THE STRAIT OF HORMUZ AND THE THREAT OF AN OIL SHOCK

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Executive Summary

- Twenty percent of the world's daily oil supply traverses the Strait of Hormuz. The thought of a supply disruption affecting this much oil raises fears of severe economic repercussions and evokes memories of the 1973 Arab oil embargo.
- However, the spiking oil price, the gas lines, and the economic dislocations that followed the embargo did not result from the volume of oil withheld, which was relatively small. The effects were attributable mainly to (a) worsened long-term oil supply conditions subject to the continuing manipulation by OPEC, and (b) unfavorable baseline conditions and government policies that compounded the challenge to the economy of making the necessary adjustments.
- The world holds a large amount of oil in inventory that could replace Persian Gulf oil for many months. The problem is that a closure of the Strait could signal a long-term loss of access to 55 percent of the world's known oil reserves. Fear of this outcome could prevent release of oil in storage and motivate additional precautionary purchases—in the extreme, panic buying and hoarding.
- The Persian Gulf region itself would suffer severely from a Strait closure. What threat exists to the oil trade emanates from extremists' ambitions and regional leaders that engage in brinkmanship to exercise leverage with the major economic powers.
- The U.S. economy and the world economy now are better positioned to absorb a short oil supply disruption. But economic models have limited capability to project the effects because they cannot foretell whether long-term changes in supply would occur or what the market's perceptions would be. The risks and uncertainties of an oil shock are lower but persist.

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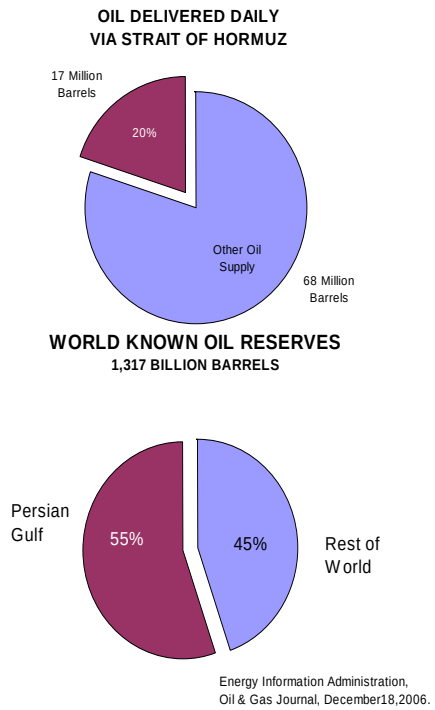
INTRODUCTION AND SUMMARY

The Strait of Hormuz carries 20 percent of the world's daily oil supply. The thought of a disruption to that flow evokes visions of an enormous shock to the economy and memories of the Arab oil embargo of 1973. However, the volume of oil withheld during the embargo by itself was not the cause of the price spikes, gas lines, and economic dislocations that followed. Changes in the permanent condition of the oil supply, weak economic baseline conditions, government policies, and market fears were the main causes. This paper examines the dynamics of a major oil supply disruption in today's setting and reaches several conclusions:

Figure 1



Energy Information Administration, Oil & Gas Journal, December18,2006.

- The size of an oil supply disruption matters less than what comes afterward. Even a small disruption can have a huge impact if it portends permanent supply problems.
- The Persian Gulf holds 55 percent of the world's known oil reserves. Even the remote possibility that access to this much oil could be impaired long-term raises concerns. Expectations drive market reactions and changing expectations can cause large oil price swings even without changes in actual supply conditions.
- World oil inventories are sufficient to replace a large stream of oil for many months. A disruption could have little economic effect, if it is temporary and there is no reason to expect a continuing impairment to supply.
- Competitive markets deal effectively with temporary disruptions. However, where supply manipulation is possible as in the oil market, which is dominated by OPEC and large state owned oil producing companies, opportunistic behavior can exacerbate a disruption. This potential also can heighten market fears.
- Strategic oil reserves can discourage opportunistic behavior and calm the market. However, the release of government oil cannot stave off fundamental supply changes or the market's anticipation of them. Government is at risk of exhausting its reserves to little benefit in this case.
- The main parties to the oil trade in the region have no interest in destroying the source of their enormous oil income. However, some practice brinkmanship to extract additional concessions from the world's leading economies. Extremists who have no stake in the current distribution of oil wealth and power may be motivated to wreak havoc with the oil trade but presumably have limited means to do so.
- The economy has become structurally more resilient since the Arab oil embargo. Monetary and fiscal policy likely would cushion the next oil shock, and imposition of price controls is unlikely. However, oil price spikes and economic repercussions are difficult to project, because economic models focus on disruption size and assume that the effects are proportional to it. They cannot know how supply conditions would turn out long-term or how the market would perceive them.

FEAR OF UPHEAVAL

Oil is an essential input to the world economy whose supply lines stretch across the globe. Major oil shipping routes are vulnerable to attack at various locations—so-called chokepoints—of which the Strait of Hormuz is the most vital. The Strait narrows to 34 miles with 2-mile wide in-bound and out-bound sea-lanes and a 2-mile buffer zone. There is no other way to move comparably large volumes of oil out of the Persian Gulf region.

An attack on shipping traffic through the Strait would directly threaten access to 55 percent of the world's known oil reserves and could mean that terrorists or rogue nations are able to alter the basic conditions of the world oil supply.[1]

Figure 2

As it stands, a disruption to the flow of oil wherever it occurs and whatever its nature could have repercussions that set it apart from disruptive events in other markets, because the oil market is vulnerable to opportunistic behavior. In an effort to support a price surge or exploit the situation politically, various oil-producing nations could decide to reduce their exports rather than increase them during a disruption. Ordinarily, suppliers are motivated to restore supply and buyers have no reason to fear self-perpetuating supply problems. In competitive markets, buyers and sellers will overcome a temporary disruption through use of inventories, rerouting, or intensified production elsewhere. But, a cartel consisting of state monopolies—the Organization of Petroleum Exporting Countries (OPEC)—dominates the oil supply, and most oil production outside the cartel is state controlled as well. In addition, growing world oil demand has left most producers with little or no spare pumping capacity, which could enhance the ability of any of a number of large producing countries to manipulate supply, especially if the oil flow already is impaired by a disruption.

For these reasons, any hint of a significant impairment to the oil supply is associated with fear of a widening supply crisis. Since 2004, the market price of oil has once again contained a "fear premium," i.e., the price includes the effect of additional demand for oil futures contracts and for oil to be placed in storage as a precaution in case the oil supply is reduced. The premium varies widely depending on potentially foreboding events and is especially sensitive to developments in the Middle East. While Iran was holding 15 British soldiers hostage, the world oil price rose by about $7 per barrel (8 percent), even though the flow of oil was not affected.

[1] There is little risk of a ship running aground. Fully loaded supertankers reach a maximum depth of 50 to 60 feet while the shipping lanes are 200 to 300 feet deep. The Persian Gulf also holds 40 percent of the world's known natural gas reserves and accounts for 18 percent of liquefied natural gas (LNG) shipments. Though of growing importance, the LNG trade is still relatively small.

DISRUPTIONS AND THE PRICE OF OIL

Market Perceptions and Price. A supply disruption will cause the oil price to rise but the next step depends on the market's perception of what will happen to supply going forward. Owners of oil inventories want to sell their oil in the period of the highest expected price. If they do not believe that a disruption will last long, they will release more oil immediately as they expect the price to fall again soon. Consequently, the market price in the current period will not rise as much and the economic impact of the disruption will be smaller than if no oil were released from inventory. On the other hand, a disruption that is expected to get worse will support expectations of still higher prices in the future. In this case, oil from inventory will not be released. Instead, there will be additional precautionary demand for oil to be placed in storage. As a result, the current market price will rise even more. Changes in expectations about long-term supply conditions will immediately affect buying behavior and inventory management objectives and can lead to significant oil price movements absent changes in the actual oil supply.

The world has experienced six oil crises since the Second World War, all arising from the Middle East:

- 1990 Iraq-Kuwait war and Desert Storm
- 1979-81 Iranian revolution/ Iran-Iraq war
- 1973 Arab oil embargo
- 1967 Six Day War
- 1956 Suez Canal closure
- 1951 Iran's nationalization of BP's holdings

In each case, the market feared deteriorating supply conditions beyond the initial reduction in oil supply. However, in the three crises prior to 1973, the U.S. had enough excess oil production capacity to re-supply its allies and continue to meet its own needs. This capability forestalled long-term effects and quickly returned the oil price to its pre-disruption level.[2] In 1973, market fears were realized as the Arab oil embargo exposed the limits of U.S. oil production, which had peaked three years earlier. By jointly limiting subsequent supply increases, Persian Gulf oil producers henceforth could drive the market price sharply higher and keep it high, given that world oil demand continued to rise. The embargo itself imposed a smaller physical reduction on the oil supply than some other crises (see Figure 3 below), but it marked long-term changes that had a lasting impact on the oil market and the economy.

Violent conflicts in the Persian Gulf region set off the oil shocks that followed. Even higher price spikes occurred than during the embargo, but they also were not attributable to the immediate reductions in oil supply. Instead, fear that access to Persian Gulf oil fields would be severely impaired or the production capacity of those fields damaged permanently drove the price spikes. In each case, when the perceived risk of these outcomes subsided, the price fell again. The clearest example occurred at the beginning of Desert Storm, launched to liberate Kuwait from Iraq's occupation. The oil price had risen from $30 to $40 per barrel, but when coalition air strikes on Iraq met a weak response, the price plunged to $20 within hours as the market concluded that Iraq could not seriously threaten Saudi Arabia's oil facilities.[3]

[2] Supertankers developed after the Suez crisis with five times greater capacity also played a major role by 1967.
[3] David Yergin, *The Prize, The Epic Quest for Oil, Money, and Power* (Simon & Schuster, 1992), 777. Information about past oil supply disruptions presented is largely from this book.

Access to Reserves is the Deeper Concern. In a competitive market for a non-strategic commodity, the determinants of the initial price increase caused by a disruption would be the decline in the rate of supply, the rate of consumption, the short-run price elasticity of consumption demand, and the amount of oil held for contingencies. But Persian Gulf oil is different. The Strait of Hormuz is the main artery of the world oil supply. It carries 17 million barrels per day (mbd) from the world's largest known oil reserves—728 billion barrels. It would take many years to raise non-Persian Gulf oil production by 17 mbd (25 percent). Saudi Arabia, the world's largest oil producer, has increased its oil production in some previous crises but, as it is located in the Persian Gulf, would be thwarted by a Strait of Hormuz closure. Unencumbered future access to Persian Gulf oil reserves therefore concerns oil buyers the most. A closure of the Strait could signify that terrorists or rogue states have wrested control of the oil supply from OPEC and, as an act of hostility against oil importing nations, would constrict supply henceforth to a rate far below that maintained by the cartel to enlarge its profit. Even if the shipping lanes reopen, access to the Gulf could remain impaired, for example, if missiles continued to threaten tanker traffic. Notwithstanding that oil in storage may be sufficient to offset the shortfall in supply for a period of time, a disruption in the Strait that threatens future access to the major share of the world's oil reserves would greatly affect the price of oil.

Ample Oil in Storage. Worldwide the amount of oil stored and accessible during a disruption is at least 4.2 billion barrels, but its release will depend on the circumstances. There is a large amount of crude oil in private storage. In OECD[4] countries alone industry holds 2.6 billion barrels at the primary level (refineries, oil importers, and traders) that can bridge a temporary disruption. Additional oil stores exist in other countries and all along the supply chain down to motorists' gas tanks and homeowners' heating oil tanks. But, inventories will be used as a stop-gap measure only if the market believes a disruption is temporary. Fear of prolonged supply impairment, on the contrary, will cause buyers to add more oil to inventory. This increased precautionary demand for oil would push up the market price beyond the level attributable to the initial physical reduction in supply. During the Iranian revolution, companies with inventories brimming resorted to storing additional oil on chartered supertankers while they bid the price up higher and higher.

There are 690 million barrels of crude oil in the U.S. Strategic Petroleum Reserve (SPR). The Energy Information Administration (EIA) estimates that another 900 million barrels of crude oil and refined petroleum products exist in government-controlled storage abroad, principally in Japan, Germany, and France. Thus, national governments around the world under the coordination of the International Energy Administration (IEA) can deploy 1.59 billion barrels.[5]

[4] The OECD (Organization for Economic Cooperation and Development) has 30 members: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, South Korea, Spain, Sweden, Switzerland, Turkey, the U.K., and the U.S.

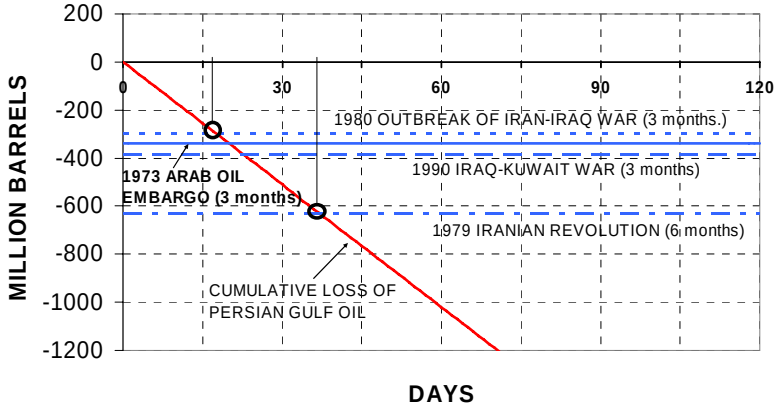
[5] The IEA's emergency response mechanisms were set up under the 1974 Agreement on an International Energy Program (IEP). The IEP Agreement requires IEA countries to hold oil stocks equivalent to at least 90 days of net imports of the previous calendar year and to release oil stocks, restrain demand, switch to other fuels, increase domestic production, and, if necessary, share available oil, in the event of an oil supply disruption of 7 percent or more affecting the IEA or individual countries. The IEA also has a complementary set of measures known as Coordinated Emergency Response Measures (CERM). These are intended to provide a rapid and flexible system of response to actual or imminent oil supply disruptions of any size.

National governments as well need to assess market dynamics and likely future supply developments in releasing their oil.

A closure of the Strait of Hormuz has the potential to reduce the flow of oil by far more than any previous disruption, both in absolute and percentage terms. Of the 85 million barrels the world consumes each day, 20 percent passes through the Strait of Hormuz. By comparison, the Arab oil embargo of 1973, at its peak, resulted in a gross supply loss of 5 mbd, representing 9 percent of world oil consumption (which has increased by 28 mbd since the embargo). Figure 3 shows that the cumulative oil supply loss from a Strait closure could reach the total amount of oil lost during previous oil shocks in 17 to 37 days. Nevertheless, the OECD countries have enough oil in primary inventory to last them more than eight months, should Persian Gulf oil cease to flow.[6]

Figure 3

STRAIT OF HORMUZ CLOSURE VS. PAST OIL SUPPLY DISRUPTIONS*

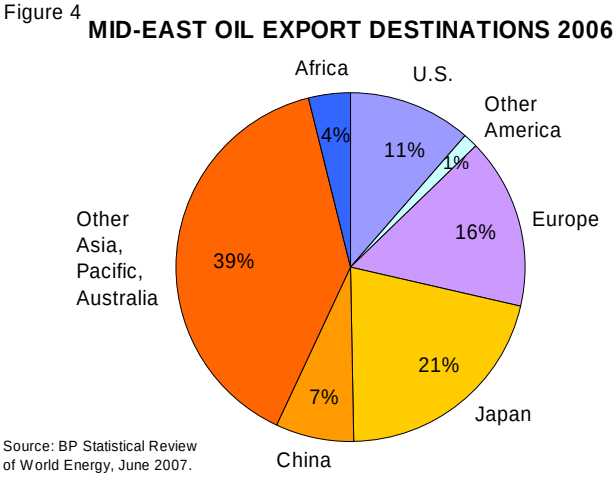


(*) Author's calculations and estimates from Anthony H. Cordesman, "Global Oil Security: Risks by Region and Supplier," Center for Strategic and International Studies (CSIS), November 13, 2006, p. 31; and M.A. Adelman, *The Genie out of the Bottle* (MIT Press, 1995), 110. The number of months in parentheses indicates the estimated duration of the net oil supply shortfall.

Persian Gulf Oil Dependency. Two-thirds of Middle East oil exports are shipped to Asia and 16 percent to Europe compared with only 11 percent to the United States. The U.S. imports 2.2 million barrels from Persian Gulf countries. It is tempting to compare this stream to the oil in the SPR and feel reassured, but U.S. consumers face competitive bidding for the remaining 9 million barrels of imports as well as for domestically produced oil, unless the government were to impose export restrictions such as a previous ban on Alaskan oil exports. Oil buyers whose primary source of supply is cut off will approach alternative sources immediately with offers to pay higher prices. Ocean tankers are easily rerouted to the highest bidder. Consequently, it makes little difference how much oil a given country imports from any particular source. Individual countries are subject to shifts in oil supply and demand (up or down), even when they

[6] Eight months at 17 mbd comes to about 4.2 billion barrels; however, there are physical constraints to the release of oil from strategic reserves (see below, pp. 9, 10). Other pertinent facts include that additional oil is stored in non-OECD countries and that oil tankers in transit worldwide carry about 500 million barrels. The average delivery time for oil shipped by tanker to the U.S. is about 13 days; Persian Gulf oil takes about 30 to 40 days to reach the U.S.

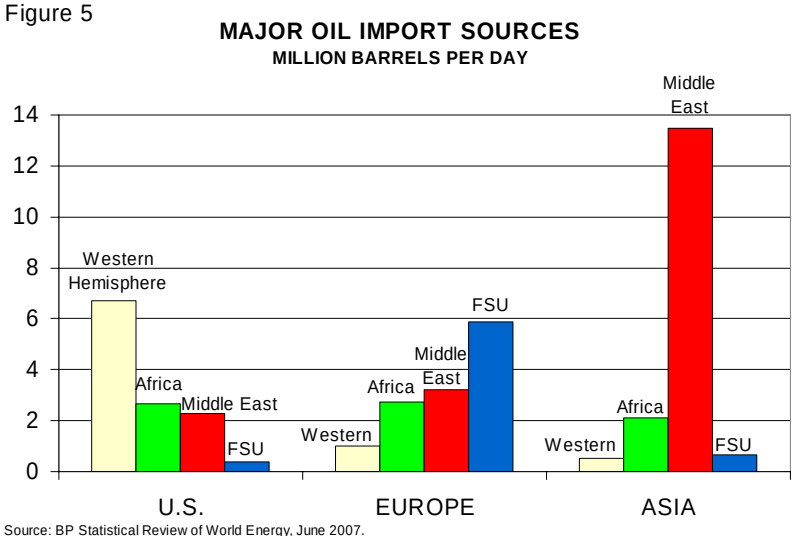
Figure 4



emanate from regions with which they have no direct dealings. Generally, the ease with which oil is shipped around the globe works to the benefit of buyers, because sellers cannot prevent resale and thus are unable to impose selective embargos or discriminatory prices.[7]

The transactions costs of securing alternative supplies and of having to ship oil over longer distances due to a disruption, however, would fall disproportionately on Asian and European buyers, who obtain most of their oil from outside their continents. The U.S. obtains two-thirds of its oil from the western hemisphere (domestic sources, Canada, Mexico, Venezuela, and other South American countries).[8] The average transportation cost per barrel for oil delivered to the U.S. is about $2. As a group, Asian countries obtain only one-third of the oil they consume from within their continent; 57 percent is imported from the Middle East and 8 percent from Africa. Middle East oil accounts for 83 percent of Asian oil imports. Forty-four percent of Europe's oil imports are from Former Soviet Union (FSU) states (the share of Europe's natural gas imports from Russia is even higher), 24 percent from the Middle East, and 20 percent from Africa.

Figure 5



[7] Landlocked supply can be subject to significant regional price differentials.
[8] The U.S. imports a significant amount of refined oil products from Europe not shown in Figure 5.

Likelihood of a Disruption. Economic interdependency discourages embargos, boycotts, and other interference with trade. The Middle East is no exception. Persian Gulf economies are dependent on oil revenue and Persian Gulf governments reinvest substantial sums in the global capital market. They buy goods, services, and technology from oil consuming countries and even import petroleum products. Iran, for example, is the world's second-largest importer of gasoline. An interdiction of shipping traffic in the Strait of Hormuz would interfere with delivery to the Gulf of all imports that arrive by sea. If Persian Gulf countries cut off the oil trade, they would lose their enormous oil export revenue (more than $400 billion in 2006); they likely would be subject to economic sanctions; and their financial interests outside the region would suffer. Oil exporters collectively can change the terms of the oil trade with the rest of the world, but OPEC has already done that. At a single market price, there is no order-of-magnitude improvement in the terms of trade left to extract by the oil producers.

Nevertheless, in addition to OPEC, whose mode of operating at least is understood, oil buyers face two problems that are difficult to gauge. The first is intra-regional conflict over the distribution of oil profits and control of the oil fields that can diminish the available supply to an unpredictable extent and for an indefinite period. Particularly extremists who hold little or no stake in the current distribution of oil wealth or the regional power structure may be impervious to the costs a disruption would impose on the region.

The second problem is brinkmanship by individual oil producing countries with respect to interrupting the oil supply. In economic terms, producers could extract more value, if they could charge different prices to individual buyers or control the amount of oil that reaches individual countries. Since they are unable to do so, some large producers resort to the threat of withholding their oil exports entirely (holding the world economy hostage so to speak) in an attempt to extract from the governments of the wealthiest oil consuming nations additional concessions, some of which may be political rather than economic. This explains why Iran threatens the U.S. and Western European countries with an oil embargo, even though its customers are primarily in Asia and the U.S. does not import any oil from Iran. The strategy can escalate to include threats against the oil exports of other countries if another's surplus pumping capacity could replace the exports withheld in an embargo. Iran's oil export volume is 2.5 mbd. The EIA estimates that Saudi Arabia has recently increased its surplus pumping capacity to between 1.9 and 2.4 mbd. Hence, Saudi Arabia alone is in a position to replace between 76 and 96 percent of Iran's oil exports. This could explain why Iran also threatens to block the Strait of Hormuz.

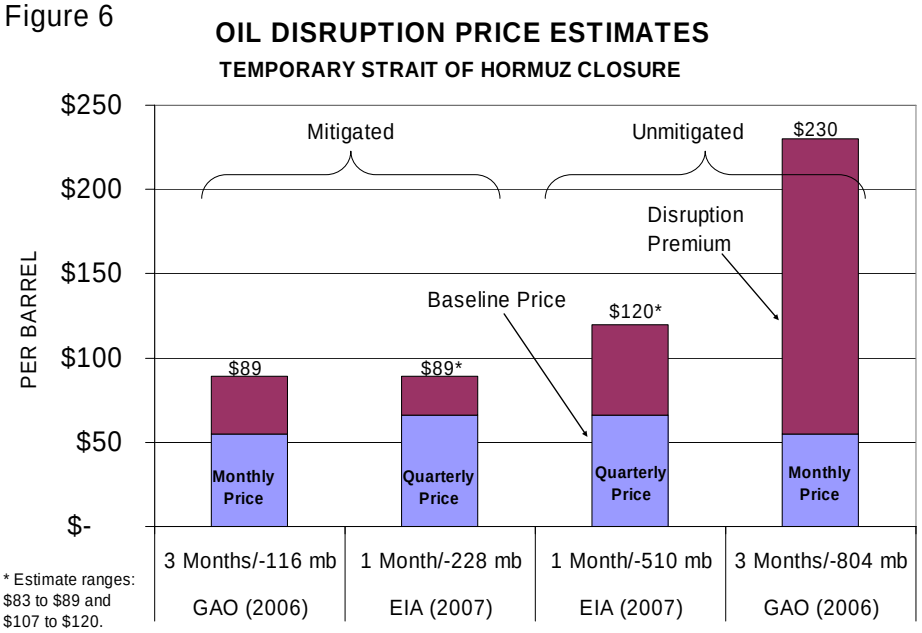
Such threats imply a willingness to absorb substantial detrimental repercussions.[9] It is therefore a matter of judgment how real the threats are, but the market does attribute some credibility to them as evidenced, for example, by the oil price increase when Iran took British soldiers hostage.

EIA and GAO Oil Price Simulations. The EIA and the Government Accountability Office (GAO) have conducted recent simulations of disruptions to the oil flow through the Strait of Hormuz.[10] Their approach is to estimate the price increase necessary to reduce world oil

[9] Iran's effort to ration domestic gasoline consumption already has caused open anger by consumers, for example.
[10] EIA performed two simulations for this report. GAO, in "Strategic Petroleum Reserve," Report to Congressional Requesters, August 2006, employed two different models. The Office of Petroleum Reserves uses one of the

consumption by the amount of oil taken off the market due to a disruption. The simulations assume that the world oil market would continue to function without added trade restrictions or price controls. Figure 6 shows price estimates for disruptions of different sizes. GAO's estimates are of the highest monthly price during a 3-month disruption and not directly comparable to EIA's. The EIA does not attempt to capture the market's immediate reaction to

Figure 6



the disruption. It averages a 1-month supply reduction over three months and derives a quarterly price. Moving from left to right on the graph, the first two cases depict lost oil volumes mitigated by fuel switching, rerouting some shipments, and releasing oil from storage.

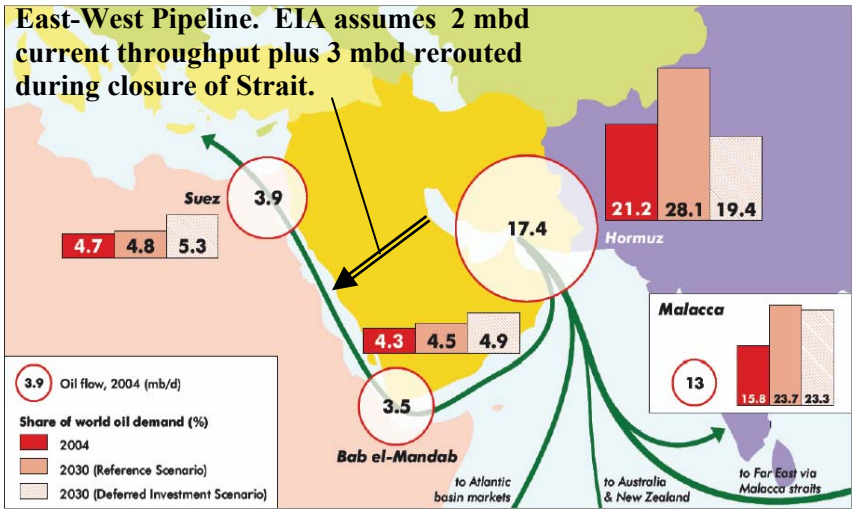
In the two cases to the right, the entire 17 mbd of oil shipments through the Strait are lost for 30 days—510 million barrels—under EIA's assumption, to which GAO adds continuing losses in the two subsequent months for a total of 804 million barrels. (GAO assumes that oil shipments through the Strait partially recover after the first 30 days.) The EIA's projected disruption-induced price for West Texas Intermediate (WTI) crude in the case of the unmitigated supply loss rises to a range between $107 and $120 per barrel in the second quarter 2007, returning to an assumed baseline price of $66 thereafter. GAO's peak price estimate, with a baseline of $55, is $230 per barrel in the first month.

Alternatively, the EIA assumes that 3 mbd of oil currently shipped by tanker could be rerouted from the Persian Gulf to the port of Yanbu on the Red Sea through Saudi Arabia's East-West Pipeline (see Figure 7), which currently has excess throughput capacity, and that 6.4 mbd would be drawn from strategic stockpiles. The oil loss thus is held to 7.6 mbd, which would amount to 228 million barrels after 30 days. The quarterly oil price rises less in this case, to between $83 and $89 per barrel.

models, and the EIA had previously used the other. The GAO results shown here are from the former compared with those from the updated model that EIA used for this report.

Figure 7

MAJOR OIL FLOWS FROM THE PERSIAN GULF
CURRENT AND PROJECTED



Source: William C. Ramsey, Deputy Executive Director, IEA, "Political Risk Revisited, The Global Resource Challenge," presented at the Royal Institute for International Affairs, London, February, 6, 2007. East-West Pipeline and caption added.

GAO does not assume rerouting of oil shipments but a much larger draw from storage than EIA. In addition to some fuel switching, the oil released from strategic reserves mitigates the disruption, and consequently calls for a smaller reduction in oil consumption. For this case, GAO projects a supply loss of 116 million barrels and a peak monthly price of $89 per barrel. In both the EIA and GAO models the smaller the physical loss of oil experienced by the market, the lower the disruption price. If the entire volume of lost oil shipments were restored from storage, there would be no price increase; save for a $2 per barrel market risk premium added by the EIA to its estimates.

Limitations of Oil Price Simulations. The EIA and GAO analyses simulate a market that either immediately or soon after the closure comes to expect a short, self-contained disruption with no adverse aftereffects. This scenario is certainly possible, but it is not what everyone fears the most. Also, within these models there is tension between two assumptions, namely that the disruption, on the one hand, is temporary but, on the other, is not fully offset by oil from ample private oil stores. Private inventory owners would not hold onto their oil when offered a steep price increase, if they expect the price to fall again soon. Both models assume that private inventory levels remain unchanged during the disruption and that oil is released only from government-controlled stockpiles. (The scenarios do not address the need to refill the strategic reserves.) But, the use of strategic stockpiles may be problematic when the market is holding back:

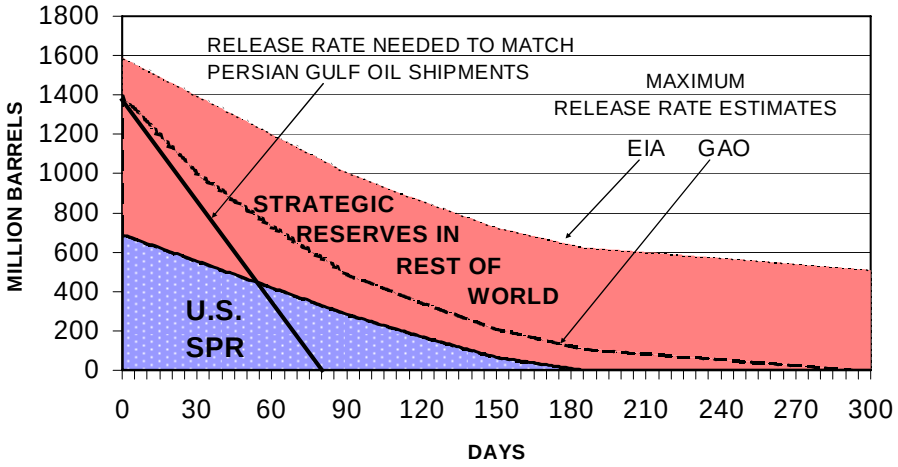
1. Oil from the SPR could be bought up and moved into private storage.

2. However, there is a physical limit to the rate at which this oil can be released. The maximum rate for the SPR is 4.4 mbd for 90 days. Thereafter, due to declining pressure in the salt

domes where the oil is stored, the rate drops in 30-day intervals from 4.4 to 3.8, 3.5, and 1.9 mbd. The EIA estimates that reserves outside the U.S. can be released at a rate no higher than 2 mbd. GAO assumes that foreign governments have stored 700 rather than 900 million barrels but can release the oil much faster initially: 8.5 mbd, declining to 4.4, 3.5, and then 1 mbd in 30-day intervals. Figure 8 depicts the maximum release rates estimated by the EIA and GAO relative to the rate necessary to compensate for the full loss of Persian Gulf oil shipments, if private oil inventories did not contribute. After 30 days, 510 million barrels would be lost, but only 387 million released according to GAO and even less, 192 million, according to EIA.

Figure 8

STRATEGIC OIL RESERVES AT MAXIMUM RELEASE RATE



3. Most important, depleting the SPR diminishes its potential for future market intervention. Strategic stocks have their strongest rationale in discouraging foreign opportunistic supply manipulation during a crisis and preventing panic in the market. Early announcement of the *intention* to use the SPR in a crisis together with the release of *some* oil to establish credibility can discourage opportunistic supply cutbacks, reassure the market, and moderate speculative buying. Hence, its greatest value lies in being available for use while not actually being used to any appreciable extent. Strategic reserves, in fact, have been released under emergency conditions only twice, 17.3 million barrels at the outset of Desert Storm and 20.8 million barrels after hurricane Katrina.

In sum, government oil reserves are not well suited to make up for a large physical shortfall in the oil flow *by themselves*.

Modeling the oil price during a supply disruption is difficult, because the intensity with which the market may seek to secure oil for storage and future delivery is not predictable. One can postulate a disruption scenario for quantitative analysis, but one cannot know what the perceptions and expectations of the market would be should the scenario actually occur. If the market believes, rightly or wrongly, that the disruption will be worse than postulated, the estimates will understate the price. During the Iranian revolution, the price of oil increased 2.6 times, because the rush to build up inventories effectively widened the gap between the quantities of oil demanded and supplied from four to ten percent. Motorists carried one billion

gallons of additional fuel in their gas tanks, raising the average fill factor from 25 to 75 percent. When Iraq attacked Iran, the price increased by another 24 percent due to oil purchases for storage even though world oil *consumption* was weakening.[11]

DISRUPTIONS AND THE ECONOMY

The Shock Effect. A large, sudden increase in the cost of a widely used resource such as oil may leave the economy no time to prepare or adjust. Increased oil payments act like an unexpected tax that suddenly leaves consumers less money to spend on other purchases as they scramble to curtail their oil consumption and find substitutes for oil products.[12] In addition, fear of worsening economic conditions can lead consumers to postpone major purchases, which further reduces current demand. If the cost increase is permanent, the change in relative resource costs calls for restructured investments, which initially can slow capital spending. Reductions and shifts in demand cause a drop in utilization of existing production facilities and in employment until the disruptive event has passed or the economy can reallocate its resources. When consumers and producers have adjusted to the change in the price of oil, the actual rate of output will recover, but if the economy must continue to operate with less oil, the potential rate of output will be lower. Thus, a reduction in the oil supply causes an output gap and possibly a recession in the short run and may lower the long-run production frontier due to greater resource scarcity. The effort expended to reallocate resources is a loss to society, but is productive activity and does not lower the gross domestic product (GDP) as measured. Some analysts of oil shocks view such "frictional" costs as very substantial.

Monetary and fiscal policies can mitigate the effective loss of income resulting from an oil price increase by allowing consumers and firms to borrow cheaply for a time and by lowering their taxes. But "easy money" does not assure improved economic expectations and carries the risk of overcompensation for the loss of real income, thereby setting off inflation—general price increases unrelated to the increased scarcity of oil.

Since the U.S. imports 60 percent of its oil, most of the income devoted to paying higher oil prices leaves the country ($45 billion per year for every $10 increase in the annual price of oil). Foreign "petrodollars" pay for additional U.S. exports and finance additional capital investment in the U.S., thereby returning some of the oil money and reducing the drain on the domestic economy. Nonetheless, higher oil prices enrich foreign oil producers and allow them to claim a larger share of U.S. output and assets. Therefore, GDP is reduced by a higher oil price and a larger share goes abroad to pay for oil.

All the oil shocks were associated with recessions. In the 1970s, their impact was most severe. From 1973 to 1975, U.S. output dropped by more than 3 percent and unemployment doubled to 9 percent. Inflation already had been rising before the oil shock of 1973, and the government had imposed wage-price controls. The price system generally was much less flexible than it is today. Starting in 1973, the condition of the oil supply worsened long-term. The government lifted the wage-price controls by April 1974, but continued to regulate the petroleum industry under a

[11] Yergin, *The Prize*, 687 and 711.
[12] The 1973 oil price increase gave rise to what became known as the "OPEC tax," see Yergin, *The Prize*, 635.

price and allocation regime that gave rise to inefficiency and shortages. The economy stagnated and experienced rising inflation ("stagflation") under a monetary policy that became overly accommodative. Following the decade's second oil shock that began in 1979, the Federal Reserve chose to raise interest rates to fight inflation rather than cushion the shock. This action intensified reductions in output and employment. Thus, several factors combined to impede economic activity. There is no consensus among economists concerning the relative effect each had individually.[13]

Today's Economy is More Flexible. Since the end of 2003, oil has become twice as costly, yet the economy has continued to grow at an annual rate of more than three percent in real terms. The Congressional Budget Office (CBO) has estimated that U.S. GDP was about one percent lower in 2006 than it would have been if energy costs had not risen.[14] While this is a significant reduction, it represents incremental output forgone over and above the growth realized, not a decline in the actual output level. The Federal Reserve expects the U.S. growth rate to increase again in the second half of 2007 from a relatively slow start in the first quarter, even with crude oil exceeding $70 per barrel. This growth is possible because the economy is structurally more flexible. Important industries in the U.S. now face fewer regulatory constraints including banking, home mortgage finance, trucking, airlines, telecommunications, and petroleum, which makes the price system more efficient. Inflationary expectations have been wrung out of the system and interest rate risk premiums have been substantially lowered. Globalization—the advancing integration of national economies—combined with economic liberalization in former communist bloc and other developing countries has contributed to low levels of inflation, interest rates, and labor costs. The resulting acceleration in global economic activity has raised the demand for oil, and, in response, the supply has increased, albeit at a higher price. Under these conditions, paying more for oil has not reduced the level of consumer spending on other goods and services, only the rate of growth. The drag of higher oil prices is eased also because the economy is less energy intensive than before—it produces more output with smaller increments of oil.

The Oil Supply Remains Critical. While the economy so far has absorbed substantial energy cost increases, an oil supply disruption remains a threat. It is not clear how the economy would react to a sudden as opposed to a gradual increase in the price of oil or how it would overcome a long-term reduction in the oil supply. A jump in the cost of oil would strike at the margin of an economy that is facing substantially elevated oil cost already. U.S. expenditures on petroleum have risen from less than 2 percent of GDP during much of the 1990s to 3.5 percent, the same percentage as in 1973. Oil consumption now is more concentrated in the transportation sector where there are few substitutes and demand is inelastic. Given improved economic baseline conditions, monetary and tax policies could mitigate the negative income effect of a steep oil price increase, but their success would depend on how high the price moves. Moreover, perceptions of the future condition of the oil supply would have an effect on consumption and investment decisions. An improved economy and more efficient use of oil do not imply that oil is no longer a constraint to the production frontier. Government policies cannot relieve the

[13] For an excellent review of the economic research on oil shocks see Mark Labonte, "The Effects of Oil Shocks on the Economy: A Review of the Empirical Evidence," CRS Report for Congress (RL31608), January 18, 2006.
[14] "The Economic Effects of Recent Increases in Energy Prices," CBO paper prepared for the Chairman of the Senate Budget Committee, July 2006.

economy of the need to adjust to a long-term change in the oil supply. From a global perspective, a stoppage of Middle Eastern oil supply would force oil consumption back to the level of 1993 and substantially shrink the world economy.

Economic Impact Simulations. The models used to quantify the economy's reaction to a disruption are limited in their ability to simulate expectations and measure how today's economy would function under stress. Macroeconomic models cannot distinguish between changes in parameters that are viewed as benign as opposed to threatening. Time series models (so-called vector autoregressions) capture market reactions to past crises but link them to known outcomes, not to the potential outcomes feared at the time. In extrapolating projected outcomes, they do not incorporate improvements in economic baseline conditions and crisis management. Models obviously also cannot predict whether a disruption would introduce an era of substantially impaired supply. The simulations presented in the following assume that the Federal Reserve would lower interest rates temporarily in response to a disruption.

Prior to the Iraq war, the Center for Strategic and International Studies (CSIS) conducted economic simulations of Persian Gulf oil supply disruptions using a macroeconomic model.[15] At the time, the oil price was less than $30 per barrel, and the economy was recovering from a recession. The CSIS scenarios did not include closure of the Strait of Hormuz, but the results for the worst case examined, in which oil production falls by five to six mbd, remain instructive. The following summarizes the effects of the oil disruption as they unfold by quarter:

- **First and second quarter**: U.S. and international strategic reserves release 3 mbd of oil but private stock building occurs nevertheless. The oil price shoots up to $80 from $27 per barrel. Consumer confidence and the stock market both plummet, and the risk premium on private bond interest relative to Treasury bonds doubles. The Federal Reserve lowers the federal funds rate. A recession begins as the annualized rate of growth declines from 1 percent to -3.5 percent. The major 35 U.S. trading partners experience GDP growth rate declines about 60 percent as great. Unemployment rises gradually, and the dollar declines modestly.[16]
- **Third and fourth quarter**: The recession ends in the third quarter. The price of oil substantially declines, mainly because oil consumption contracted in the recession, but the price remains elevated. Consumer confidence and the stock market partially recover. Interest rate risk premiums moderate, but unemployment continues to rise, exceeding seven percent.
- **Fifth to seventh quarter**: The stock market continues a moderate recovery, interest rate risk premiums decline, the Fed normalizes the federal funds rate, output growth rises substantially, but unemployment remains elevated.

[15] Robert Ebel, Herman Franssen, Larry Goldstein, and Adam Sieminski, "After an Attack on Iraq: The Economic Consequences," CSIS, 11/12/02, and "Conference Summary," by Laurence Meyer, 11/21/02. The disruption prices postulated were based on the judgment of a team of oil analysts who took into account market expectations, though without detailing the methodology. For this reason, they were not included in the price simulation section above.

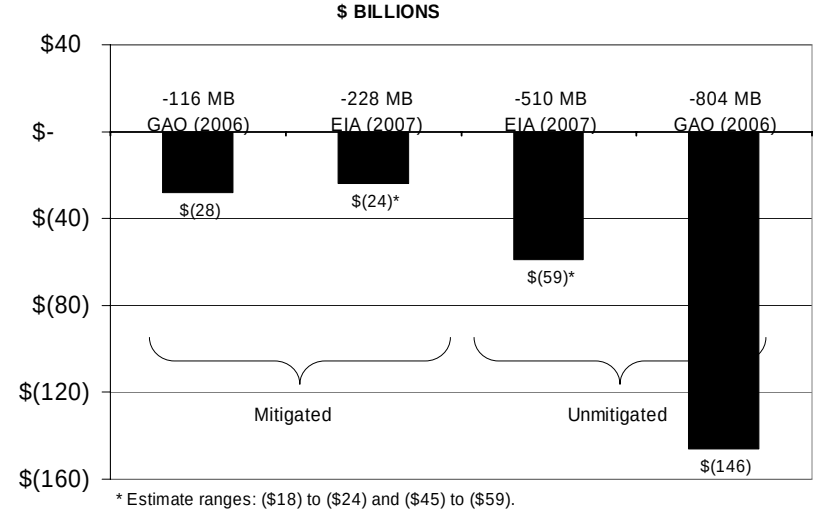
[16] Countervailing forces are at work: The crude oil price is denominated in dollars, which can raise the demand for U.S. currency when the oil price goes up, and the U.S. may be seen as a "safe haven" during crises. On the other hand, interest rates likely are lower in the U.S. than abroad.

The simulated recession reduces national output by about $190 billion or 1.8 percent of annual GDP. The output loss relative to the economy's growth estimated by CSIS absent an oil shock is much greater, about $475 billion over four quarters.[17] The CSIS scenario does not address what happens subsequently to the oil supply or to the economy.

EIA also uses a macroeconomic model.[18] It estimates outcomes that are much less severe, because the disruption is temporary with no lingering effect or threat to future supply. The forces that first shift oil demand up (additions to inventory) and then down (recession) in the CSIS scenario do not come into play. For the case where the market loses the entire volume of oil shipments from the Gulf for 30 days, 510 million barrels, EIA calculates a reduction in real GDP between $45 and $59 billion over two years (see Figure 9), which represents between 0.4 and 0.5 percent of GDP. EIA also estimates a cumulative two-year increase in the unemployment rate of 0.19 to 0.24 percent and in the inflation rate of 0.24 to 0.31 percent. In the case where oil can be rerouted through the East-West Pipeline, the GDP loss is $18 to $24 billion (less than 0.2 percent of GDP) and the associated increases in unemployment and inflation are 0.12 to 0.16 percent and 0.04 to 0.07 percent, respectively.

GAO, using a time series model, projects a much larger GDP reduction of $146 billion (1.2 percent of GDP) for a loss of 804 million barrels. For the case in which oil from strategic reserves reduces the shortfall in supply to 116 million barrels, the projected GDP loss shrinks to $28 billion (0.2 percent of GDP).

Figure 9



All three projections of the consequences arising from a major oil supply disruption focus primarily on size and duration. CSIS postulates a plausible sequence of events for a large and extended reduction in the oil supply and takes into account initial precautionary oil purchases, but it does not address the ultimate condition of the oil supply or the market's perception of it.

[17] The GDP impact estimates were derived from information presented in the study; CSIS did not state them explicitly.

[18] "Impacts of Hypothetical Oil Supply Disruption—Strait of Hormuz," EIA, April 5, 2007. (Prepared on request for the Joint Economic Committee.) Also see EIA, "Issues in Focus," *Annual Energy Outlook 2006*, 35. EIA has reported that the model used by the Federal Reserve tends to produce similar results.

EIA assumes the disruption is brought under control in one month, and the oil market is completely normalized after one quarter. It assigns a risk premium of only $2 per barrel to the quarterly price. GAO postulates a somewhat longer disruption than EIA and predicts a much larger GDP loss, but assumes that the disruption's effect is quelled to the extent that strategic oil reserves make up for the loss of supply.

Besides the physical dimensions of a disruption, however, there are other key determinants of whether it would escalate into an oil shock or how severe the shock would be:

a) fear of worsening conditions;
b) opportunistic cutbacks by suppliers unimpaired by the disruption; and
c) long-term deterioration of the conditions of the oil supply.

While difficult to model, these factors will determine whether private inventories, which are considerably larger than government controlled ones, are released to ameliorate the situation and how consumers and investors throughout the economy will change their behavior. The market's reaction to a Strait of Hormuz closure clearly could be worse than presented above but it also could be milder, if the outcome is deemed benign early on. The Persian Gulf region has undergone severe conflicts and the worst fears regarding access to its oil reserves have not materialized. In the case of a Strait of Hormuz disruption, if compounding actions by opportunistic suppliers do not occur (perhaps discouraged by strategic oil releases) and if adversaries are unable to maintain control of the Strait, then after an initial spike the oil price conceivably could fall abruptly as happened after the onset of Desert Strom. Significant economic fallout then may be averted.

CONCLUSIONS

Oil shocks can be distinguished by whether they are isolated events or mark the onset of a change in supply conditions. The Arab oil embargo marked the beginning of OPEC supply manipulation that has kept the price permanently higher than before. Previously, demand could increase and supply would expand at cost. Subsequently, supply expansion was constrained and price pushed far above cost. A closure of the Strait of Hormuz could signal that terrorists or rogue states are able to wrest control of the oil supply from OPEC and that the flow of oil henceforth is permanently impaired far beyond the level that would enlarge the cartel's profit. Even if the Strait is reopened in short order and the loss of oil kept relatively small, as was indeed the case with the 1973 embargo, recurring closures and the threat thereof could keep the price substantially elevated.

The Persian Gulf region holds 55 percent of the world's known oil reserves, and the oil market reacts with caution to disturbances in the region that could threaten access to them by buying or contracting for more oil than it consumes. The oil shocks experienced to date were not discrete, random events such as if natural disasters or accidents had caused them. Each crisis was associated with deliberate action in the Middle East to constrain the oil flow or threaten the reserves. The market's perception of events and assessment of the likelihood of adverse long-term outcomes thus determine oil-trading decisions and consequently have considerable influence over the oil price. Changes in the market's assessments alone can bring about huge price swings.

The key aspects of a disruption of tanker traffic in the Strait of Hormuz, therefore, are whether it would reshape future supply from the Persian Gulf and how the market assesses this possibility. The immediate loss of oil from the disruption would be secondary. Due to the experience of six oil crises since World War II, most oil importing nations have accumulated substantial oil stores already. While a blockage of the Strait would have a much larger impact on the daily flow of oil than any prior interruption in supply, oil released from private and strategic inventories, in theory, could manage the physical loss of oil for many months. But, it is the market's assessment of reserve access going forward that would determine actual inventory management decisions.

Governments of oil importing countries must choose the timing and the amount of strategic oil releases carefully to calm the market and to preserve their future influence. Strategic oil reserves can discourage opportunistic cutbacks by large, state owned oil exporters during a supply disruption but by themselves cannot offset a large disruption if the market fears that worse is to come.

Price and economic impact models of oil supply disruptions can reliably simulate only limited dislocations or extrapolate the experience of prior crises. Neither approach can foretell whether supply conditions would be altered permanently by a future disruption or how the market would react to events as they unfold. Of necessity, such studies tend to focus on the size of the disruption and assume that the economic impact is proportional to it.

Two additional observations are important. First, the likelihood is not great that Persian Gulf oil will be denied to the world. The incentives of most of the parties in the region lead them to continue to produce and sell oil. OPEC abruptly shifted the terms of the oil trade in its favor once and cannot do it again; it can only improve the terms incrementally as the demand for its oil increases. The parties from whom threats to the oil supply emanate are either disenfranchised extremists with no regard for the costs they might impose on their compatriots or those who are engaging in brinkmanship. The former presumably lack the power to constrain permanently the region's oil supply. The latter can use to their advantage only the *threat* of cutting off the oil trade and not the action, for the repercussions would be most severe for all of the Persian Gulf. The collective oil revenue of Persian Gulf countries exceeded $400 billion last year.

Second, the U.S. economy and the world economy have become far more flexible and adaptive. Economic liberalization throughout the world has helped to keep inflation, interest rates, and labor costs low and laid a foundation for growth, despite the doubling of oil prices in recent years. Public policy responses to an oil supply disruption are likely to be flexible as a result and avoid the use of price controls. This is not to say that an abrupt reduction in the oil supply could not cause a recession or derail economic advancement in the developing world, but the chances of overcoming a disruption have improved, provided it does not usher in an era of deteriorating oil supply.

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