. Prices declined by over 60 percent, suggesting a (short-run) demand elasticity of about 0.6 (in absolute value), a number substantially higher than the 0.25 or so reported in the literature. Since global GDP growth was about 2.6 percent in 2014 and 2.4 percent in 2015, a relative


22 I have yet to find in the literature or elsewhere a definition of “sustainability” that is analytically useful.

23 It is hardly the case that the (approximate) marginal production costs for Saudi competitors are unknown. See Koema, “Cost of Oil Production by Country”; and Rystad Energy, “Overview.”

24 For the price data, see Investing.com, “Brent Oil Historical Data.” For the production and consumption data, see the US Energy Information Administration, “Short-Term Energy Outlook,” Table 3a, https://www.eia.gov/forecasts/steo/data.cfm?type=tables. The production data include lease condensate, natural gas liquids, and other liquids; the consumption data are defined roughly as total petroleum products supplied, which includes products produced from non-crude liquids, refinery processing gains, and the like.

25 See Hamilton, “Understanding Crude Oil Prices.”

downward shift in demand conditions is unlikely to explain this price decline, particularly given that global consumption of crude oil increased from 92.4 mmbd in 2014 to 93.7 mmbd in 2015.27

One is led to conclude that something about market expectations changed, a parameter much more difficult to measure. Whatever the reality, the price data are not consistent with an expectation of future prices sharply higher because of a Saudi strategy of dynamic profit maximization or punishment of competitors. Figure 3 presents the monthly price data shown in Figure 2, for 2014–2016, and data also on commercial inventories of crude oil held in the Organisation for Economic Co-operation and Development (OECD) economies.28 Figure 4 presents the monthly inventory data for 1997–2016.29

In Figure 3, the sharp decline in prices beginning in the summer of 2014 presents a problem for the argument that low current prices will yield higher future ones, as an expected increase in future prices ought to be reflected in current prices. But the increase in commercial inventories held in the OECD economies—from about 2.6 billion barrels in January 2014 to about 3.1 billion barrels in March 2016, or about 19 percent—is consistent with that argument, in that an expectation of an increase in prices faster than the market rate of interest should engender efforts to profit from that anticipated price change by stockpiling more oil for sale when prices are expected to have increased. This is illustrated more clearly in Figure 4, which shows the monthly OECD inventories for January 1997 through March 2016. Inventories were more or less constant over the entire period until the spring of 2014, a bit before prices collapsed during the ensuing summer and fall.

Note that there is no obvious reason that efforts to arbitrage the difference between current and future prices should yield increases in inventories; some crude oil that otherwise would be produced during the current time period could be left in the ground, to be lifted when prices prove higher. There might be some

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27 See the US Energy Information Administration, “Short-Term Energy Outlook,” Table 3a.
28 Ibid.
29 Ibid.
Figure 3. Crude Oil Prices and OECD Commercial Inventories

![Graph showing crude oil prices and OECD commercial inventories over time.]


Figure 4. OECD Crude Oil Commercial Inventories

![Graph showing OECD crude oil commercial inventories over time.]

sort of plausible argument to the effect that holders of inventories are more efficient than oil producers at such arbitrage activities, although they often are the same people or firms, and this hypothesis seems a bit forced. Or there might be engineering, contractual, cost, or other considerations or constraints on production changes once wells are producing, parameters that might make in-reservoir storage more costly as an arbitrage tool. This question of identifying the efficient provider of inventory capacity is a side issue that I leave for another day.

In any event, we have a conundrum: Even given the price increases since January, the price data seem inconsistent with the dynamic profit maximization argument, in particular if the attendant prediction is for a return to prices approximating $100 per barrel. But the inventory data are consistent with it. Perhaps the problem is that the dynamic profit maximization argument for Saudi behavior predicts only a qualitative future price increase, rather than an actual quantitative forecast. In any event, there is no obvious path toward reconciling this problem, but a simple conceptual experiment and the data on futures prices do, I believe, allow us to favor the inferences from the price data over those from the inventory data.

At a conceptual level, suppose that because of the investment effect of dynamic profit maximization by the Saudis, low prices today will yield high prices over the foreseeable future. Suppose also that prices were to return to a level approximating those observed at the beginning of 2014, say, $100 per barrel. If prices now are $40 per barrel, it is useful to ask what annual rate of return would be earned by those conserving a barrel of oil in 2016 in favor of selling it at alternative times in the future over those from the inventory data.

Any other assumed future price can be substituted in place of $100. For example, suppose that $60 is the assumed future price. Then for the years shown in Table 1, the implicit annual rates of return would be 50, 22, 14, 11, 8, 7, 6, 5, 4.6, and 3 percent, respectively. In particular for a $60 price anticipated in the earlier years, these rates of return seem sufficiently high to induce the arbitrage behavior just described, and with it a reflection of future expected prices in current prices.

However risky the nature of implicit investment in future oil sales, it simply is not plausible that current prices would not reflect such high rates of return. Even the 7 percent annual return earned from selling oil at $100 in 2030 is comparable to recent returns earned on high-yield (“junk”) debt.31 (I put aside here the issue of inflation expectations and the distinction between nominal and real rates of return.) And it is unlikely that the prediction of price increases caused by Saudi dynamic profit maximization extends out more than 15 years in the future; why would the investment, production, and price effects of current low prices take so long?32

Any other assumed future price can be substituted in place of $100. For example, suppose that $60 is the assumed future price. Then for the years shown in Table 1, the implicit annual rates of return would be 50, 22, 14, 11, 8, 7, 6, 5, 4.6, and 3 percent, respectively. In particular for a $60 price anticipated in the earlier years, these rates of return seem sufficiently high to induce the arbitrage behavior just described, and with it a reflection of future expected prices in current prices.

Nor are such high prospective returns reflected in futures prices, as illustrated in Figure 5, which displays the April 25, 2016, data on futures prices for delivery of Brent crude oil for each month from June 2016 through December 2023.33

As of April 25, 2016, prices for Brent crude oil increased (in nominal dollars) from $45.43 for delivery in June 2016 to $57.54 for delivery in December 2023. This is a compound annual increase of

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30 The calculations are straightforward: The annual compound rate of return is \( \frac{\log(p_t/p_0)}{\log(y_t - y_0)} \) where \( p_t \) is the assumed price in future year \( t \) ($100 in our example), \( p_0 \) is the current price ($40), \( y_t \) is the year of sale (e.g., 2020), and \( y_0 \) is the current year (2016).


32 The discovery and development of new oil fields can take a number of years, particularly for offshore resources, but the other dimensions of industry expansion (at both intensive and extensive margins) often are accomplished more quickly. See IFP School, “What Are the Main Steps of an Oil or Gas Field Development Project?” http://www.ifp-school.com/upload/docs/application/pdf/2015-02/3_main_steps_oil_gas_field_development.pdf.

33 See the futures price data reported in Barchart.com, “Crude Oil Brent (F) Futures Prices,” http://www.barchart.com/commodityfutures/Crude_Oil_Brent_(F)_Futures/QA.
3.2 percent, somewhat higher than current 10-year inflation expectations of 1.71 percent. This disparity seems reasonable given the volatility of oil prices, the greater riskiness of investment in a given commodity sector, and the possibility of future disruptions in oil supplies, a topic to which I turn below. The possibility of oil supply disruptions ought to shift the entire expected price path upward, rather than increase its slope, unless there are reasons to believe—development of an Iranian nuclear weapon as an example—that the likelihood of such a disruption will increase over time. The prospect of future technological advances in oil production could be predicted to reduce the slope of this futures function or to shift the entire function downward to the extent that such technological advances can be foreseen. Future technological advances in oil consumption might shift the function up or down, as efficiency improvements could be offset partially, fully, or more than fully by new ways to use oil. However speculative such parameters, a future large price increase driven by current Saudi pricing policy either is absent from the futures data or is being hidden by other factors more important. Neither the current nor the futures price data appear to support the dynamic profit maximization argument, although the inventory data are consistent with it.

III. Observations on Threats to the House of Saud

That the Middle East is a dangerous neighborhood is no secret, a reality that for decades has confronted the House of Saud with threats both internal and external. A few examples should suffice to illustrate the point.

The Grand Mosque in Mecca was seized in late 1979, and that violent rebellion was put down only after almost two weeks and with the unofficial aid of French
troops. The bombings in Riyadh in May and November of 2003 exposed the violent rifts between the monarchy and the Wahhabi religious establishment. (In this context, bombings directed against Americans clearly were a continuation of domestic politics by other means.) More generally, bombings and shooting incidents aimed at the regime have occurred on a regular basis, too numerous to detail in this essay.

The central long-term external threat has come from Iran in the wake of the overthrow of the Shah of Iran and the establishment of the Iranian theocratic regime. One result has been a series of proxy battles in Lebanon, Iraq, Afghanistan, Syria, Bahrain, and Yemen. The more recent development of the Iranian nuclear weapons program poses a direct and enormous perceived threat to the House of Saud.

Of greater interest here are the implications of these threats for Saudi oil production policy, and in particular the shift in that policy several years after the overthrow of the Shah. For 1973–1986, Saudi production was consistent with the goal of protecting the official OPEC price; the Saudis acted as the “swing producer” increasing or cutting output so as to maintain that

price. This led to a steady decline in Saudi output from 9.9 mbmd in 1980 to 3.4 mbmd in 1985. Saudi production increased more or less monotonically beginning in 1986, a year in which the market price for Brent crude oil fell by almost half, from $27.56 in 1985 to $14.43 (in nominal dollars).

One interpretation of this shift during the mid- to late-1980s is consistent with a straightforward effort by the Saudis to protect their market share and sales revenues. Another interpretation is consistent with Hassett’s argument: a production/pricing model that can be described as “market punishment” behavior designed to reduce the profitability of foreign investment in competing crude oil reserves. That model suggests an increase in Saudi reserves and production capacity, so as to create a threat to flood the market in the face of increasing potential competition. That indeed is what we find: an increase in proven Saudi crude oil reserves from 173 billion barrels in 1989 to 258 billion barrels in 1990. (Investment in the discovery and development of new production capacity would be expected to show up in the data suddenly, as new fields are “proven” in an engineering sense.) However, Saudi reserves have remained virtually unchanged since 1990, increasing from 258 billion barrels that year to only 268 billion barrels in 2015, even as Saudi production increased from 5.6 mbmd in 1989 to 11.6 mbmd in 2014. Figure 6 shows these data for


43 Ibid., IndexMuni.


45 See Zycher, “OPEC.” As noted above, any individual producer faces elastic demand—price and sales revenues move in opposite directions, other things equal—so that a cut in price and increased production would increase (or protect) sales revenues.

46 See the historical data reported by the US Energy Information Administration, “Crude Oil Proved Reserves (Billion Barrels),” http://www.eia.gov/iafapip/idxipjofd/jedindex3.cfm?tid=5&pid=57&aid=6&cid=regions&syid=1995&eyid=2015&unit=BB.

47 See the historical production data reported by the US Energy Information Administration, “International Energy
The Saudi market share of world crude oil production for 1991–2014 remained fairly stable at 12–14 percent, as world production increased from 65.3 mmbd to 90.7 mmbd, or by 39 percent.\footnote{Ibid.}

The dynamic profit maximization argument seems not to answer the obvious question: Why have the Saudis failed to increase capacity so as to profit from this growing market? Or: Why have they failed (at least until mid-2014) to punish the market so as to discourage investment by competitors?

One answer might be consistent with the growing threats perceived by the House of Saud. If the risk of an overthrow by hostile forces has increased, the Saudi ruling family might have greater incentives to maximize sales revenue over a shorter time horizon. That can be interpreted as “dynamic profit maximization” with a much higher discount rate. After all, in the extreme case in which the royal family’s private jets are kept fully fueled and ready for quick departure to Switzerland, the suppression of investment incentives for international competitors becomes far less important.

Accordingly, it may be useful to conduct a rough conceptual exercise to see what change in Saudi production levels might result from increased fears of some sort of overthrow or coup d’état, that is, an increase in the discount rate used (implicitly) by the House of Saud to evaluate the value of future oil revenues. I assume here that the Saudi maximand is the present value of total sales revenue, and a price elasticity of demand for Saudi oil of three (in absolute value). Obviously, other figures could be substituted, but the qualitative nature of the analysis would not change.

Table 2 summarizes these calculations for two cases: time horizons for the House of Saud of 100 years and 10 years, with an assumption that optimal production under the 100-year time horizon is 12 mmbd (about 4.4 billion barrels per year) at $40, with a discount rate of 5 percent applied to the revenue stream. These assumptions yield annual revenues of $175 billion, with a present value a bit less than $3.5 trillion.
For the 10-year period, I assume a discount rate of 10 percent, reflecting an increase in the perceived threats to the House of Saud and thus a shortening of its time horizon. That increased fear in this conceptual exercise changes the Saudi maximand to the present value of sales revenues over that 10-year horizon. Under the assumption discussed above that sales revenue is a reasonable proxy for profits, this change in conditions induces a price cut from $40 to $30 per barrel, a production increase to about 21 mmbd (about 7.7 billion barrels per year), and annual revenues of about $300 billion, with a present value of $1.8 trillion. Under a demand elasticity assumption of 3, a $35 price increases annual Saudi sales to about 6 billion barrels and annual sales revenues to $211 billion, with a present value of about $1.3 trillion. For a $25 price, the respective figures are 9.3 billion barrels, $233 billion, and $1.4 trillion. For a $20 price, the respective figures are 11 billion barrels, $219 billion, and $1.3 trillion. If we assume no change in the discount rate from 5 percent, the 10-year horizon yields the same maximizing price of $30, production of 7.7 billion barrels per year, and annual sales revenues of $300 billion with a present value of $2.3 trillion.

This conceptual exercise is far from obviously “correct” in the sense that several alternative quantitative assumptions would be equally plausible and might yield different numbers. But neither is it obviously flawed. The interesting observation to be made is that the current production/price implications of an overthrow/coup d’état threat assumption appear not very different from those attendant upon a dynamic profit-maximization assumption in which the goal is punishment of overseas competitors. But those alternative hypotheses imply different implications for future investment by those competitors. The coup d’état hypothesis at least arguably yields higher long-run prices in the future periods during which the House of Saud no longer is dumping oil on the market. Investment incentives for foreign competitors might be preserved. The punishment hypothesis also might yield higher future prices, but it still maintains the threat to drive prices down after foreign competitors have sunk large investments into new production facilities.

Note also that a (perhaps explicitly Wahhabi) regime replacing the House of Saud also would face threats to its political control of the Arabian government and oil revenues, and presumably would need revenues to placate its enemies both internal and external. Other regimes in the region would have the same incentives to disrupt Arabian production so as to raise market prices. At the same time, it is reasonable to hypothesize that an Arabian regime driven explicitly by Wahhabi ideology might have stronger political preferences to “punish” the West by reducing output and perhaps investment, yielding higher prices over the short run. But in contrast with a Saudi dynamic profit maximization/punish competitors strategy, this Arabian/Wahhabi strategy implies a reduction in the importance of Arabian oil production over time and increased incentives for investment in production capacity by overseas competitors.

The recent decline in prices is consistent with a number of hypotheses, and several may play a part in observed changes in Saudi behavior and resulting market conditions. A straightforward example is the Saudi desire to reduce revenues earned by the Iranians, a regime that can be described without exaggeration as a Saudi enemy and military threat.

Table 2. House of Saud Oil Production Under 100-Year and 10-Year Horizons

<table>
<thead>
<tr>
<th></th>
<th>100-Year Horizon (5% discount rate)</th>
<th>10-Year Horizon (10% discount rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual oil production (billion barrels)</td>
<td>4.4</td>
<td>7.7</td>
</tr>
<tr>
<td>Price per barrel ($)</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>Annual total revenues ($ billions)</td>
<td>175</td>
<td>233</td>
</tr>
<tr>
<td>Revenues present value ($ billions)</td>
<td>3,473</td>
<td>1,843</td>
</tr>
</tbody>
</table>

Source: Author’s computations, available upon request.

49 Under a demand elasticity assumption of 3, a $35 price increases annual Saudi sales to about 6 billion barrels and annual sales revenues to $211 billion, with a present value of about $1.3 trillion. For a $25 price, the respective figures are 9.3 billion barrels, $233 billion, and $1.4 trillion. For a $20 price, the respective figures are 11 billion barrels, $219 billion, and $1.3 trillion. If we assume no change in the discount rate from 5 percent, the 10-year horizon yields the same maximizing price of $30, production of 7.7 billion barrels per year, and annual sales revenues of $300 billion with a present value of $2.3 trillion.

50 The Wahhabi or other “Arabian” regime replacing the House of Saud is likely to face similar incentives: threats to its control of oil revenues and a time horizon shorter rather than longer. This might not be the case if the new regime were to enjoy protection from the Iranians and their (future) nuclear umbrella.

51 See Wilson Center, “Timeline of Iran-Saudi Relations.”
cannot explain the increase in prices observed since January. One conjecture might be that the increasing size of world output disruptions has driven the increase, as illustrated in Figure 7.\textsuperscript{52}

Non-OPEC disruptions have been declining, while OPEC disruptions are both larger and growing. For the world as a whole, the average monthly disruption in 2012 was 1.9 mmbd. For 2013–2015, the respective figures are 2.7 mmbd, 2.9 mmbd, and 3.1 mmbd. (If we include the smaller numbers for January through March 2016 in the 2015 average, it still is 2.9 mmbd.) Figure 8 shows the trend for world supply disruptions as a percent of world production; that percentage has been growing as a longer-term trend since 2011.

Accordingly, the recent price increases seem to be consistent with a possible perception that growing supply disruptions may be a more or less permanent feature of the market. Since 2000, Saudi production of crude oil (not including associated liquids) has increased from roughly 8.4 mmbd to about 10.0 mmbd in 2015.\textsuperscript{53} This might be consistent with heightened Saudi fears of political threats increasing the attractiveness of current revenues relative to future ones. Revenues earned sooner also might be viewed as more valuable in terms of buying political support.

IV. Price Effects of a “Severe” Supply Disruption

To the extent that the higher prices observed since January 2016 have resulted from increased market expectations of supply disruptions, it is interesting to think about the likely price effects of a “severe” disruption, the most obvious scenario for which would be a cutoff

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of Persian Gulf crude supplies due to a war interrupting shipments through the Strait of Hormuz.

Persian Gulf production in 2015 was about 24.4 mmbd, or 30 percent of world production of about 80.1 mmbd. Let us assume a worst-case scenario in which these supplies are removed from the world market for, say, 10 years. I assume also that Persian Gulf production would not have increased in the absence of the disruption, and that the world price elasticity of demand for crude oil is 0.10 (in absolute value) in the short run, increasing by 0.025 each year for the duration of the disruption. The immediate effect upon the world market price of oil, caused by a supply reduction of 30 percent, would be an increase of about 300 percent, that is, a quadrupling. Let us assume also that producers outside the Persian Gulf increase output by, say, 1 million barrels per day each year beginning in the second year. This response in part is caused by the price increase and in part moderates the price increase. If we assume that half of that total production increase moderates prices, the true “supply” effect is 500,000 barrels per day each year beginning in the second year. Table 3 summarizes these production and price effects for the 10 years beginning with the disruption assumed to occur in 2017.

This simulation is highly simplistic and artificial. In particular, Persian Gulf production is assumed to have been constant (not growing) over the disruption period had there been no disruption, and the same is true for market demand conditions (only the disruption and resulting price effects change consumption behavior).


55 This assumption is driven by the standard axiom that the elasticities of demand and supply increase with time, that is, ever-greater adjustments to a shift in exogenous conditions become economic as more time is allowed to make them.

56 In other words, part of the supply response is an upward movement along the existing non–Persian Gulf supply function due to higher prices, and part is an outward shift of the non–Persian Gulf supply curve resulting from the increased investment (rate of return) driven by the price increase.
To the extent that Persian Gulf output is the marginal source of world supplies, those assumptions offset each other qualitatively, but it is not the case that increased world output comes only from the Persian Gulf.57

But this exercise, whatever its shortcomings, is revealing. World crude oil prices only two years ago were at about $109 per barrel, only about one-third lower than the price ($162) to which the market in the first year would be driven by this severe hypothetical disruption under a reasonable approximation of current market conditions. The assumption of a demand elasticity of 0.1 biases the derived price increase upward; the actual elasticity is likely to be higher.58 Market forces yield steady declines in prices over time, after only a few years to levels not vastly higher than those observed recently in the absence of severe disruptions, but with some considerable ongoing turmoil in the Middle East. Figure 9 illustrates this pattern of relatively quick recovery from the effects of supply disruptions by displaying the historical data on oil prices for 1861–2014.59

What is interesting is how short the periods of high or rising prices are. This may be due to market adjustment processes, the effect of high prices on new investment, or perhaps other factors. This historical pattern is consistent with the results of the simple simulation reported in Table 3.

V. An Aside: Two Criticisms of Conventional Wisdom

The analytic errors inherent in two common dimensions of conventional wisdom can be summarized as follows.

First, many observers and commentators on the international oil market often refer to pricing and production behavior by “the OPEC cartel,” but that characterization is problematic.60 OPEC has never behaved like a cartel, at least in the classic sense of allocating production shares so as to equate marginal production cost across producers. It is Saudi production that historically has determined world market prices simply because Saudi production and reserves have been so large. It is more useful analytically to view OPEC as one big producer determining the market price as driven by some complex mix of policy goals, and a number of

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57 See US Energy Information Administration, “Crude Oil Proved Reserves.”
58 See Hamilton, “Understanding Crude Oil Prices.”
smaller ones who accept that price and then try to find ways to erode it so as to garner bigger market shares (revenues) for themselves. An example of such price shaving is credit for buyers extending beyond the usual 30 days. Games can be played also with the qualities of oil delivered and with a number of other parameters.  

Second, many observers argue that it was the 1973 OPEC oil embargo that created the gasoline queues and other market distortions observed in the United States, but that historical interpretation is not correct. Since there was and remains one world market for crude oil, an embargo—a refusal to sell to a given buyer (i.e., impose a higher price on that buyer only)—cannot work because market forces will reallocate oil until prices are equalized everywhere, adjusting for such minor complications as differential transport costs. The 1973 embargo aimed at the US, the Netherlands, and a few others had no effect at all: The targeted nations obtained oil on the same terms as all other buyers, although the transport directions of oil trade changed because of the reallocation process. It was the production cutback by Arab OPEC that raised international prices, and it was the US system of price and allocation controls that created the queues and other market distortions. There was no embargo in 1979, but there was a production cutback in the wake of the Iranian revolution, and the US again imposed price and allocation regulations. Once again, there were queues and market distortions.  

VI. Conclusions  

The basic problem with the dynamic profit maximization/market punishment model of Saudi strategy is straightforward: It seems to imply a sine wave of price increases and declines over time. Should those not be foreseeable? That model falls short as economic analysis because it asks the wrong question: Will future oil prices remain low? The correct question is much more difficult: Why are current prices not far higher already? After all, dynamic profit maximization by the Saudis, aimed at reducing competitive investments in

61 See Zycher, “OPEC.”  

production capacity, is hardly a secret, and it simply is not plausible that current prices do not reflect this factor. Accordingly, the resulting inference—having fallen sharply, prices will rise at a rate faster than the market rate of interest—can be restated a bit more provocatively: The market is making a mistake obvious, fundamental, and systematic. Perhaps it is, but that is not the smart way to bet when armed only with *ex ante* information available to all. If the proponents of that view have inside information—would they share it?—or hindsight derived from some sort of time travel, they are going to find themselves very wealthy indeed.

Moreover, that common view seems to ignore the certainty that technological advances will continue, even if we cannot describe them *ex ante*. Will such expectations have the effect of reducing both the level and the slope of the future price path? It seems reasonable to hypothesize that they will, and a discussion of price paths for oil should take this factor into account.

Hassett has done a real service by writing an intelligent essay forcing all of us to confront the conundrum of international oil prices generally, and the complex and fascinating optimization problem faced by the House of Saud in particular. This truly is an area in which specialists in economics and in the international politics and defense dynamics of the Middle East have much to learn from each other.

**About the Author**

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