Historical Oil Shocks*

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December 22, 2010
Revised: February 1, 2011

ABSTRACT

This paper surveys the history of the oil industry with a particular focus on the events associated with significant changes in the price of oil. Although oil was used much differently and was substantially less important economically in the nineteenth century than it is today, there are interesting parallels between events in that era and more recent developments. Key post-World-War-II oil shocks reviewed include the Suez Crisis of 1956-57, the OPEC oil embargo of 1973-1974, the Iranian revolution of 1978-1979, the Iran-Iraq War initiated in 1980, the first Persian Gulf War in 1990-91, and the oil price spike of 2007-2008. Other more minor disturbances are also discussed, as are the economic downturns that followed each of the major postwar oil shocks.

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1. 1859-1899: Let there be light.

Illuminants, lubricants, and solvents in the 1850s were obtained from a variety of sources, such as oil from lard or whale, alcohol from agricultural products, and turpentine from wood. Several commercial enterprises produced petroleum or gas from treatment of coal, asphalt, coal-tars, and even shale. But a new era began when Edwin Drake successfully produced commercially usable quantities of crude oil from a 69-foot well in Pennsylvania in 1859.

From the beginning, this was recognized as an extremely valuable commodity, as *Derrick's Hand-Book of Petroleum* (1898, p. 706) described:

> Petroleum was in fair demand at the time of Colonel Drake and his associates.... for practical experiments had proved that it made a better illuminant than could be manufactured from cannel coal by the Gessner and Downer processes. All that could be obtained from the surface springs along Oil creek and the salt wells of the Allegheny valley found a ready market at prices ranging from 75 cents to $1.50 and even $2.00 per gallon.

With about 40 gallons in a barrel, the upper range quoted corresponds to $80 per barrel of crude oil, or $1,900/barrel in 2009 dollars. Given the expensive process of making oil from coal and the small volumes in which an individual household consumed the product, obtaining oil by drilling into the earth appeared to be a bargain:

> Drake's discovery broke the market. The fact that the precious oil could be obtained in apparently inexhaustible quantities by drilling wells in the rocky crust of the earth, was a great surprise. The first product of the Drake well was sold at 50 cents a gallon, and the price for oil is generally given at $20.00 a barrel from August, 1859 down to the close of the year.

As production from Pennsylvania wells increased, the price quickly fell, averaging $9.60/barrel during 1860, which would correspond to $228/barrel in 2009 dollars.

Not surprisingly, such prices stimulated a fury of drilling efforts throughout the region. Production quadrupled from a half million barrels in 1860 to over 2 million in

1861, and the price quickly dropped to $2/barrel by the end of 1860 and 10 cents a barrel by the end of 1861. Many new would-be oil barons abandoned the industry just as quickly as they had entered.

1862-1864: The first oil shock. The onset of the U.S. Civil War brought about a surge in prices and commodity demands generally. The effects on the oil market were amplified by the cut-off of supplies of turpentine from the South and more importantly by the introduction of a tax on alcohol, which rose from 20¢/gallon in 1862 to $2/gallon by 1865 (Ripy, 1999) in contrast to the 10¢/gallon tax on petroleum-derived illuminants. Assuming a yield of about 20 gallons of illuminant per barrel of crude, each 10¢/gallon tax differential on illuminant amounted to a $2/barrel competitive advantage for oil. As a result, the tax essentially eliminated alcohol as a competitor to petroleum as a source for illuminants. Moreover, the price collapse of 1861 had led to the closure of many of the initial drilling operations, while water flooding and other problems forced out many others. The result was that oil production began to decline after 1862, even as new pressures on demand grew (see Figure 1).

Figure 2 plots the inflation-adjusted price of oil from 1860 to 2009.[1] The price is plotted on a logarithmic scale, so that a vertical move of 10 units corresponds approximately to a 10% price change.[2] As a result of these big increases in demand and drops in supply, the increase in the relative price of oil during the U.S. Civil War was as

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[1] The number plotted is the series for oil prices in 2009 dollars from British Petroleum, *Statistical Review of World Energy 2010,* which are also the numbers used by Dvir and Rogoff (2010). The source for the BP nominal price series appears to be the same as Jenkins (1985, Table 18), which were then evidently deflated using the consumer price index (BLS) for all items from *Historical Statistics of the United States,* Table E135-166. Since Jenkins original series goes back to 1860, that value ($9.59/barrel, almost identical to that reported in *Derrick's Hand-Book,* p. 711) is also included in the figure provided here. As noted in the text, the early Pennsylvanian market started even higher than this and was somewhat chaotic.

[2] If $100 \times [\ln(P_t) - \ln(P_s)] = 10,$ then $P_t / P_s = e^{0.1} = 1.105,$ meaning that P_t is 10.5% higher than P_s.

big as the rise during the 1970s.

1865-1899: Evolution of the industry. After the war, demand for all commodities fell significantly. At the same time, drilling in promising new areas of Pennsylvania had resulted in a renewed growth in production. The result was a second collapse in prices in 1866, though more modest than that observed in 1860-61. Two similar boom-bust cycles were repeated over the next decade, with relative stability at low prices becoming the norm after development of very large new fields in other parts of Pennsylvania. By 1890, oil production from Pennsylvania and New York was 5 times what it had been in 1870. Production in other states had grown to account for 38% of the U.S. total, and Russia was producing almost as much oil as the United States. These factors and the recession of 1890-91 had brought oil back down to 56¢/barrel by 1892.

However, that proved to be the end of the easy production from the original Pennsylvanian oilfields. Annual production from Pennsylvania fell by 14 million barrels between 1891 and 1894 (see Figure 1), and indeed even with the more technologically advanced secondary recovery techniques adopted in much later decades, never again reached the levels seen in 1891 (Caplinger, 1997). Williamson and Daum (1959, p. 577) suggested that the decline in production from the Appalachian field (Pennsylvania, West Virginia, and parts of Ohio and New York) along with a loss of world access to Russian production due to a cholera epidemic in Baku in 1894 were responsible for the spike in oil prices in 1895.

Dvir and Rogoff (2010) emphasized the parallels between the behavior of oil prices in the nineteenth century and that subsequently observed in the last quarter of the twentieth century. There are some similarities, in terms of the interaction between the

exhaustion in production of key fields with strong demand, and in either century there were buyers who were willing to pay a very high price. But despite similarities, there are also some profound differences. First, oil was of much less economic importance in the nineteenth century. In 1900, the U.S. produced 63.6 million barrels of oil. At an average price of $1.19/barrel, that represents $75.7 million, which is only 0.4% of 1900 estimated GNP of $18,700 million. For comparison, in 2008, the U.S. consumed 7.1 billion barrels of oil at an average price of $97.26/barrel, for an economic value of $692 billion, or 4.8% of GDP.

2. 1900-1945: Power and transportation.

There is another key respect in which petroleum came to represent a fundamentally different economic product as the twentieth century unfolded. In the nineteenth century, the value of oil primarily derived from its usefulness for fabricating illuminants. As the twentieth century developed, electric lighting came to replace these, while petroleum gained increasing importance for commercial and industrial heat and power as well as transportation, first for railroads and later for motor vehicles. Figure 3 shows that U.S. motor vehicle registrations rose from 0.1 vehicle per 1,000 residents in 1900 to 87 by 1920 and 816 in 2008.

In addition to growing importance in terms of direct economic value, oil came to become an integral part of many other key economic sectors such as automobile manufacturing and sales, which as we shall see would turn out to be an important factor in business cycles after World War II.

The West Coast Gasoline Famine of 1920. Problems in the gasoline market on the U.S. west coast in 1920 might be viewed as the first oil-related shock of the transportation era. U.S. consumption of crude oil had increased 53% between 1915 and

1919 and increased an additional 27% in 1920 alone (Pogue, 1921, p. 61). Olmstead and

Rhode (1985, pp. 1044-1045) provided this description:

> In the spring and summer of 1920 a serious gasoline famine crippled the entire
> West Coast, shutting down businesses and threatening vital services. Motorists
> endured hour-long lines to receive 2-gallon rations, and, in many localities, fuel
> was unavailable for as long as a week at a time....
>
> [A]uthorities in Wenatchee, Washington, grounded almost 100 automobiles after
> spotting them late one Saturday night "on pleasure bent." Police ordered
> distributors not to serve these "joyriders" for the duration of the shortage.
> Seattle police began arresting drivers who left their parked vehicles idling.
> Everywhere individuals caught hoarding or using their privileged status to earn
> black market profits were cut off and even prosecuted. Many localities
> issued ration cards, and most major cities seriously considered it....
>
> On July 2 in Oakland, California, 150 cars queued at one station impeding
> traffic over a four-block area. On July 16, Standard's stations in Long Beach
> relaxed restrictions so that after 2:00 P.M., all cars (as opposed to only
> commercial vehicles) could buy up to 2 gallons. This caused such a jam
> that "it was necessary for the assistant special agent to spend two hours in keeping
> the traffic from blocking the streets".... Drivers in the Pacific Northwest endured
> 2-gallon rations for several months, and even with these limits stations often
> closed by 9:00 A.M. In San Francisco, gunplay erupted in a dispute over ration
> entitlements.

Petroleum was still much less important for the economy in 1920 than it was to

become after World War II. Moreover, these problems seem to have been confined to the

West Coast, a much less populated region than it was later to become. It is nevertheless

perhaps worth noting that these shortages coincided with a U.S. business cycle

contraction that the NBER dates as beginning January 1920 and ending July 1921, a

correlation which as we will see would be repeated quite frequently later in the century.[3]

The Great Depression and state regulation. Huge gains in production from

Texas, California, and Oklahoma quickly eliminated the regional shortages of 1920 and

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[3] Interestingly, McMillin and Parker (1994) also found evidence that over the period 1924:M2-1938:M6,
oil price changes could help predict subsequent changes in industrial production, with the effects both
economically and statistically significant.

induced a downward trend in oil prices over the next decade, with oil prices falling 40% between 1920 and 1926. The decline in demand associated with advent of the Great Depression in 1929 magnified the price impact of phenomenal new discoveries such as the gigantic East Texas field which began production in 1930. By 1931, the price of oil had dropped an additional 66% from its value in 1926.

These competitive pressures facing the industry interacted with another challenge that had been present from the beginning-- how to efficiently manage a given reservoir. The industry had initially been guided by the rule of capture, which resulted in a chaotic race among producers to extract the oil from wells on adjacent properties. For example, the gusher in Spindletop, Texas in 1901 was soon being exploited by over a hundred different companies (Yergin, 1991, p. 70) with more than 3 wells per acre (Williamson, et. al., 1963, p. 555). This kind of development presented a classic tragedy of the commons problem in which significantly less oil was eventually extracted than would have been possible with better management of the reservoir. The legitimate need for better-defined property rights interacted with the three other tides of the Great Depression-- growing supplies, falling demand, and a shifting political consensus favoring more regulation of industry and restrictions on competition.

The result was that the United States emerged from the Great Depression with some profound changes in the degree of government supervision of the industry. At the state level the key players were regulatory agencies such as the Texas Railroad Commission (TRC) and the Oklahoma Corporation Commission. The states' power was supplemented at the federal level by provisions of the National Industrial Recovery Act of 1933 and the Connally Hot Oil Act of 1935, which prohibited interstate shipments of

oil produced in violation of the state regulatory limits.

Of the state agencies, the most important was Texas, which accounted for 40% of the crude petroleum produced in the United States between 1935 and 1960. The TRC's mandate was to "prevent waste", which from the beginning was a mixture of the legitimate engineering issue of efficient field management and the more controversial economic goal of restricting production in order to ensure that producers received a higher price. As the system evolved, the TRC would assign a "maximum efficient rate" at which oil could be extracted from a given well, and then specify an allowable monthly production flow for that well at some level at or below the maximum efficient rate.

In terms of the narrow objective of preserving the long-run producing potential of oil fields, these regulatory efforts would be judged to be a success. For example, Williamson, et. al. (1963, p. 554) noted that in fields in Texas and Oklahoma that were exploited before regulation, within 4-6 years the fields were producing less than 1/10 of what they had at their peak. By contrast, fields developed after regulations were in place were still producing at 50-60% of their peak levels 15 years later. Once production from the entire state of Texas peaked in 1972, the decline rate was fairly gradual (see Figure 4), in contrast to the abrupt drops that were associated with the frenetic development of the Pennsylvanian fields seen in Figure 1.

3. 1946-1972: The early postwar era.

The United States has always been the world's biggest consumer of oil, and remained the world's biggest producer of petroleum until 1974 when it was surpassed by the Soviet Union. In the initial postwar era, prices throughout the world were quoted relative to that for oil in the Gulf of Mexico (Adelman, 1972, Chapter 5), making the Texas Railroad Commission a key player in the world oil market.

Although state regulation surely increased the quantity of oil that would ultimately be recovered from U.S. fields, it also had important consequences for the behavior of prices. The production allowables set by the Texas Railroad Commission came to be based on an assessment of current market demand rather than pure considerations of conservation. Each month, the TRC would forecast product demand at the current price and set allowable production levels consistent with this demand. The result was that discounts or premiums were rarely allowed to continue long enough to lead to a change in posted prices, and the nominal price of oil was usually constant from one month to the next. On the other hand, the commissions would often take advantage of external supply disruptions to produce occasional abrupt changes in oil prices in the early postwar era (see Figure 5). The nominal price of oil in the era of the Texas Railroad Commission thus turned out to be a fairly unique time series, changing only in response to specific identifiable events.[4]

1947-1948: Postwar dislocations. The end of World War II marked a sharp acceleration in the transition to the automotive era. U.S. demand for petroleum products increased 12% between 1945 and 1947 (Williamson, et. al., 1963, p. 805) and U.S. motor vehicle registrations increased by 22% (see Figure 3). The price of crude oil increased 80% over these two years, but this proved insufficient to prevent spot accounts of shortages. Standard Oil of Indiana and Phillips Petroleum Company announced plans in June of 1947 to ration gasoline allocations to dealers,[5] and in the fall there were reports of shortages in Michigan, Ohio, New Jersey, and Alabama.[6] Fuel oil shortages resulted in

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[4] This and the following discussion draws heavily from Hamilton (1983b, 1985).
[5] *New York Times,* June 25, 1947, 1:6; June 27, 33:2.
[6] *New York Times,* August 12, 1947, 46:1; August 22, 9:2; November 3, 25:7; November 19, 24:3.

thousands without heat that winter.[7] An overall decline in residential construction spending began in 1948:Q3, with the first postwar U.S. recession dated as beginning in November of 1948.

1952-1953: Supply disruptions and the Korean conflict. The price of oil was frozen during the Korean War as a result of an order from the Office of Price Stabilization in effect from January 25, 1950 to February 13, 1953.[8] Prime Minister Mohammad Mossadegh nationalized Iran's oil industry in the summer of 1951, and a world boycott of Iran in response removed 19 million barrels of monthly Iranian production from world markets.[9] A separate strike by U.S. oil refinery workers on April 30, 1952 shut down a third of the nation's refineries.[10] In response, the United States and British governments each ordered a 30% cut in delivery of fuel for civilian flights, while Canada suspended all private flying.[11] Kansas City and Toledo instituted voluntary plans to ration gasoline for automobiles, while Chicago halted operations of 300 municipal buses.[12] When the price controls were lifted in June of 1953, the posted price of West Texas Intermediate increased 10%. The second postwar recession is dated as beginning the following month.

1956-1957: Suez Crisis. Egyptian President Nasser nationalized the Suez Canal in July of 1956. Hoping to regain control of the canal, Britain and France encouraged Israel to invade Egypt's Sinai territories on October 29, followed shortly after by their

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[7] *New York Times,* January 5, 1948, 11:2.
[8] From the *New York Times,* May 8, 1951, 45:1: The Office of Price Stabilization "announced a regulation establishing ceiling prices for new oil, generally at prices posted on January 25, for any given pool. Prices for crude oil have been governed up to now by the general price 'freeze' which set the ceilings at the highest price attained between December 19, 1950 and January 25."
[9] *International Petroleum Trade,* Bureau of Mines, U.S. Department of Interior, May 1952, p. 52.
[10] *Wall Street Journal,* May 7, 1952, p. 2.
[11] *Wall Street Journal,* May 5, 1952, 3:1; May 7, 2:2, May 12, 2:2.
[12] *New York Times,* May 5, 1952, 1:6; May 9, 16:7.

own military forces. During the conflict, 40 ships were sunk, blocking the canal through

which 1-1/2 million barrels per day of oil were transported. Pumping stations for the Iraq

Petroleum Company's pipeline, through which an additional half-million barrels per day

moved through Syria to ports in the eastern Mediterranean, were also sabotaged.[13] Total

oil production from the Middle East fell by 1.7 mb/d in November 1956. As seen in

Figure 6, that represents 10.1% of total world output at the time, which is a bigger

fraction of world production than would be removed in any of the subsequent oil shocks

that would be experienced over the following decades.

These events had dramatic immediate economic consequences for Europe, which

had been relying on the Middle East for 2/3 of its petroleum. Consider for example in

this account from the *New York Times*:[14]

> LONDON, December 1-- Europe's oil shortage resulting from the Suez Canal
> crisis was being felt more fully this week-end. . . . Dwindling gasoline supplies
> brought sharp cuts in motoring, reductions in work weeks and the threat of layoffs
> in automobile factories.
>
> There was no heat in some buildings; radiators were only tepid in others. Hotels
> closed off blocks of rooms to save fuel oil. . . . [T]he Netherlands, Switzerland,
> and Belgium have banned [Sunday driving]. Britain, Denmark, and France have
> imposed rationing.
>
> Nearly all British automobile manufacturers have reduced production and put
> their employees on a 4-day instead of a 5-day workweek. . . . Volvo, a leading
> Swedish car manufacturer, has cut production 30%.
>
> In both London and Paris, long lines have formed outside stations selling
> gasoline. . . . Last Sunday, the Automobile Association reported that 70% of the
> service stations in Britain were closed.
>
> Dutch hotel-keepers estimated that the ban on Sunday driving had cost them up to
> 85% of the business they normally would have expected.
>
> Within a few months, production from outside the Middle East was able to fill in

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[13] *Oil and Gas Journal,* Nov 12, 1956, 122-125.

much of the gap. For example, U.S. exports of crude oil and refined products increased a third of a million barrels a day in December.[15] By February, total world production of petroleum was back up to where it had been in October. Middle East production had returned to its pre-crisis levels by June of 1957 (see Figure 6).

Notwithstanding, overall real U.S. exports of goods and services started to fall after the first quarter of 1957 in what proved to be an 18% decline over the next year. This decline in exports was one of the factors contributing to the third postwar U.S. recession that began in August of that year.

1969-1970: Modest price increases. The oil price increases in 1969 and 1970 are in part a response to the broader inflationary pressures of the late 1960s (see Figure 7). However, the institutional peculiarities of the oil market caused these to be manifest in the form of the abrupt discrete adjustments observed in Figures 5 and 7 rather than a smooth continuous adaptation. The immediate precipitating events for the end-of-decade price increases included a strike by east coast fuel oil deliverers in December of 1968, which was associated with local accounts of consumer shortages,[16] and followed by a nationwide strike on January 4 of the Oil, Chemical, and Atomic Workers Union. After settlement of the latter strike, Texaco led the majors in announcing a 7% increase in the price of all grades of crude oil on February 24, 1969, citing higher labor costs as the justification.[17] The rupture of the Trans-Arabian pipeline in May 1970 in Syria may have helped precipitate a second 8% jump in the nominal price of oil later that year. The fifth postwar recession is dated as beginning in December of 1969, 10 months after the

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[14] *New York Times,* Dec 2, 1956, 1:5.
[15] *Minerals Yearbook,* 1957, p. 453.
[16] *New York Times,* Dec 25, 1968, 1:3; Dec 27, 1:5.
[17] *New York Times,* Feb 25, 1969, 53:3.

first price increase.

4. 1973-1996: The age of OPEC.

It is helpful to put subsequent events into the perspective of some critical broader trends. In the late 1960s, the Texas Railroad Commission was rapidly increasing the allowable production levels for oil wells in the state, and eliminated the "conservation" restrictions in 1972 (see Figure 8). The subsequent drop in production from Texas fields observed in Figure 4 was due not to state regulation but rather to declining flow rates for mature fields. Oil production for the United States as a whole also peaked in 1972, despite the production incentives subsequently to be provided by huge price increases after 1973 and the exploitation of the giant Alaskan oilfield in the 1980s (see Figure 9).

Although there proved to be abundant supplies available in the Middle East to replace declining U.S. production, the transition from a world petroleum market centered in the Gulf of Mexico to one centered in the Persian Gulf did not occur smoothly. In addition to the depletion of U.S. oil fields, Barsky and Kilian (2001) pointed to a number of other factors that would have warranted an increase in the relative price of oil in the early 1970s. Among these was the U.S. unilateral termination of the rights of foreign central banks to convert dollars to gold. The end of the Bretton Woods system caused a depreciation of the dollar and increase in the dollar price of most internationally traded commodities. In addition, the nominal yield on 3-month Treasury bills was below the realized CPI inflation rate from August 1972 to August 1974. These negative real interest rates may also have contributed to increases in relative commodity prices (Frankel, 2008). Between August 1971 and August 1973, the producer price index for lumber increased 42%. The PPI for iron and steel was up 8%, while nonferrous metals increased 19% and foodstuffs and feedstuffs 96%. The 10% increase in the producer

price index for crude petroleum between August 1971 and August 1973 was if anything more moderate than many other commodities. Given declining production rates from U.S. fields, further increases in the price of oil would have been expected.

Another factor making the transition to a higher oil import share more bumpy was the system of price controls implemented by President Nixon in conjunction with the abandonment of Bretton Woods in 1971. By the spring of 1973, many gasoline stations had trouble obtaining wholesale gasoline, and consumers began to be affected, as described for example in this report from the *New York Times*:[18]

> With more than 1,000 filling stations closed for lack of gasoline, according to a Government survey, and with thousands more rationing the amount a motorist may buy, the shortage is becoming a palpable fact of life for millions in this automobile-oriented country.

The sixth postwar recession began in November 1973, just after the dramatic geopolitical events that most remember from this period.

1973-1974: OPEC Embargo. Syria and Egypt led an attack on Israel that began on October 6, 1973. On October 17, the Arab members of the Organization of Petroleum Exporting Countries announced an embargo on oil exports to selected countries viewed as supporting Israel, which was followed by significant cutbacks in OPEC's total oil production. Production from Arab members of OPEC in November was down 4.4 mb/d from what it had been in September, a shortfall corresponding to 7.5% of global output.[19] Increases in production from other countries such as Iran offset only a small part of this (see Figure 10). On January 1, 1974 the Persian Gulf countries doubled the price of oil.

Accounts of gasoline shortages returned, such as this report from the *New York*

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[18] *New York Times,* Jun 8, 1973, 51:1.

Times:[20]

> HARTFORD, Dec 27-- "Some of the customers get all hot and heavy," [Exxon service station attendant Grant] McMillan said. "They scream up and down.... It's ridiculous.
>
> The scene is a familiar one in Connecticut as service station managers find themselves having to decide whether to ration their gasoline or sell it as fast as they can and cut the number of arguments....
>
> "People driving along, if they see anyone getting tanked up, they pull in and get in line," said Bruce Faucher, an attendant at [a Citgo] station. "If we don't limit them, we'd be out in a couple of hours and wouldn't have any for our regular customers."

Frech and Lee (1987) estimated that time spent waiting in queues to purchase gasoline added 12% to the cost of gasoline for urban residents in December 1973 and 50% in March 1974. They assessed the problem to be more severe in rural areas, with estimated costs of 24% and 84%, respectively.

Barsky and Kilian (2001) have emphasized the importance of the economic motivations noted earlier rather than the Arab-Israeli War itself as explanations for the embargo. They noted that the Arab oil producers had discussed the possibility of an embargo prior to the war, and that the embargo was lifted without the achievement of its purported political objectives. While there is no doubt that economic considerations were very important, Hamilton (2003, p. 389) argued that geopolitical factors played a role as well:

> If economic factors were the cause, it is difficult to see why such factors would have caused Arab oil producers to reach a different decision from nonArab oil producers. Second, the embargo appeared to be spearheaded not by the biggest oil producers, who would be expected to have the most important economic stake,

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[19] Kilian (2008) suggested that this calculation overstates the effects of the embargo. He argued that production by Saudi Arabia and Kuwait was unusually high in September 1973 and that there would have been some decreases from those levels even in the absence of an embargo.
[20] *New York Times,* Dec 18, 1973, 12.

but rather by the most militant Arab nations, some of whom had no oil to sell at all.

My conclusion is that, while it is extremely important to view the oil price increases of 1973-1974 in a broader economic context, the specific timing, magnitude, and nature of the supply cutbacks were closely related to geopolitical events.

1978-1979: Iranian revolution. The 1973 Arab-Israeli War turned out to be only the beginning of a turbulent decade in the Middle East. Figure 11 plots the monthly oil production for 5 of the key members of OPEC since 1973. Iran (top panel) in defiance of the Arab states had increased its oil production during the 1973-74 embargo, but was experiencing large public protests in 1978. Strikes spread to the oil sector by the fall of 1978, bringing Iranian oil production down by 4.8 mb/d (or 7% of world production at the time) between October 1978 and January 1979. In January the Shah fled the country, and Sheikh Khomeini seized power in February. About a third of the lost Iranian production was made up by increases from Saudi Arabia and elsewhere (see Figure 12).

Gasoline queues were again a characteristic of this episode, as seen in this report from the *New York Times*:[21]

> LOS ANGELES, May 4-- "It's horrible; it's just like it was five years ago," Beverly Lyons, whose Buick was mired 32d in a queue of more than 60 cars outside a Mobil station, said shortly after 8 o'clock this morning.
>
> I've been here an hour; my daughter expects her baby this weekend," she added. "I've got to get some gas!"
>
> Throughout much of California today, and especially so in the Los Angeles area, there were scenes reminiscent of the nation's 1974 gasoline crisis.
>
> Lines of autos, vans, pickup trucks and motor homes, some of the lines were a half mile or longer, backed up from service stations in a rush for gasoline that appeared to be the result of a moderately tight supply of fuel locally that has been

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[21] *New York Times,* May 5, 1979, 11.

aggravated by panic buying.

Frech and Lee (1987) estimated that time spent waiting in line added about a third to the money cost for Americans to buy gasoline in May of 1979. The seventh postwar recession is dated as beginning in January of 1980.

1980-1981: Iran-Iraq War. Iranian production had returned to about half of its pre-revolutionary levels later in 1979, but was knocked out again when Iraq (second panel of Figure 11) launched a war against the country in September of 1980. The combined loss of production from the two countries again amounted to about 6% of world production at the time, though within a few months, this shortfall had been made up elsewhere (see Figure 13).

Whether one perceives the Iranian Revolution and Iran-Iraq War as two separate shocks or a single prolonged episode can depend on the oil price measure. Some series, such as the WTI plotted in Figure 14, suggest one ongoing event, with the real price of oil doubling between 1978 and 1981. Other measures, such as the U.S. producer price index for crude petroleum or consumer price index for gasoline, exhibit two distinct spurts. Interpreting any price series is again confounded by the role of price controls on crude petroleum, which remained in effect in the United States until January 1981.

The National Bureau of Economic Research characterizes the economic difficulties at this time as being two separate economic recessions, with the seventh postwar recession ending in July 1980 but followed very quickly by the eighth postwar recession beginning July of 1981.

1981-1986: The great price collapse. The war between Iran and Iraq would continue for years, with oil production from the two countries very slow to recover.

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However, the longer term demand response of consuming countries to the price hikes of the 1970s proved to be quite substantial, and world petroleum consumption declined significantly in the early 1980s. Saudi Arabia voluntarily shut down 3/4 of its production between 1981 and 1985, though this was not enough to prevent a 25% decline in the nominal price of oil and significantly bigger decline in the real price. The Saudis abandoned those efforts, beginning to ramp production back up in 1986, causing the price of oil to collapse from $27/barrel in 1985 to $12/barrel at the low point in 1986. Although a favorable development from the perspective of oil consumers, this represented an "oil shock" for the producers. Hamilton and Owyang (forthcoming) found that the U.S. oil-producing states experienced their own regional recession in the mid 1980s.

1990-1991: First Persian Gulf War. By 1990, Iraqi production had returned to its levels of the late 1970s, only to collapse again (and bring Kuwait's substantial production down with it) when the country invaded Kuwait in August 1990. The two countries accounted for nearly 9% of world production (see Figure 15), and there were concerns at the time that the conflict might spill over into Saudi Arabia. Though there were no gasoline queues in America this time around, the price of crude oil doubled within the space of a few months. The price spike proved to be of short duration, however, as the Saudis used the substantial excess capacity that they had been maintaining throughout the decade to restore world production by November to the levels seen prior to the conflict. The ninth postwar U.S. recession is dated as beginning in July of 1990.

5. 1997-2010: A new industrial age.

The last generation has experienced a profound transformation for billions of the world's citizens as countries made the transition from agricultural to modern industrial

economies. This has made a tremendous difference not only in their standards of living, but also for the world oil market. A subset of the newly industrialized economies used only 17% of world's petroleum in 1998 but accounts for 69% of the increase in global oil consumption since then.[22] Particularly noteworthy are the 1.3 billion residents of China. China's 6.3% compound annual growth rate for petroleum consumption since 1998, if it continues for the next decade, would put the country at current American levels of oil consumption by 2022 and double current U.S. levels by 2033. And such extrapolations do not seem out of the question. Already China is the world's biggest market for buying new cars. Even so, China only has one passenger vehicle per 30 residents, compared with one vehicle per 1.3 residents in the United States (Hamilton, 2009a, p. 193). Whereas short-run movements in oil prices in the first half-century following World War II were dominated by developments in the Middle East, the challenges of meeting petroleum demand from the newly industrialized countries has been the most important theme of the last 15 years.

1997-1998: East Asian Crisis. The phenomenal growth in many of these countries had begun long before 1997, as economists marveled at the miracle of the "Asian tigers". And although their contribution to world petroleum consumption at the time was modest, the Hotelling Principle suggests that a belief that their growth rate would continue could have been a factor boosting oil prices in the mid 1990s.[23] But in the summer of 1997,

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[22] These calculations to are based on Brazil, China, Hong Kong, India, Singapore, South Korea, Taiwan, and Thailand. Data source: EIA, total petroleum consumption (http://tonto.eia.doe.gov/cfapps/ipdbproject/iedindex3.cfm?tid=5&pid=5&aid=2&cid=regions&syid=1980 &eyid=2009&unit=TBPD).

[23] World oil consumption grew by more than 2% per year between 1994 and 1997. Moreover, if oil producers correctly anticipated the growth in petroleum demand from the newly industrialized countries, it would have paid them to hold off some production in 1995 in anticipation of higher prices to come. By this mechanism, the perceived future growth rate can affect the current price. See Hamilton (2009a, Section 3.3) for a discussion of the Hotelling Principle.

Thailand, South Korea, and other countries were subject to a flight from their currency and serious stresses on the financial system. Investors developed doubts about the Asian growth story, putting economic and financial strains on a number of other Asian countries. The dollar price of oil soon followed them down, falling below $12 a barrel by the end of 1998. In real terms, that was the lowest price since 1972, and a price that perhaps never will be seen again.

1999-2000: Resumed growth. The Asian crisis proved to be short-lived, as the region returned to growth and the new industrialization proved itself to be very real indeed. World petroleum consumption returned to strong growth in 1999, and by the end of the year, the oil price was back up to where it had been at the start of 1997. The price of West Texas Intermediate continued to climb an additional 38% between November 1999 and November 2000, after which it fell again in the face of a broader global economic downturn. The tenth postwar U.S. recession began in March of 2001.

2003: Venezuelan unrest and the second Persian Gulf War. A general strike eliminated 2.1 mb/d of oil production from Venezuela in December of 2002 and January of 2003. This was followed shortly after by the U.S. attack on Iraq, which removed an additional 2.2 mb/d over April to July. These would both be characterized as exogenous geopolitical events, and they show up dramatically in Figure 11. Kilian (2008) argued they should be included in the list of postwar oil shocks. However, the affected supply was a much smaller share of the global market than many of the other events discussed here, and the disruptions had little apparent effect on global oil supplies (see Figure 16). Indeed, when one takes a 12-month moving average of global petroleum production, one sees nothing but phenomenal growth throughout 2003 (Figure 17). While oil prices rose

between November 2002 and February 2003, the spike proved to be modest and short lived (see Figure 14).

2007-2008: Growing demand and stagnant supply. Global economic growth in 2004 and 2005 was quite impressive, with the IMF estimating that real gross world product grew at an average annual rate of 4.7%.[24] World oil consumption grew 5 mb/d over this period, or 3% per year. These strong demand pressures were the key reason for the steady increase in the price of oil over this period, though there was initially enough excess capacity to keep production growing along with demand.

However, as seen in Figure 17, production did not continue to grow after 2005. Unlike many other historical oil shocks, there was no dramatic geopolitical event associated with this. Ongoing instability in places like Iraq and Nigeria were a contributing factor. Another is that several of the oil fields that had helped sustain earlier production gains reached maturity with relatively rapid decline rates. Production from the North Sea accounted for 8% of world production in 2001, but had fallen more than 2 mb/d from these levels by the end of 2007.[25] Mexico's Cantarell, which recently had been the world's second largest producing field, saw its production decline 1 mb/d between 2005 and 2008. Indonesia, one of the original members of the Organization of Petroleum Exporting Countries, saw its production peak in 1998 and is today an importer rather than an exporter of oil.

But the most important country in recent years has surely been Saudi Arabia. The kingdom accounted for 13% of global field production in 2005, and had played an active role as the world's residual supplier during the 1980s and 1990s, increasing production

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[24] Details for the these calculations are provided in Hamilton (2009b, p. 229).

whenever needed. Many analysts had assumed that the Saudis would continue to play this role, increasing production to accommodate growing demand in the 2000s.[26] In the event, however, Saudi production was 850,000 barrels a day lower in 2007 than it had been in 2005.

Explanations for the Saudi decline vary. Their magnificent Ghawar field has been in production since 1951 and in recent years has perhaps accounted for 6% of world production all by itself. Simmons (2005) was persuaded that Ghawar may have peaked. Gately (2001), on the other hand, argued that it would not be in the economic interest of OPEC to provide the increased production that many analysts had assumed. Although they reached their conclusions for different reasons, both Simmons and Gately were correct in their prediction that Saudi production would fail to increase as other analysts had assumed it would.

Notwithstanding, demand continued to grow, with world real GDP increasing an additional 5% per year in 2006 and 2007, a faster rate of economic growth than had accompanied the 5 mb/d increased oil consumption between 2003 and 2005. China alone did increase its consumption by 840,000 barrels a day between 2005 and 2007. With no more oil being produced, that meant other countries had to decrease their consumption despite strongly growing incomes. The short-run price elasticity of oil demand has never been very high (Hamilton, 2009a), and may have been even smaller over the last decade (Hughes, Knittel, and Sperling, 2008), meaning that a very large price increase was necessary to contain demand. Hamilton (2009b, p. 231) provided illustrative assumptions under which a large shift of the demand curve in the face of a limited increase in supply

[25] Energy Information Administration, *Monthly Energy Review,* Table 11.1b
(http://tonto.eia.doe.gov/merquery/mer_data.asp?table=T11.01b).

would have warranted an increase in the price of oil from $55 a barrel in 2005 to $142 a barrel in 2008.

Others have suggested that the return to negative ex post real interest rates in August 2007 and the large flows of investment dollars into commodity futures markets magnified these fundamentals and introduced a speculative bubble in the price of oil and other commodities; for discussion see Hamilton (2009b), Tang and Xiong (2010), Kilian and Murphy (2010), and Büyükşahin and Robe (2010). Whatever the cause, the oil price spike of 2007-2008 was by some measures the biggest in postwar experience, and the U.S. recession that began in December of 2007 was likewise the worst in postwar experience, though of course the financial crisis rather than any oil-related disruptions were the leading contributing factor in that downturn.[27]

6. Discussion.

Table 1 summarizes key features of the postwar events discussed in the preceding sections. The first column indicates months in which there were contemporary accounts of consumer rationing of gasoline. Ramey and Vine (forthcoming) have emphasized that non-price rationing can significantly amplify the economic dislocations associated with oil shocks. There were at least some such accounts for 5 of the 7 episodes prior to 1980, but none since then.

The third column indicates whether price controls on crude oil or gasoline were in place at the time. This is relevant for a number of reasons. First, price controls are of course a major explanation for why non-price rationing such as reported in column 1 would be observed. And although there were no explicit price controls in effect in 1947,

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[26] See for example International Energy Agency, *World Economic Outlook,* 2007.

the threat that they might be imposed at any time was quite significant (Goodwin and Herren, 1975), and this is presumably one reason why reports of rationing are also associated with this episode. No price controls were in effect in the United States in 1956, but they do appear to have been in use in Europe, where the rationing at the time was reported.

Second, price controls were sometimes an important factor contributing to the episode itself. Controls can inhibit markets from responding efficiently to the challenges and can be one cause of inadequate or misallocated supply. In addition, the lifting of price controls was often the explanation for the discrete jump eventually observed in prices, as was the case for example in June 1953 and February 1981. The gradual lifting of price ceilings was likewise a reason that events such as the exile of the Shah of Iran in January of 1979 showed up in oil prices only gradually over time.

Price controls also complicate what one means by the magnitude of the observed price change associated with a given episode. Particularly during the 1970s, there was a very involved set of regulations with elaborate rules for different categories of crude oil. Commonly used measures of oil prices look quite different from each other over this period. Hamilton (forthcoming) found that the producer price index for crude petroleum has a better correlation over this period with the prices consumers actually paid for gasoline than do other popular measures such as the price of West Texas Intermediate or the refiner acquisition cost. I have for this reason used the crude petroleum PPI over the period 1973-1981 as the basis for calculating the magnitude of the price change reported in the second column of Table 1. For all other dates the reported price change is based on

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[27] Hamilton (2009b) nevertheless noted some avenues by which the oil shock contributed directly to the financial crisis itself.

the monthly WTI.

The fourth column of Table 1 summarizes key contributing factors in each episode. Many of these episodes were associated with dramatic geopolitical developments arising out of conflicts in the Middle East. Strong demand confronting a limited supply response also contributed to many of these episodes. The table collects the price increases of 1973-74 together, though in many respects the shortages in the spring of 1973 and the winter of 1973-74 were distinct events with distinct causes. The modest price spikes of 1969 and 1970 have likewise been grouped together for purposes of the summary.

The discrete character of oil price changes seen in Figure 5 for the era of the Texas Railroad Commission makes the choice of dates to include in the table rather straightforward prior to 1972. After 1972, oil prices changed continuously, and there is more subjective judgment involved in determining which events are significant enough to be included. For example, the price increase of 2000 could well be viewed as the continuation of a trend that started with the trough reached after the southeast Asian crisis of 1997. However, the price increases in 1998 and 1999 only restored the price level back to where it had been in January 1997. Based on the evidence reported in Hamilton (2003), the episode is dated in Table 1 as beginning with the new highs reached in December 1999.

An alternative approach to the narrative summary provided by Table 1 is to try to use statistical methods to determine what constitutes an oil shock (e.g., Hamilton, 2003), or to disentangle broadly defined shocks to oil supply from changes in demand arising from growing global income, as in Kilian (2009) and Baumeister and Peersman (2009).

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Although it is very helpful to bring such methods to these questions, the identifying assumptions necessary to interpret such decompositions are controversial. Kilian (2009) and Baumeister and Peersman (2009) attributed a bigger role to demand disturbances in episodes such as the oil price increase of the late 1970s than the narrative approach adopted here has suggested, and also explored the possible contribution of speculative demand and inventory building to the price increases.

As noted in the previous sections, these historical episodes were often followed by economic recessions in the United States. The last column of Table 1 reports the starting date of U.S. recessions as determined by the National Bureau of Economic Research. All but one of the 11 postwar recessions were associated with an increase in the price of oil, the single exception being the recession of 1960. Likewise, all but one of the 12 oil price episodes listed in Table 1 were accompanied by U.S. recessions, the single exception being the 2003 oil price increase associated with the Venezuelan unrest and second Persian Gulf War.

The correlation between oil shocks and economic recessions appears to be too strong to be just a coincidence (Hamilton, 1983a, 1985). And although demand pressure associated with the later stages of a business cycle expansion seems to have been a contributing factor in a number of these episodes, statistically one cannot predict the oil price changes prior to 1973 on the basis of prior developments in the U.S. economy (Hamilton, 1983a). Moreover, supply disruptions arising from dramatic geopolitical events are prominent causes of a number of the most important episodes. Insofar as events such as the Suez Crisis and first Persian Gulf War were not caused by U.S. business cycle dynamics, a correlation between these events and subsequent economic

downturns should be viewed as causal. This is not to claim that the oil price increases themselves were the sole cause of most postwar recessions. Instead the indicated conclusion is that oil shocks were a contributing factor in at least some postwar recessions.

That an oil price increase could exert some drag on the economy of an oil-importing country should not be controversial. On the supply side, energy is a factor of production, and an exogenous decrease in its supply would be expected to be associated with a decline in productivity. However, standard neoclassical reasoning suggests that the size of such an effect should be small. If the dollar value of the lost energy is less than the dollar value of the lost production, it would pay the firm to bid up the price of energy so as to maintain production. But the dollar value of the lost energy is relatively modest compared with the dollar value of production lost in a recession. For example, the global production shortfall associated with the OPEC embargo (the area above the dashed line in Figure 10) averaged 2.3 mb/d over the 6 months following September 1973. Even at a price of $12/barrel, this only represents a market value of $5.1 billion spread over the entire world economy. By contrast, U.S. real GDP declined at a 2.5% annual rate between 1974:Q1 and 1975:Q1, which would represent about $38 billion annually in 1974 dollars for the U.S. alone. The dollar value of output lost in the recession exceeded the dollar value of the lost energy by an order of magnitude.

Alternatively, oil shocks could affect the economy through the demand side. The short-run elasticity of oil demand is very low.[28] If consumers try to maintain their real purchases of energy in the face of rising prices, their saving or spending on other goods

must fall commensurately. Although there are offsetting income gains for domestic oil producers, the marginal propensity to spend out of oil company windfall profits may be low, and by 1974, more than a third of U.S. oil was imported. Again, however, the direct effects one could assign to this mechanism are limited. For example, between September 1973 and July 1974, U.S. consumer purchases of energy goods and services increased by $14.4 billion at an annual rate,[29] yet the output decline was more than twice this amount.

Hamilton (1988) stressed the importance of the composition of consumer spending in addition to its overall level. For example, one of the key responses seen following an increase in oil prices is a decline in automobile spending, particularly the larger vehicles manufactured in the United States (Edelstein and Kilian, 2009; Ramey and Vine, forthcoming). Insofar as specialized labor and capital devoted to the manufacture and sales of those vehicles are difficult to shift into other uses, the result can be a drop in income that is greater than the lost purchasing power by the original consumers. Table 2 reproduces the calculations in Hamilton (2009b) on the behavior of real GDP in the 5 quarters following each of 5 historical oil shocks, and the specific contribution made to this total from motor vehicles and parts alone. This did seem to make a material contribution in many cases. For example, in the 5 quarters following the oil price increases of 1979:Q2 and 1990:Q3, real GDP would have increased rather than fallen had there been no decline in autos. In addition, there appears to be an important response of consumer sentiment to rapid increases in energy prices (Edelstein and Kilian, 2009). Combining these changes in spending with traditional Keynesian multiplier

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[28] See for example the literature surveys by Dahl and Sterner (1991), Dahl (1993), Espey (1998), Graham and Glaister (2004) and Brons, et. al. (2008). Examples of studies finding higher elasticities include Kilian (2010), Baumeister and Peersman (2009), and Davis and Kilian (forthcoming).
[29] Bureau of Economic Analysis, Table 2.3.5.U.

effects appears to be the most plausible explanation for why oil shocks have often been followed by economic downturns.

In addition to disruptions in supply arising from geopolitical events, another contributing factor for several of the historical episodes is the interaction of growing petroleum demand with production declines from the mature producing fields on which the world had come to depend. In the postwar experience, this appears to be part of the story behind the 1973-1974 and 2007-2008 oil price spikes, and, going back in time, in the 1862-1864 and 1895 price run-ups as well. It is unclear as of this writing where the added global production will come from to replace traditional sources such as the North Sea, Mexico, and Saudi Arabia, if production from the latter has indeed peaked.

But given the record of geopolitical instability in the Middle East, and the projected phenomenal surge in demand from the newly industrialized countries, it seems quite reasonable to expect that within the next decade we will have an additional row of data to add to Table 1 with which to inform our understanding of the economic consequences of oil shocks.

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Table 1. Summary of significant postwar events.

Gasoline shortages	Price increase	Price controls	Key factors	Business cycle peak
Nov 47- Dec 47	Nov 47-Jan 48 (37%)	no (threatened)	strong demand, supply constraints	Nov 48
May 52	Jun 53 (10%)	yes	strike, controls lifted	Jul 53
Nov 56-Dec 56 (Europe)	Jan 57-Feb 57 (9%)	yes (Europe)	Suez Crisis	Aug 57
none	none	no	---	Apr 60
none	Feb 69 (7%) Nov 70 (8%)	no	strike, strong demand, supply constraints	Dec 69
Jun 73 Dec 73- Mar 74	Apr 73-Sep 73 (16%) Nov 73-Feb 74 (51%)	yes	strong demand, supply constraints, OAPEC embargo	Nov 73
May 79-Jul 79	May 79-Jan 80 (57%)	yes	Iranian revolution	Jan 80
none	Nov 80-Feb 81 (45%)	yes	Iran-Iraq War, controls lifted	Jul 81
none	Aug 90-Oct 90 (93%)	no	Gulf War I	Jul 90
none	Dec 99-Nov 00 (38%)	no	strong demand	Mar 01
none	Nov 02-Mar 03 (28%)	no	Venezuela unrest, Gulf War II	none
none	Feb 07-Jun 08 (145%)	no	strong demand, stagnant supply	Dec 07

Table 2. Real GDP growth (annual rate) and contribution of autos to the overall GDP growth rate in five historical episodes.

Period	GDP growth rate	Contribution of autos
1974:Q1-1975:Q1	-2.5%	-0.5%
1979:Q2-1980:Q2	-0.4%	-0.8%
1981:Q2-1982:Q2	-1.5%	-0.2%
1990:Q3-1991:Q3	-0.1%	-0.3%
2007:Q4-2008:Q4	-0.7%	-0.7%
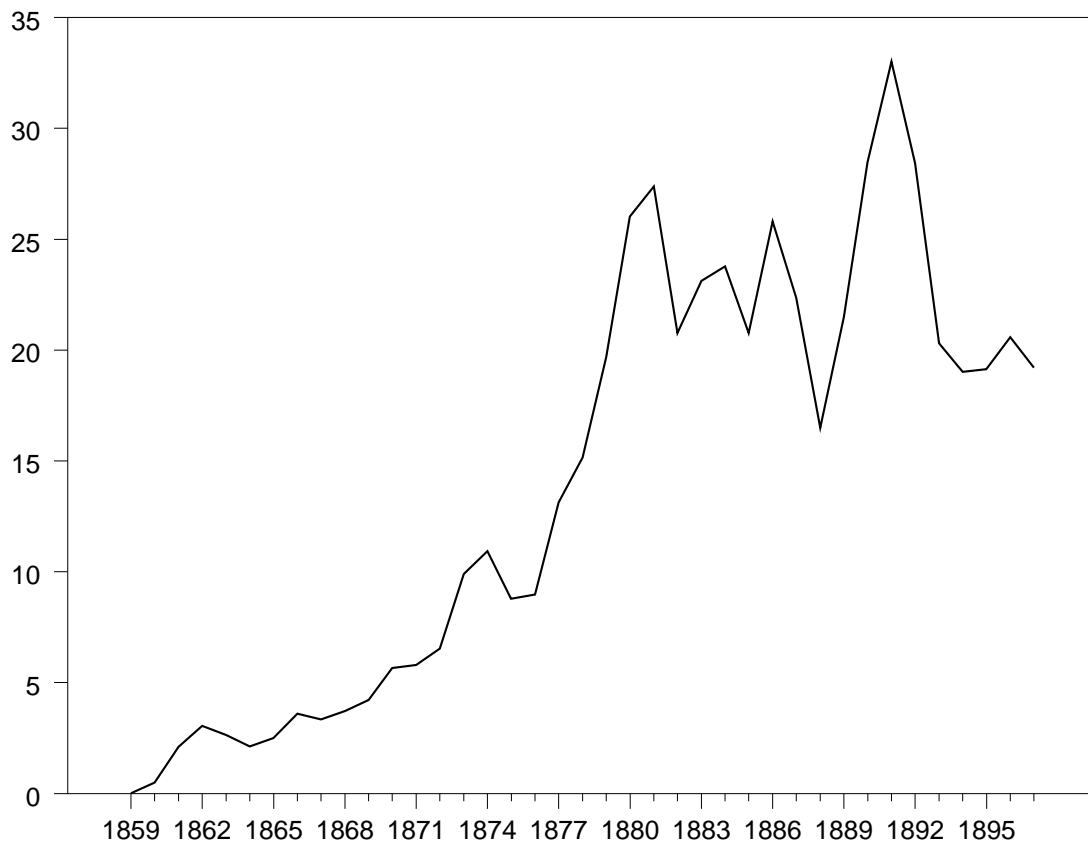
Figure 1. Estimated production from Pennsylvania and New York, in millions of barrels per year, 1859-1897. Data source: *Derrick's Hand-Book,* pp. 804-805.
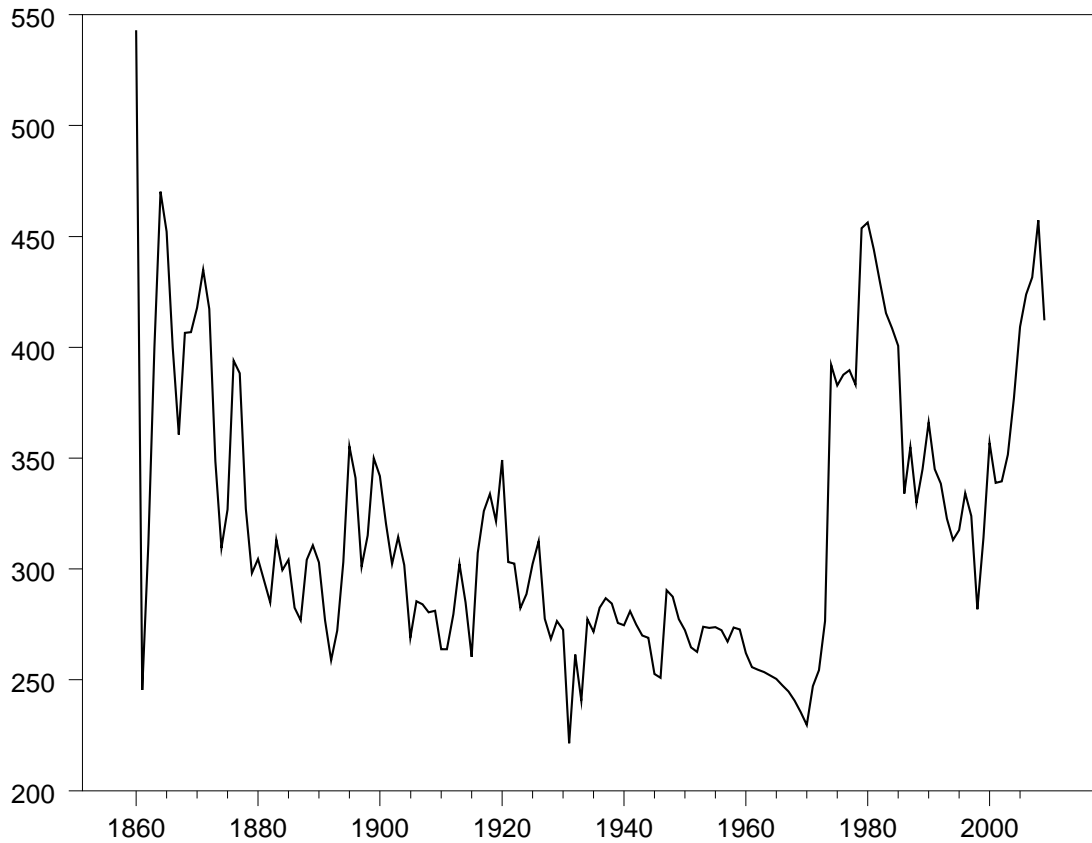
Figure 2. One hundred times the natural logarithm of the real price of oil, 1861-2009, in 2009 U.S. dollars. Data source: *Statistical Review of World Energy 2010,* BP; Jenkins (1985, Table 18); and *Historical Statistics of the United States,* Table E 135-166, Consumer Prices Indexes (BLS), All Items, 1800 to 1970, as detailed in footnote 1.
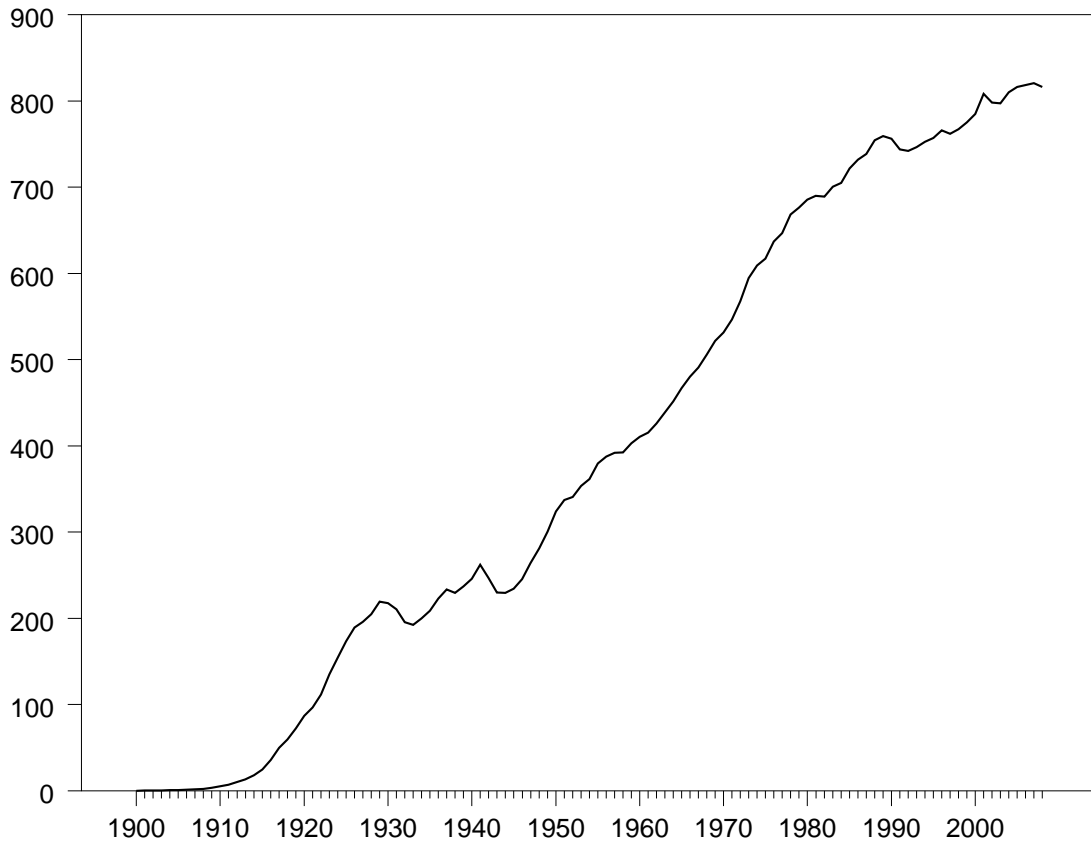
Figure 3. Total U.S. vehicle registrations per thousand U.S. residents, 1900-2008. Data source: *Historical Statistics of the United States,* Millenium Edition Online, Table Aa6-8 and Table Df339-342, U.S. Department of Census, 2010 Statistical Abstract, and U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics,* annual reports.
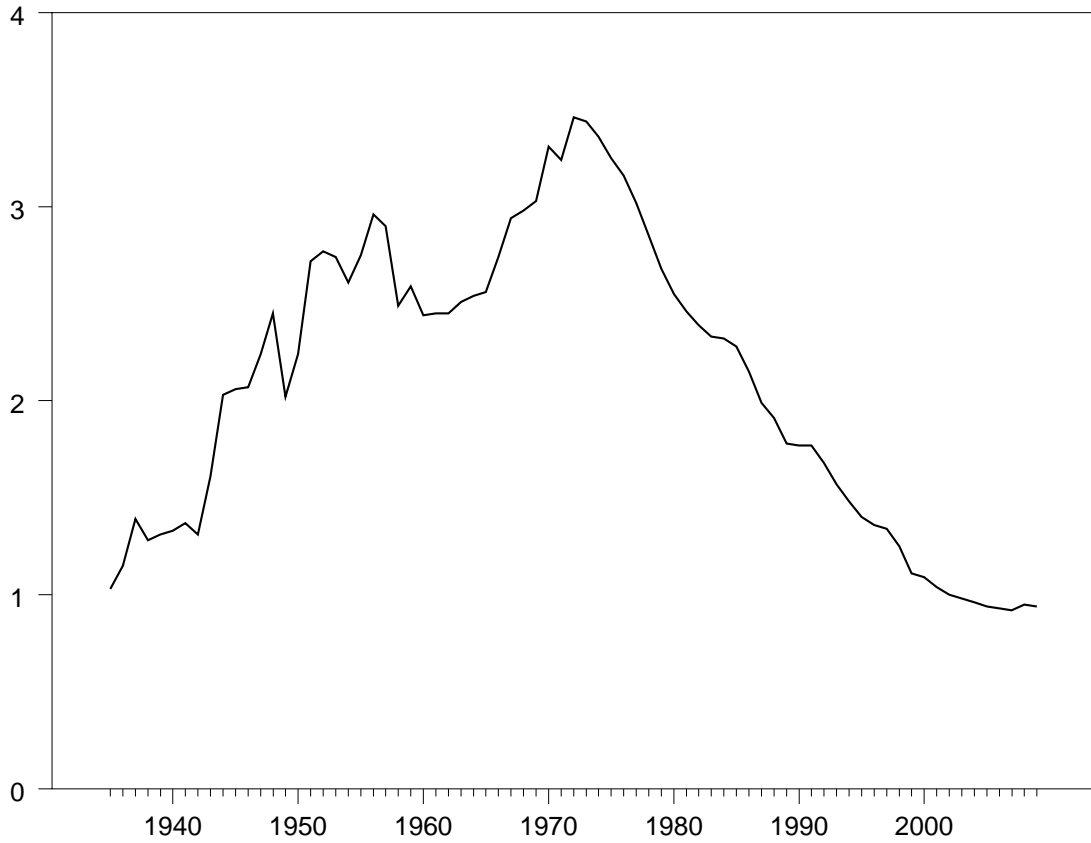
Figure 4. Annual production from the state of Texas, in millions of barrels per day, 1935-2009. Data source: Railroad Commission of Texas (http://www.rrc.state.tx.us/data/production/oilwellcounts.php).
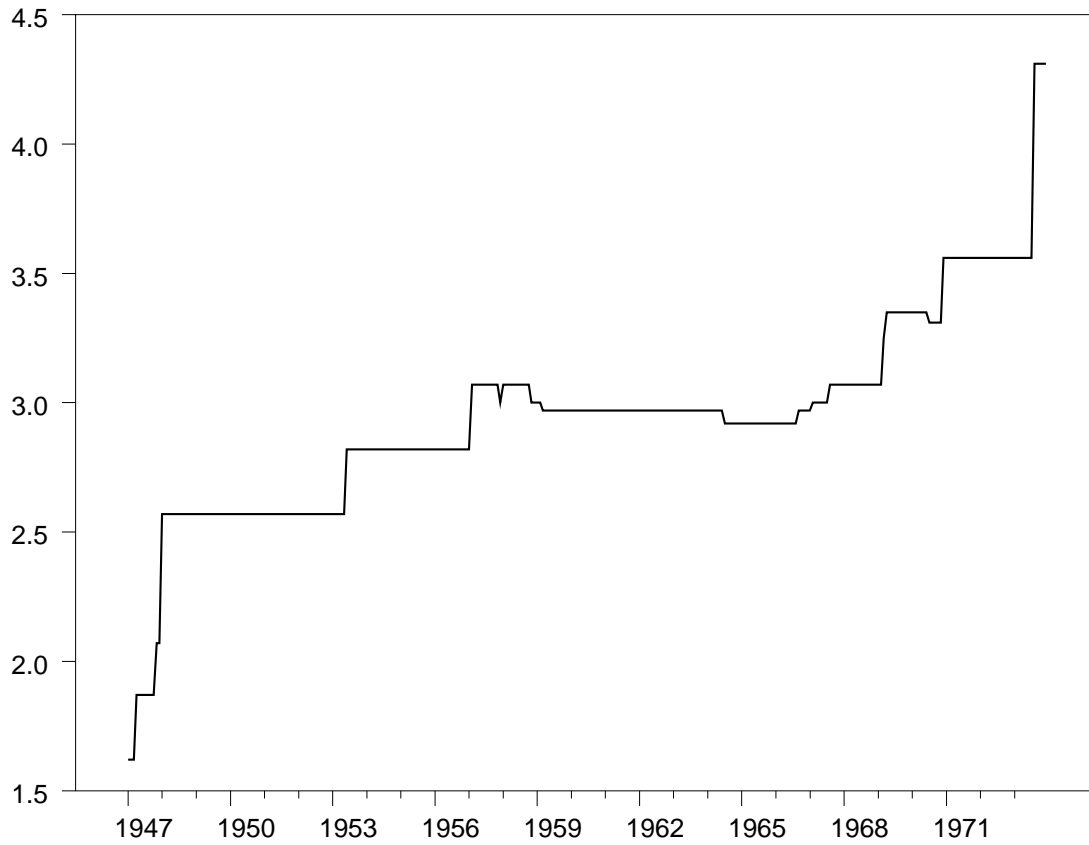
Figure 5. Dollar price per barrel of West Texas Intermediate, 1947:M1-1973:M12.
Average monthly spot oil price, from Federal Reserve Bank of St. Louis
(http://research.stlouisfed.org/fred2/data/OILPRICE.txt).
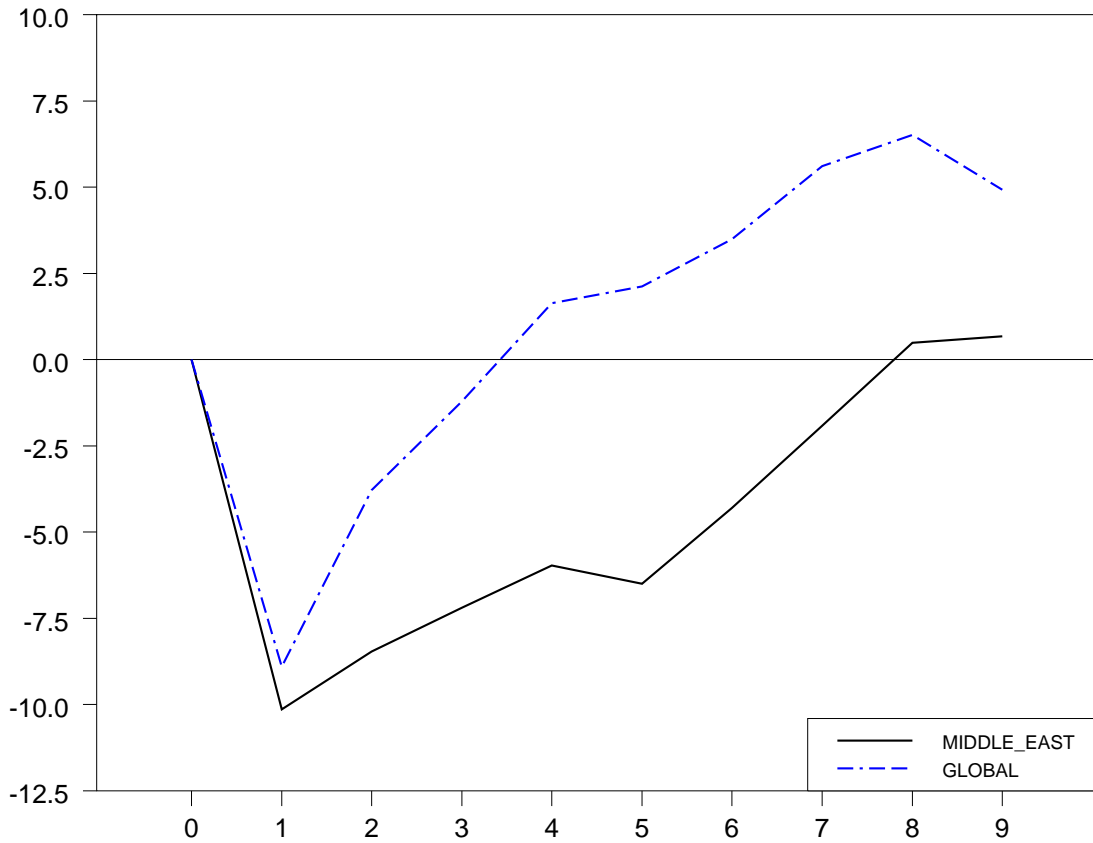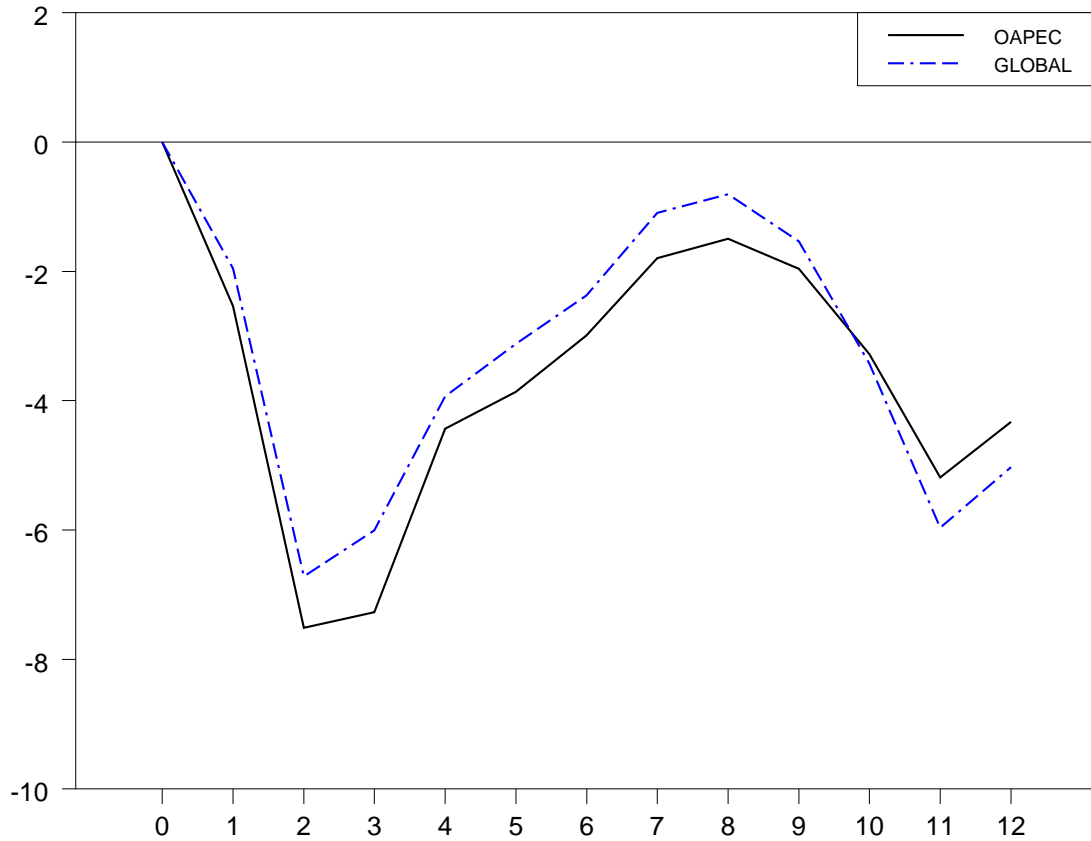
Figure 6. Oil production after the Suez Crisis. Dashed line: change in monthly global crude oil production from October 1956 as a percentage of October 1956 levels. Solid line: change in monthly Middle East oil production from October 1956 as a percentage of global levels in October 1956. Horizontal axis: number of months from October 1956. Data source: *Oil and Gas Journal,* various issues from November 5, 1956 to July 3, 1957.
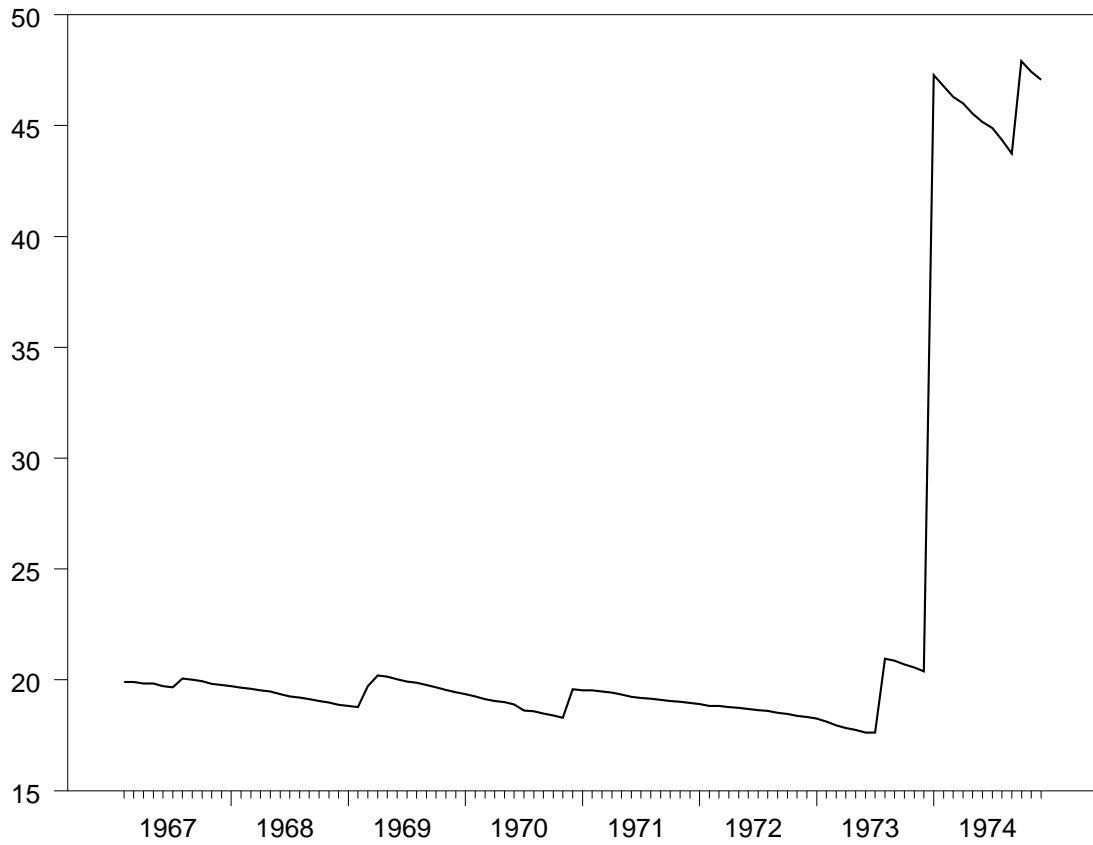
Figure 7. Price of oil in 2009 dollars, 1967:M2-1974:M12. Price of West Texas Intermediate deflated by CPI.
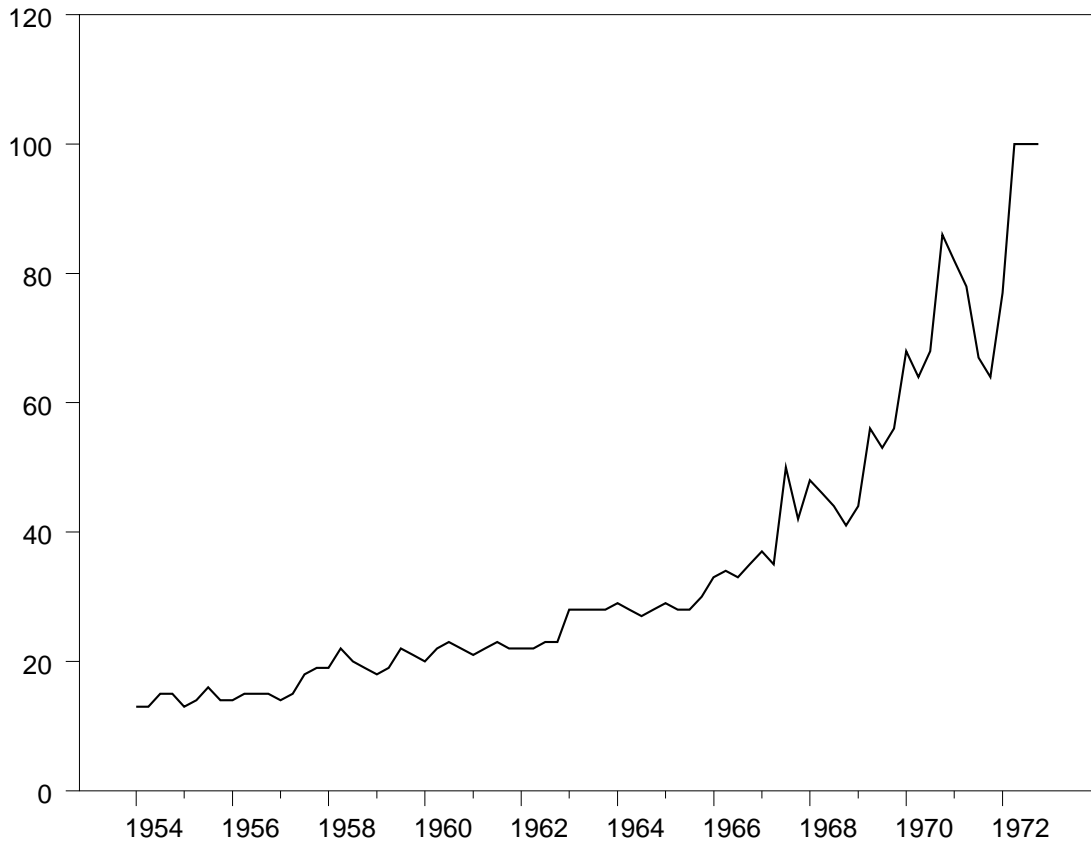
Figure 8. TRC allowable production as a percent of maximum efficient rate, 1954:Q1-
1972:Q4. Data source: Railroad Commission of Texas, *Annual Reports*.
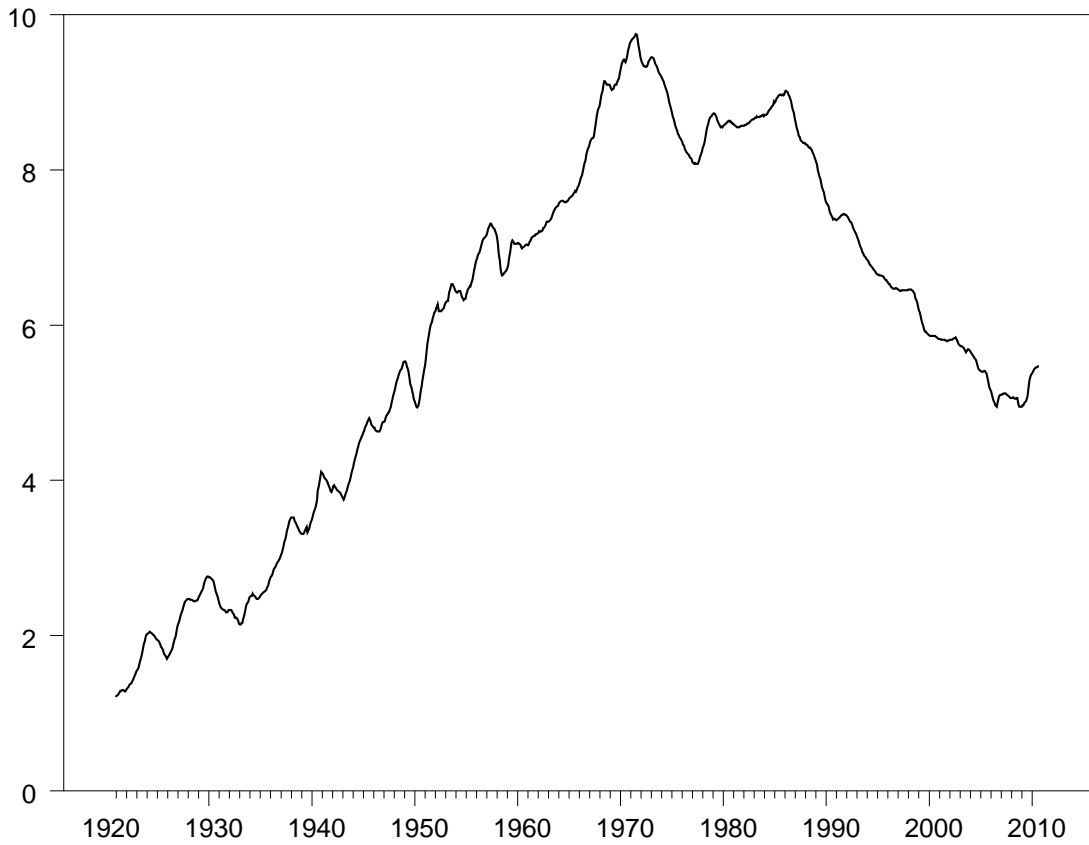
Figure 9. U.S. field production of crude oil, 1920:M12-2010:M9. Average over preceding 12 months in millions of barrels per day. Data source: Energy Information Administration (http://tonto.eia.doe.gov/dnav/pet/pet_crd_crpdn_adc_mbblpd_m.htm).
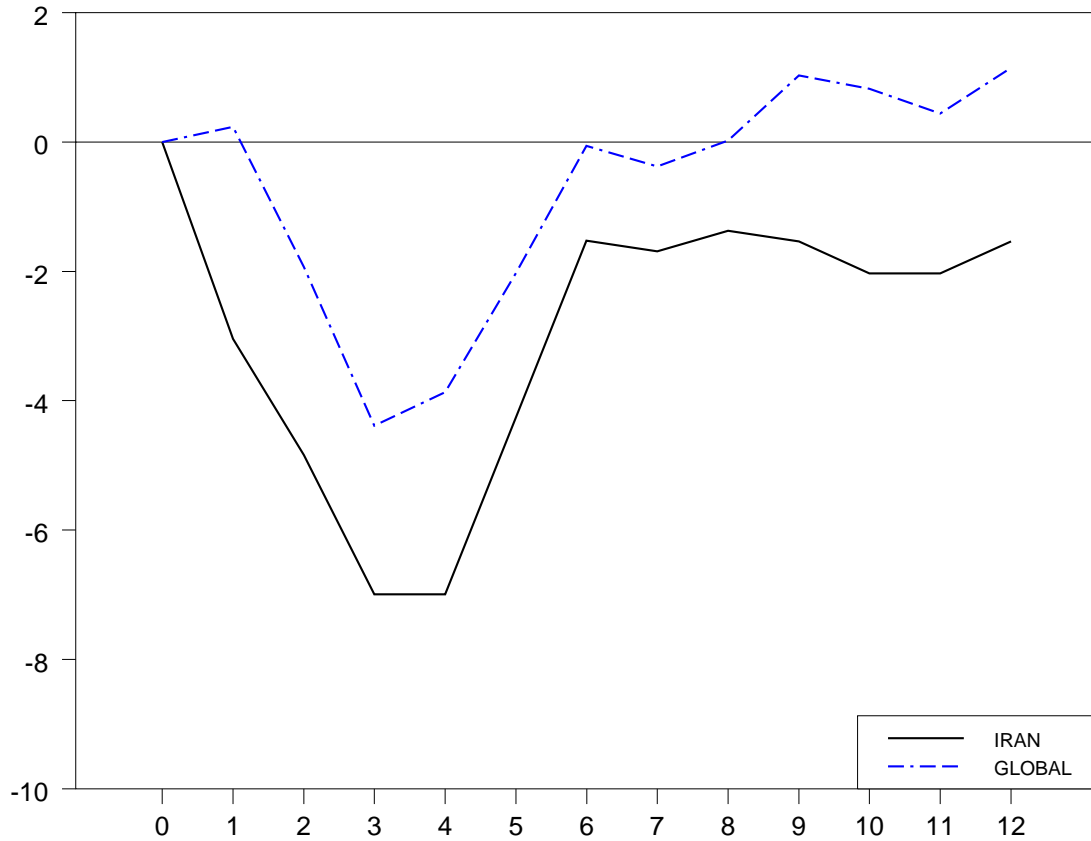
Figure 10. Oil production after the 1973 Arab-Israeli War. Dashed line: change in monthly global crude oil production from September 1973 as a percentage of September 1973 levels. Solid line: change in monthly oil production of Arab members of OPEC from September 1973 as a percentage of global levels in September 1973. Horizontal axis: number of months from September 1973. Data source: Energy Information Administration, *Monthly Energy Review,* Tables 11.1a and 11.1b (http://tonto.eia.doe.gov/merquery/mer_data.asp?table=T11.01a).
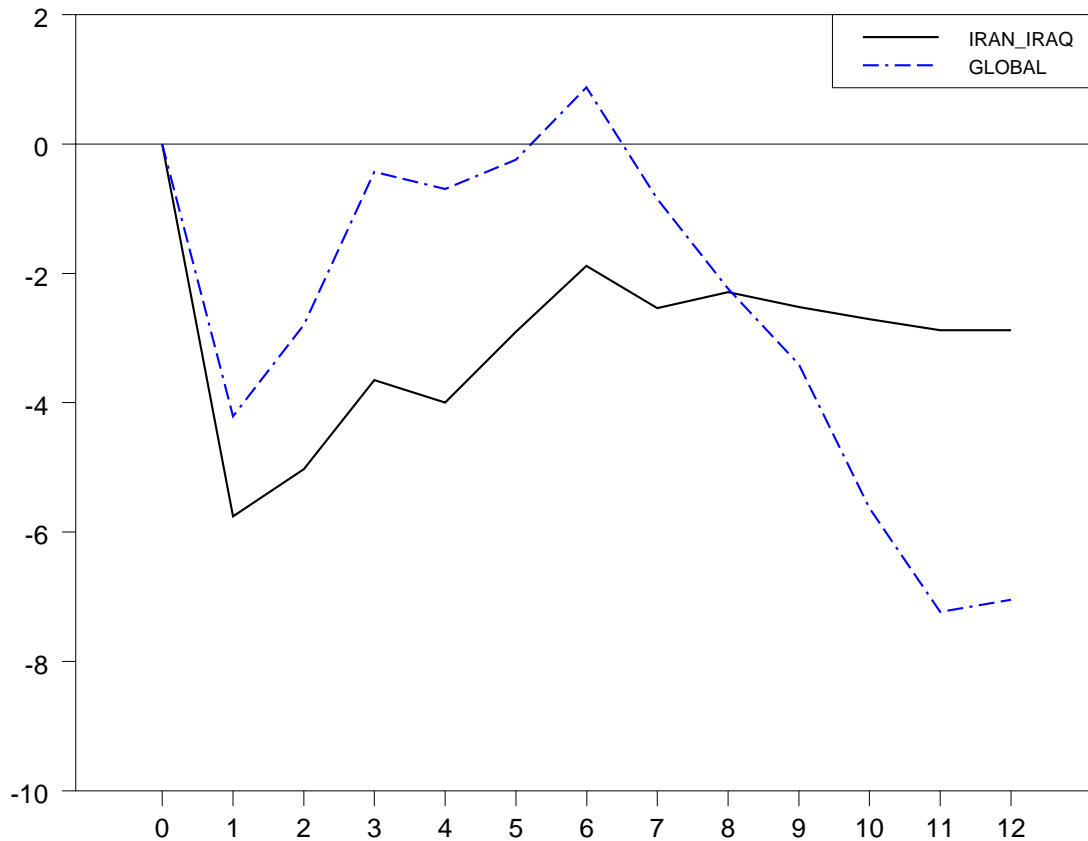
Iran

Iraq

Kuwait

Saudi Arabia

Venezuela
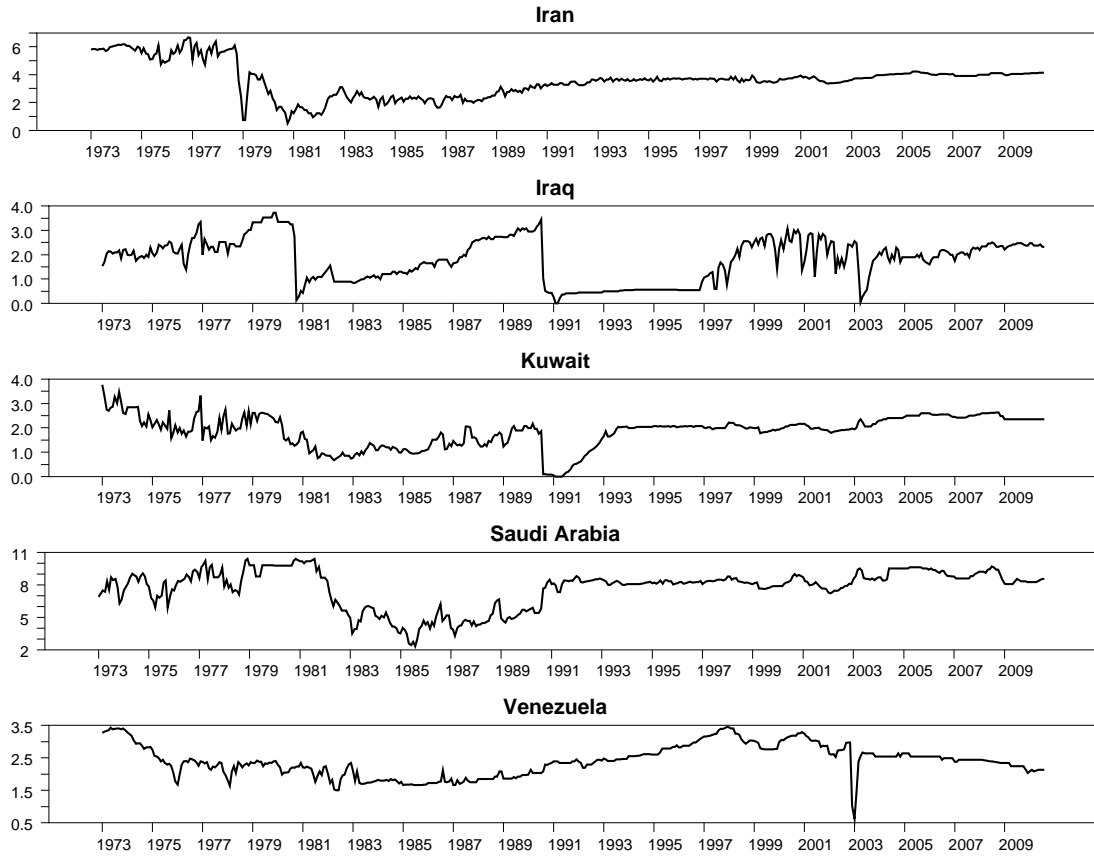
Figure 11. Monthly production rates (in mb/d) for 5 OPEC members, 1973:M1-2010:M8.
Data source: Energy Information Administration, *Monthly Energy Review,* Table 11.1a
(http://tonto.eia.doe.gov/merquery/mer_data.asp?table=T11.01a).

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Figure 12. Oil production after the 1978 Iranian revolution. Dashed line: change in monthly global crude oil production from October 1978 as a percentage of October 1978 levels. Solid line: change in monthly Iranian oil production from October 1978 as a percentage of global levels in October 1978. Horizontal axis: number of months from October 1978. Data source: Energy Information Administration, *Monthly Energy Review,* Tables 11.1a and 11.1b (http://tonto.eia.doe.gov/merquery/mer_data.asp?table=T11.01a).
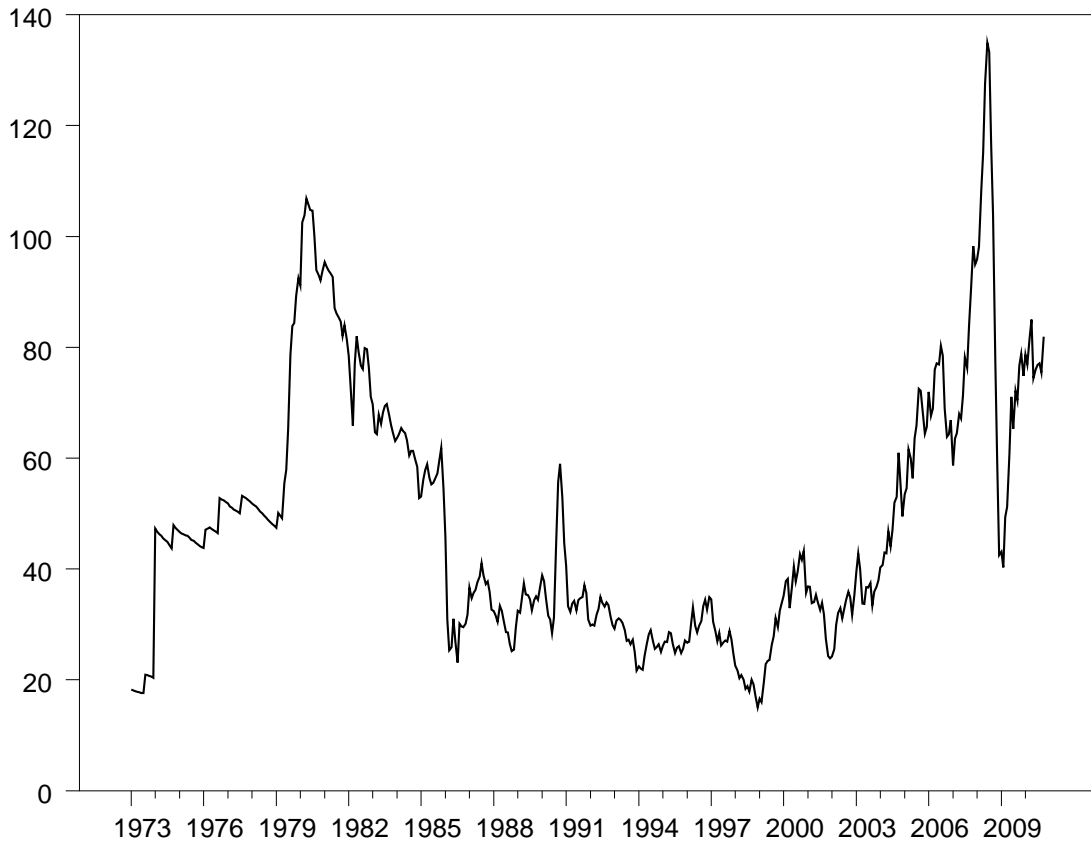
Figure 13. Oil production after the Iran-Iraq War. Dashed line: change in monthly global crude oil production from September 1980 as a percentage of September 1980 levels. Solid line: change in monthly oil production of Iran and Iraq from September 1980 as a percentage of global levels in September 1980. Horizontal axis: number of months from September 1980. Data source: Energy Information Administration, *Monthly Energy Review,* Tables 11.1a and 11.1b (http://tonto.eia.doe.gov/merquery/mer_data.asp?table=T11.01a).

Figure 14. Price of oil in 2009 dollars, 1973:M1-2010:M10. Price of West Texas Intermediate deflated by CPI.
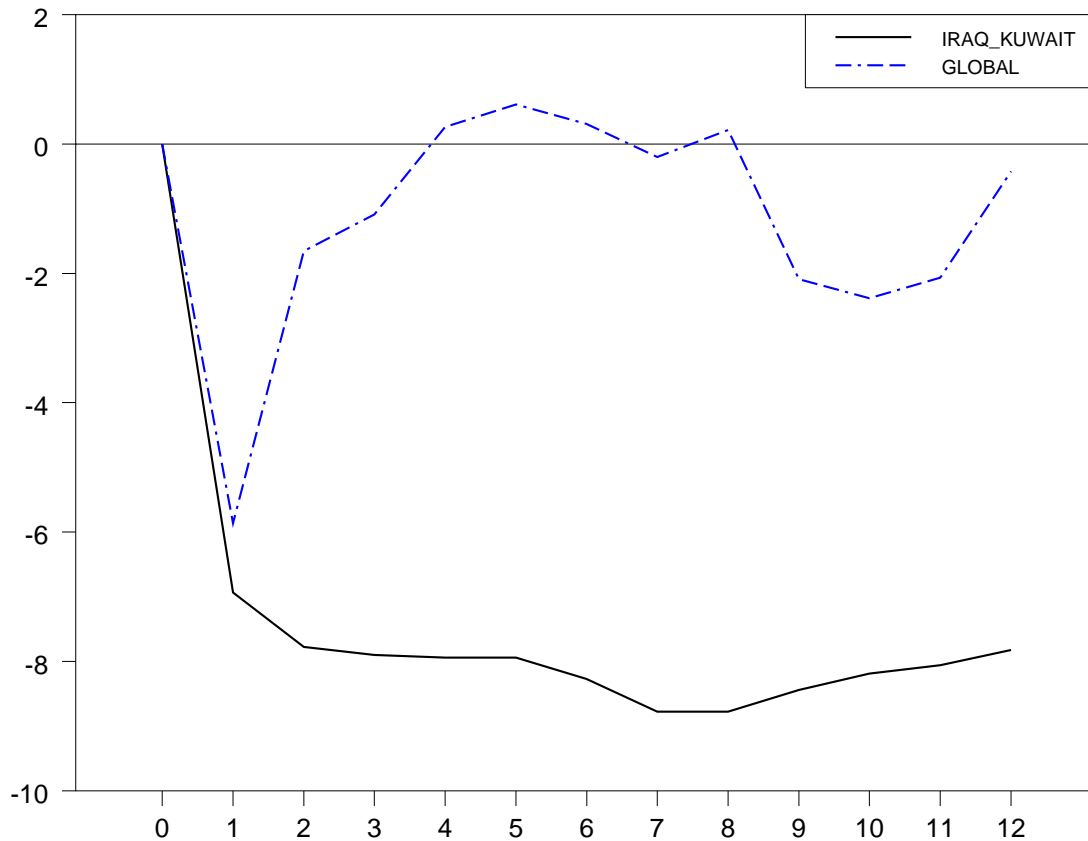
Figure 15. Oil production after the first Persian Gulf War. Dashed line: change in monthly global crude oil production from August 1990 as a percentage of August 1990 levels. Solid line: change in monthly oil production of Iraq and Kuwait from August 1990 as a percentage of global levels in August 1990. Horizontal axis: number of months from August 1990. Data source: Energy Information Administration, *Monthly Energy Review,* Tables 11.1a and 11.1b (http://tonto.eia.doe.gov/merquery/mer_data.asp?table=T11.01a).
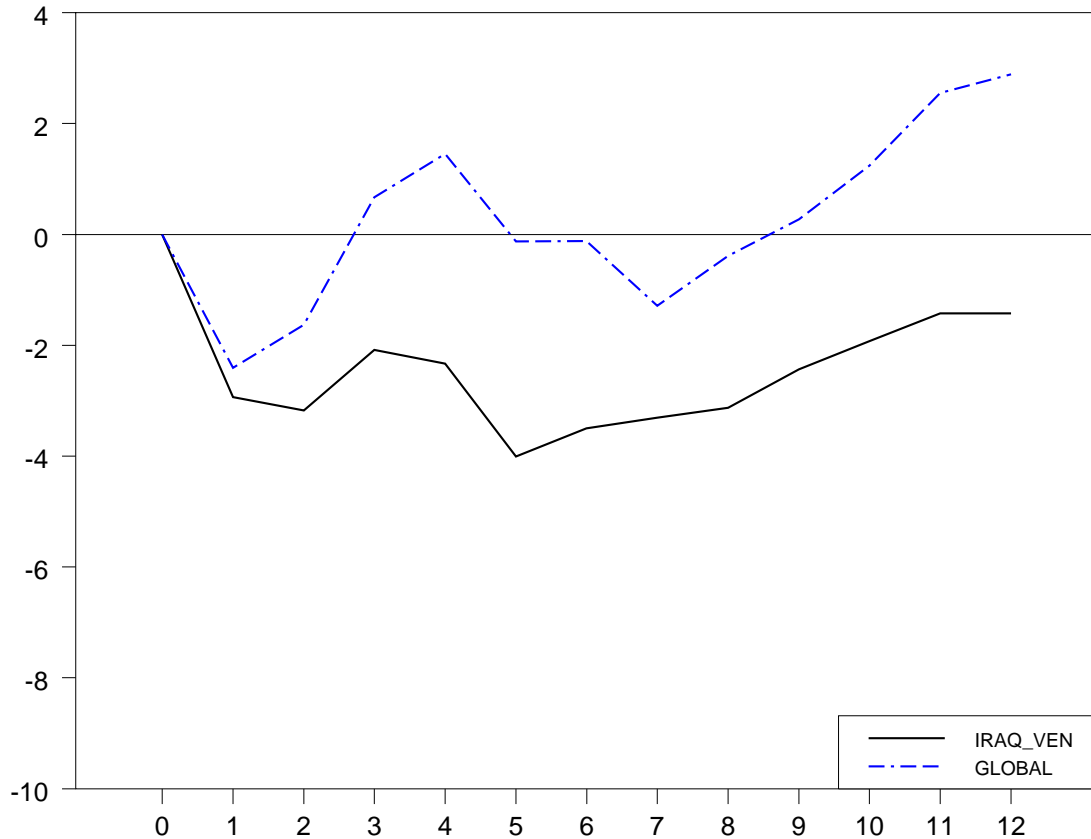
Figure 16. Oil production after the Venezuelan unrest and the second Persian Gulf War.
Dashed line: change in monthly global crude oil production from November 2002 as a
percentage of November 2002 levels. Solid line: change in monthly oil production of
Venezuela and Iraq from November 2002 as a percentage of global levels in November
2002. Horizontal axis: number of months from November 2002. Data source: Energy
Information Administration, *Monthly Energy Review,* Tables 11.1a and 11.1b
(http://tonto.eia.doe.gov/merquery/mer_data.asp?table=T11.01a).
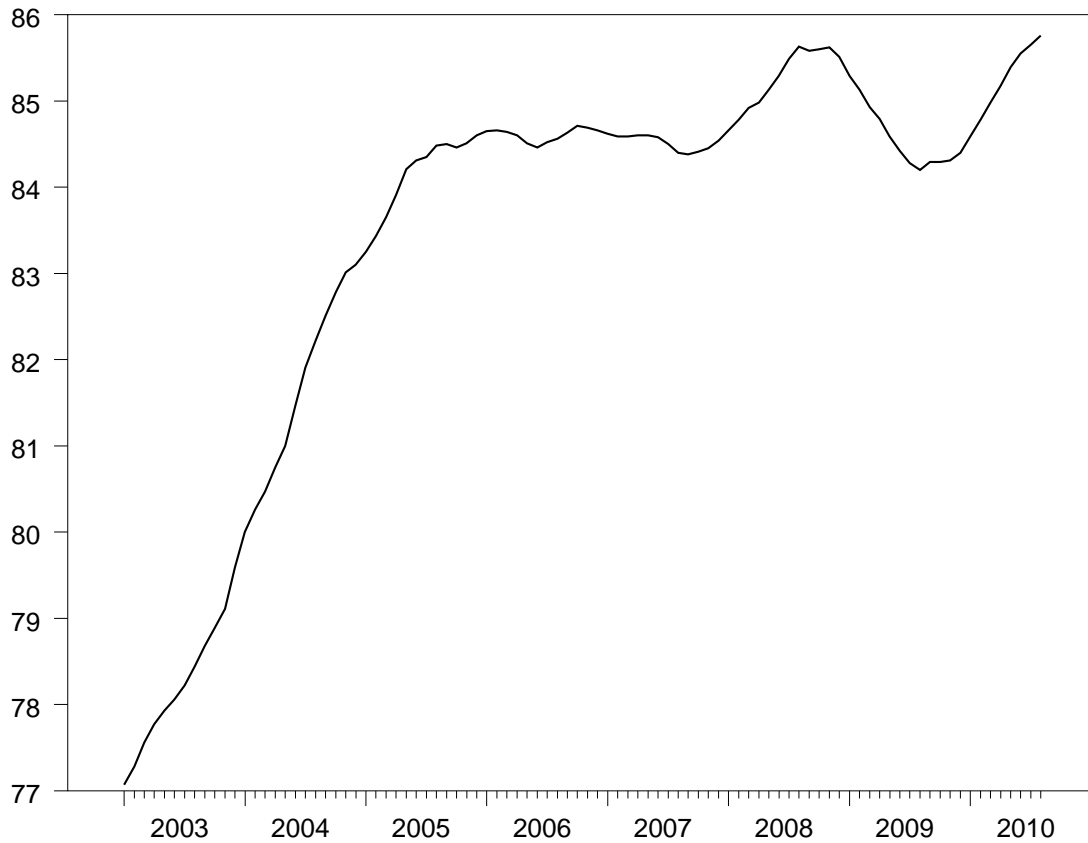
Figure 17. World oil production, 2003:M1-2010:M9. Includes lease condensate, natural gas plant liquids, other liquids, and refinery process gain. Data source: Energy Information Administration, International Petroleum Monthly (http://www.eia.doe.gov/emeu/ipsr/t44.xls).