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Routing

The Case against the Strategic Petroleum Reserve

by Jerry Taylor and Peter Van Doren

Executive Summary

The Strategic Petroleum Reserve has been almost uniformly embraced by politicians and energy economists as one of the best means to protect the nation against oil supply shocks. This study finds little evidence for the proposition that government inventories are necessary to protect the country against supply disruptions. Absent concrete market failures, government intervention in oil markets is unlikely to enhance economic welfare.

A conservative estimate finds that the SPR has cost taxpayers at least $41.2–$50.8 billion (in 2004 dollars), or $64.64–$79.58 per barrel of oil deposited therein. Accordingly, the "premium" associated with the insurance provided by the SPR is quite high relative to market prices for oil, even during 2005.

The SPR has been tapped only three times, and in each of those instances, the releases were too modest and, with the exception of the 2005 release related to Hurricane Katrina, too late to produce significant benefits. Accordingly, the costs associated with the SPR have been larger than the benefits thus far.

The SPR insurance policy is unlikely to pay off in the future either. First, major oil supply shocks are much rarer than many observers believe. Second, the executive branch has been unwilling to use the reserve as quickly and robustly as economists recommend. Third, the benefits from a release are almost certainly overstated.

Policymakers should resist calls to increase the size of the reserve and instead sell the oil within the SPR and terminate the program.

Jerry Taylor is a senior fellow at the Cato Institute. Peter Van Doren is senior fellow and editor of Cato's Regulation *magazine.*

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The SPR is the largest government-owned stockpile of petroleum in the world. Its draw-down capacity of 4.3 million barrels of oil a day is slightly larger than Iran's daily contribution to world oil supply.

The Architecture of the SPR

The Strategic Petroleum Reserve is a federally owned and operated stockpile of 700.1 million barrels of oil—285.2 million barrels of sweet crude and 414.9 million barrels of sour crude—located in approximately 50 artificially created caverns deep within salt-rock formations scattered throughout the coastal regions of Texas and Louisiana.[1] Its 727-million-barrel storage capacity will be reached within several months, but the recently enacted Energy Policy Act of 2005 authorizes expansion of the SPR to 1 billion barrels.

The SPR was established in 1975 as part of the Energy Policy and Conservation Act as a response to the 1973 Arab oil embargo.[2] The legislative goal is to store 1 billion barrels of oil for use in a "severe energy supply disruption."[3] Use of the SPR is solely at the president's discretion.[4]

The SPR is the largest government-owned stockpile of petroleum in the world.[5] To put its size into perspective, its draw-down capacity of 4.3 million barrels of oil a day is slightly larger than Iran's daily contribution to world oil supply. "In effect, a big, government-owned reserve like the SPR could be considered a new oil-producing province entering a disrupted international oil market," notes oil analyst Edward Krapels. Withdrawing the maximum amount of oil possible from the SPR would enable the federal government to replace about 36 percent of U.S. oil imports and add about 5.9 percent to the world's daily oil supply for approximately 163 days before the reserve ran dry.[6]

The maintenance and operation of the SPR is also governed by the International Energy Agency, which the United States joined in 1976. Founded in 1974 under the International Oil Program Agreement, the IEA was established to provide a consuming-nation counterweight to OPEC.[7] Under the terms of the agreement, if any of the 26 IEA member countries experiences a 7 percent or greater drop in crude oil supply, better-situated IEA members are obligated to share their supply with that country (or countries), and the IEA secretariat is charged with deciding at what price that oil will be shared and how much total oil consumption is to be allowed within each member state.[8] To make sure that such supplies are available, IEA members are obligated to ensure that enough oil from both public and private stockpiles is on hand to replace 90 days worth of imports if necessary.

The operation of the SPR has become politically controversial in recent years. The central question is whether the SPR should be used only during a "national emergency" or whether it should it be used occasionally as a means to alleviate high domestic oil and gasoline prices. The controversy is well described by Alvin Alm, former director of the Harvard Energy Security Program:

> Although almost all energy experts and politicians agree that a strategic petroleum reserve is desirable, serious disagreement exists on the purpose of the reserve and how it should be managed. Some view it as a tool of military and foreign policy, only to be used during periods of dire national security threats. The majority of political leaders and interested citizens view the reserve as a source of fuel to prevent physical shortages. The persistent concern of New Englanders and Hawaiians over regional reserves, for example, attests to the depth of this feeling. Finally, most economists and energy experts view the reserve primarily as a tool to minimize price increases during and after oil interruptions.[9]

Secondary political issues that have arisen include (1) whether, to reduce oil prices, the president should suspend additions to the SPR when global oil supplies are tight, (2) how quickly the U.S. government should increase the reserve's stockpiles, and (3) to what extent the federal government should expand storage capacity.

Academics have also sparred over the SPR, primarily concerning organizational struc-

ture,[10] release triggers,[11] release mechanisms,[12] funding methods,[13] and optimum inventory size.[14] Some economists have challenged the SPR on a more fundamental level. Disputes include (1) whether the development of financial instruments for hedging against oil prices in the early 1980s have rendered the SPR less important[15] and (2) whether, in a serious crisis, the SPR might be used as part of some future multinational oil price and allocation control regimen under the auspices of the IEA.[16]

Historically, however, both economists and politicians have supported the SPR.[17] The SPR is popular with politicians because it allows them to tell their constituents that they have done something to protect the nation against a future oil embargo. The SPR is popular with many economists because it is seen as a hedge against the economic impact of future supply disruptions.

The Theoretical Case for the SPR

The SPR is best conceptualized as a publicly provided insurance policy against petroleum market shocks. The cost of the SPR program is the premium. The benefits are the price reductions that result from its existence or use.

The SPR, however, provides insurance against only a subset of the possible supply disruptions that could occur. Oil releases from the SPR can ameliorate temporary events but cannot affect long-term disruptions in the market because the reserves are not large enough to affect world prices over extended periods of time.[18] The oil within the SPR—the largest publicly managed oil stockpile in the world—would have increased global oil supplies by only 2.55 percent (about 9 days) had it been released in its entirety in 2004.[19] The combined public reserves of the United States, Japan, and Western Europe equal only 20 days of world consumption.[20]

Is there need for insurance against supply disruptions and, if so, does the government need to provide it? The answer to those questions would appear to be "maybe" and "no."

What's Wrong with Private Inventories?

Is the management of private oil inventories inefficient?[21] As economists Douglas Bohi and W. David Montgomery note: "the presence of disruption risks alone does not alone justify government intervention. The rationale for such action must be based on some deficiency in private preparations."[22] Economists believe that profit-seeking investors will make efficient decisions regarding oil inventories unless the price signals they rely on fail to reflect total costs and benefits. Although the literature pertaining to the SPR frequently reports that private inventories are meager compared to the size of publicly held inventories, a proper accounting as of December 2004 concludes that, worldwide, publicly held reserves totaled roughly 1.5 billion barrels, whereas private inventories stood at 4.8 billion barrels.[23]

Those who argue for the existence of market failure make several claims. First, private actors hold too little inventory because they anticipate that price controls or other regulatory interventions will confiscate their profits during market shocks.[24] Although the risk of such policies is clearly above zero (oil price controls were imposed in 1971 and they lasted through 1981[25]), we know little about how great that risk might be—or how worried market actors are about future intervention. In this case, however, it is ironic that public stockpiles are proposed, not as a correction for market failure, but for government failure.[26]

Second, if the total economic benefits provided by oil inventory cannot be fully captured by the inventory holder, private actors will invest less in oil inventories than is optimal.[27] Said differently, oil inventories are thought to produce significant macroeconomic benefits upon release that are not captured by inventory holders.

How much larger would private stockpiles be if the macroeconomic benefits of release could be fully captured by inventory holders?

The answer depends on the macroeconomic damage that results from oil price

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shocks. There is extensive disagreement among economists about the macroeconomic effects of oil price spikes. If the macroeconomic damage is minimal, it is unlikely that the uninternalized macroeconomic benefits of oil inventories are particularly significant—and thus unlikely that price signals at present are sufficiently "off." Nor is it obvious that publicly held inventories are the first-best remedy for the macroeconomic dislocations associated with oil price spikes. Accordingly, economists Jeffrey Williams at Stanford University and Brian Wright at the University of Southern California maintain that "macroeconomic justifications for storage interventions rest on shaky ground. This is not to deny their potential importance; but the arguments must be made more precise before it is possible to conduct the critical evaluation that would make them persuasive."[28]

The third reason that private inventories are thought to be suboptimal is that private inventories are very costly to maintain. But given the costs associated with stockpiling commodities, it may be less costly on balance (and hence, more efficient for the economy as a whole) to allow prices to fluctuate than to hedge against them.[29]

Regardless, the operation and maintenance costs involved in stockpiling oil in large underground salt domes are presumably less than the cost of storing them in the conventional steel tanks that are used throughout the private sector. But if underground storage has lower costs and similar benefits compared with surface storage, private investors would adopt the technology in the absence of regulatory or transaction-cost impediments. And even if impediments existed, subsidized storage space for private inventories in salt domes would be the appropriate remedy. A government-owned-and-operated inventory would be unnecessary.

There is little evidence that private oil inventories are suboptimal.

Fourth, some argue that uncertainty about future oil prices results in perverse oil inventory behavior. That is, oil inventory holders hold rather than release oil during price increases because they anticipate even higher prices in the future. Such behavior exacerbates rather than ameliorates the price increase.[30] But uncertainty about the future and the appropriate timing of release also would characterize the decisions faced by public inventory managers; and there's no reason to believe that they would make more efficient decisions than market actors.[31]

There is little evidence that private oil inventories are suboptimal. But if such evidence existed, the most direct remedy would be to subsidize private inventory holders (perhaps through some sort of preferential tax treatment), not to establish publicly owned stockpiles.[32]

Unfortunately, many economists in the United States have either implicitly or explicitly embraced the SPR rather than subsidy.[33] Critics of subsidy make two claims. First, subsidy cannot guarantee the size of the resulting reserves. Second, release decisions will be left to private actors who "have strong incentives to hold back stockpile use until the price rises, precisely what the government is trying to prevent."[34] In fact, our experience with the SPR suggests that public inventory managers are even more prone to this criticism than private inventory managers.

SPR as an Embargo Hedge

A final rationale invoked by SPR supporters is that the reserve is needed to combat physical shortages that may arise from an oil embargo. But even if private actors hold suboptimal stockpiles of petroleum absent government intervention, oil embargoes per se are of no particular consequence and physical oil shortages are not a problem in the modern economy.

An oil embargo against the United States is incapable of preventing oil imports from reaching U.S. ports. Once oil leaves the territory of a producer, market agents dictate where the oil goes, not agents of the producer. The globalization of oil markets ensures that the United States will always have access to Persian Gulf oil, whether OPEC members like it or not. MIT oil economist M. A. Adelman represents the overwhelming consensus among economists on this point:

> Rarely has a word ["access"] been so compact of error and confusion. Nobody has ever been denied access to oil: anyone willing to pay the current price could have more than he wanted. One may assume what he likes about future demand, supply, and market control, and conclude that the future price will be high or low, but that price will clear the market in the future as in the past. The worry about "access" assumes something queer indeed: that *all* of the producing countries will join in refusing to sell to some particular buyer—for what strange motive is never discussed . . . it takes only one other country, with a desire for gain, to cure this irrationality.[35]

The 1973 oil embargo proves the point.[36] As MIT's Thomas Lee, Ben Ball Jr., and Richard Tabors observe:

> It was no more possible for OPEC to keep its oil out of U.S. supply lines than it was for the United States to keep its embargoed grain out of Soviet silos several years later. Simple rerouting through the international system circumvented the embargo. The significance of the embargo lay in its symbolism."[37] Granted, "there were short term supply disruptions," but "the only tangible effect of the embargo was to increase some transportation costs slightly, because of the diversions, reroutings, and transshipments necessitated.[38]

M. A. Adelman agrees: "The 'embargo' of 1973–4 was a sham. Diversion was not even necessary, it was simply a swap of customers and suppliers between Arab and non-Arab sources. . . . The good news is that the United States cannot be embargoed, leaving other countries undisturbed."[39]

Arab officials have confessed forthrightly to the empty nature of the embargo threat. Former Saudi oil minister Sheik Yamani, for instance, noted that the embargo "did not really imply that we could reduce imports of oil to the United States. The world is really just one big market. So the embargo was more symbolic than anything else."[40] A former UAE ambassador to Great Britain also stated, "There was no embargo. It was a lie we wanted you to believe."[41] Then-U.S. secretary of state Henry Kissinger belatedly grasped this point only years later. "The structure of the oil market was so little understood that the embargo became the principle focus of concern. Lifting it turned almost into an obsession for the next five months. In fact, the Arab embargo was a symbolic gesture of limited practical importance."[42]

Absent a naval blockade shutting down U.S. ports, the near disappearance of maritime oil transport, or a complete international boycott of oil sales to the United States, foreign oil will always be available to U.S. consumers.[43] As Richard Gordon puts it: "Basic economics indicates that no shortages will arise as long as prices are uncontrolled. The question is the price needed to eliminate the shortage."[44] Oil will always be available to those willing to pay the posted price in global spot markets.

The heightened political concern over "physical scarcity" rather than simple high price is a distinction without a difference. Consumers can have all the oil they want—as long as they are willing to pay the market price.

The Real Cost of the SPR

The total cost of the SPR includes the costs of building and operating the storage facilities, facility depreciation costs, the purchase of the oil, the deadweight losses associated with raising revenue for oil purchases, the higher oil prices that result from reserve additions, and the opportunity cost of holding the oil until a disruption occurs.

The U.S. Department of Energy reports that through 2003 the government has spent $18 billion for the oil in the SPR and more than $5.9 billion on operation and mainte-

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nance costs associated with the SPR for a total of $23.96 billion. Using those figures, the cost of maintaining oil in the SPR amounts to $37.55 per barrel.[45]

A more accurate calculation requires five modifications. First, the expenditures must be adjusted for inflation. Second, some contributions to the SPR are in-kind and do not involve cash outlays. Since 1996, oil companies have paid royalties for oil production from federal lands by contributing oil directly to the SPR, a practice that has taken oil acquisition for the SPR "off-budget."[46] It is necessary, therefore, to ascertaining the market value of oil deposited in that manner. Third, the opportunity cost of holding the oil should be considered.[47] Fourth, there are deadweight losses associated with raising revenue through taxes. Finally, the increased price of crude on the world market that results from SPR additions should be considered.

We modify the DOE calculation by taking inflation, in-kind contributions, and opportunity costs into account. We do not take into account the effects of the SPR fill-up on prices, deadweight losses, or the costs associated with facility depreciation.[48] The net result is that our calculation of SPR costs is conservatively low.

Increases in global crude prices from SPR inventory buildup are probably rather modest because SPR fill orders are a trivial part of global oil demand, and it is global supply and demand—not regional supply and demand—that determines oil prices. A rough calculation finds that SPR fill orders might have increased oil prices by 8–14 cents per barrel in 2001, 45–75 cents in 2002, 44–73 cents in 2003, 51–86 cents in 2004, and $.75–1.25 per barrel through April of 2005.[49] Although some observers argue that the cumulative price impact of SPR fill orders has been significant over time,[50] the scholarly literature is divided.[51] In any event our calculation will ignore such costs, which bias our analysis in favor of the benefits of the SPR being larger than the costs.

We also ignore the deadweight losses associated with various taxation regimes. Economists agree that the costs associated with raising revenue for government spending programs are significant, but there is no consensus about how large those costs may be.[52] The exclusion, once again, produces a conservative estimate of SPR costs.

Table 1, then, improves the DOE analysis simply by considering the in-kind oil royalty payments directed to the SPR since 1996 and adjusting all figures for inflation.

Table 1 indicates that the minimum real cost of the SPR has been between $41.24 and $50.77 billion (2004). The lower-bound estimate excludes opportunity costs and uses the GDP deflator. The upper-bound estimate deflates expenditures with the consumer price index and incorporates an interest rate of 7 percent to reflect opportunity costs. On a per barrel basis the SPR has cost the taxpayer between $64.64 and 79.58 per barrel (2004).[53]

Figure 1 puts those costs into perspective by examining annual average world oil prices in 2004 dollars from 1949 to 2004. The cost of the oil stockpiled in the SPR is almost certainly greater than the highest annual average cost of oil ever encountered in world markets.

The Real Benefits of the SPR

We now have a reasonable grasp of the cost of the SPR. What about the benefits?

First, the government might make money by buying low and selling high. Even though the analyses conducted during the 1980s assumed that such opportunities would exist, given that the costs of filling the SPR have exceeded any observed market price for oil (until August 2005), it is quite unlikely that SPR sales revenue would exceed the costs of acquiring and storing the oil in the SPR.

Second, SPR releases might dampen oil price hikes during disruptions and, as a consequence, reduce wealth transfers from oil consumers to oil companies during an oil shock. Some economists have argued that such uses of the SPR would reduce the political pressure for counterproductive govern-

Table 1
SPR Costs (thousands $), 1976–2003

Fiscal Year	Oil Purchases (nominal)	Facilities Expenditures (nominal)	Management Costs (nominal)	2004 Dollars Nominal Total	2004 Dollars Adjusted by GDP Deflator	Adjusted by CPI
1976	0	300,000	13,975	313,975	845,411	1,041,696
1977	440,000	0	7,824	447,824	1,133,867	1,395,494
1978	2,703,469	463,933	14,704	3,182,106	7,529,369	9,213,028
1979	2,356,456	632,504	18,111	3,007,071	6,568,694	7,825,634
1980	(2,022,272)	0	22,272	(2,000,000)	(4,004,876)	(4,585,677)
1981	3,205,094	108,168	19,391	3,332,653	6,100,297	6,922,768
1982	3,679,700	175,656	20,076	3,875,432	6,686,218	7,583,254
1983	2,074,060	222,258	19,590	2,316,178	3,844,845	4,393,373
1984	650,000	142,357	16,413	808,770	1,293,837	1,469,884
1985	2,049,550	441,300	17,890	2,508,740	3,894,732	4,404,090
1986	(12,964)	106,979	13,518	107,533	163,336	185,174
1987	0	134,021	13,412	147,433	218,001	245,112
1988	438,744	151,886	12,276	602,906	862,074	962,874
1989	242,000	160,021	13,400	415,421	572,316	633,117
1990	371,916	179,530	12,953	564,399	748,600	815,947
1991	566,318	187,728	12,846	766,892	982,860	1,063,840
1992	88,413	171,678	13,384	273,475	342,617	368,169
1993	(125,625)	161,940	14,227	50,542	61,890	66,080
1993	124,925[1]	700	0	125,625	153,831	164,247
1994	0	191,035	15,775	206,810	247,977	263,550
1995	(107,764)	226,938	16,780	135,954	159,744	168,526
1996	(511,114)	267,287	16,827	(227,000)	(261,764)	(273,358)
1997	(220,000)[2]	193,000	16,000	(56,658)	(64,265)	(66,670)
1998	(29,647)[3]	191,500	16,000	177,853	199,518	206,093
1999	0	145,120	14,805	159,925	176,851	181,342
2000	(645,744)[4]	144,000	15,000	(486,744)	(526,768)	(533,951)
2001	271,640[5]	140,672	15,965	428,277	452,620	456,879
2002	1,247,365[6]	154,009	16,871	1,418,245	1,474,521	1,489,614
2003	1,184,517[7]	157,823	13,909	1,356,238	1,384,731	1,392,609
Total	18,019,037	5,552,043	434,194	23,959,875	41,241,084	47,452,738

Source: GDP and CPI calculations performed by authors. Nominal federal expenditure data from "First Draft: Strategic Petroleum Reserve Annual Report, 2003," provided by Strategic Petroleum Reserve Headquarters, Office of Fossil Energy, U.S. Department of Energy, February 19, 2004, unpublished. Nominal value of in-kind contributions to the SPR from 1998–2003 were calculated by ascertaining sweet and sour crude additions to the reserve for each year and multiplying those additions by the average spot market price for Louisiana LLS crude and West Texas Sour crude in that year. Data regarding reserve additions were provided by the Office of Fossil Energy in correspondence dated February 24, 2005. Data regarding benchmark spot prices were provided by the Energy Information Administration on March 9, 2005.

[1] DOD transfer.

[2] Data provided by the Office of Fossil Energy show that the quantity of sour crude in the reserve in 1997 was 2.3 million barrels less than the 1996 level and sweet crude reserves were 0.1 million barrels less. The average spot market price

Continued on next page

Table 1 *Continued*

for the West Texas Sour was $18.95 a barrel in 1997 and $20.73 for Light Louisiana Sweet Crude. The nominal value of the reduced amount was $45,658,000 which is added to the 220,000,000 recorded in "First Draft: Strategic Petroleum Reserve Annual Report, 2003" when calculating the total value of oil in the reserve.

[3] The SPR declined by 2.3 million barrels of sour crude in 1998, and the average spot market price for West Texas Sour was $12.89 a barrel.

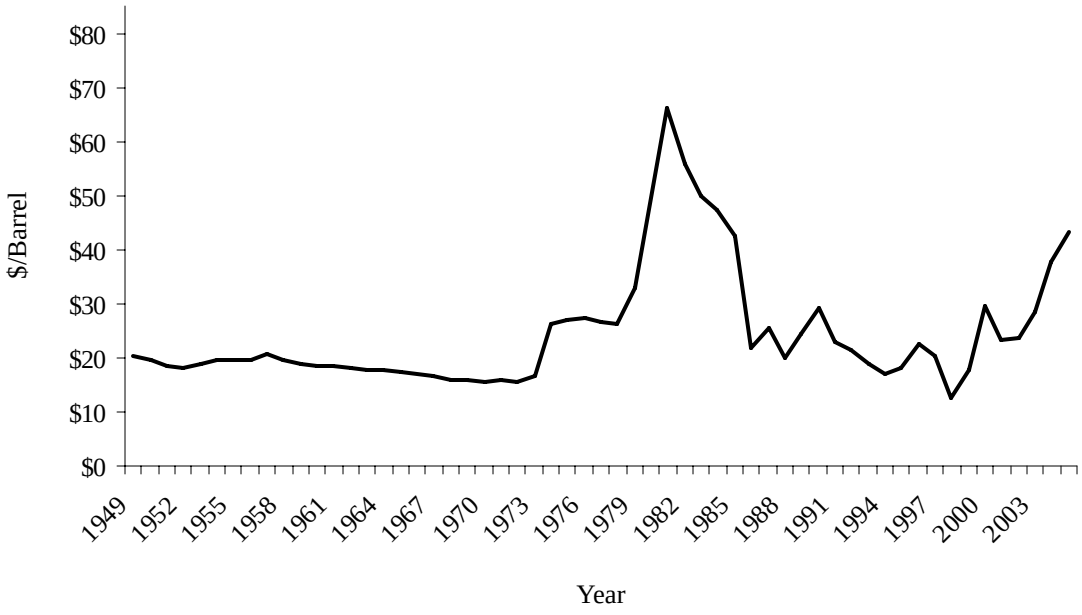
[4] In 2000, 2.1 million barrels of sour crude were added to the SPR, but 23.2 million barrels of sweet crude were removed from the reserve. The average spot market price for West Texas Sour was $28.24 a barrel, and the average spot market price for Louisiana LLS was $30.39 a barrel.

[5] In 2001, 5 million barrels of sour crude and 6 million barrels of sweet crude were added to the SPR. The average spot market price for West Texas Sour was $23.20 a barrel, and the average spot market price for Louisiana LLS was $25.94 a barrel.

[6] In 2002, 10.7 million barrels of sour crude and 37.3 million barrels of sweet crude were added to the SPR. The average spot market price for West Texas Sour was $24.86 a barrel, and the average spot market price for Louisiana LLS was $26.31 a barrel.

[7] In 2003, 14.4 million barrels of sour crude and 24.9 million barrels of sweet crude were added to the SPR. The average spot market price for West Texas Sour was $28.36 a barrel, and the average spot market price for Louisiana LLS was $31.17 a barrel.

Figure 1
Real Inflation-Adjusted Crude Oil Prices, 1949–2004



Source: Based on data from US DOE, www.economagic.com, and www.ioga.com, cited at http://inflationdata.com/Inflation/Inflation_Rate/Historical_Oil_Prices_Table.asp.

ment regulation,[54] but little can be done to test that proposition. After all, the oil and gas price run-up associated with Hurricane Katrina sparked numerous calls for intervention despite the release of oil from the SPR. It is impossible to know how much more vigorous those calls for intervention might have been absent the release.[55]

Third, the SPR might deter oil speculation during crises[56] and deter producers who might otherwise contemplate politically inspired production cutbacks.[57] The best way to test this hypothesis would be to examine the behavior of oil traders and petroleum producers both before and after the creation of the SPR. Oil trading, however, was virtually unknown prior to the creation of the futures market in the late 1970s—which is when the SPR was created. Likewise, producer states only began in the early 1970s to act in concert to raise world crude prices. Accordingly, the record of state producer behavior prior to the creation of the SPR is sparse.

Perhaps the most interesting test of the deterrence value of the SPR came in 1990 when Iraq's invasion of Kuwait temporarily knocked 7.1 percent of the world's oil production off the market. Oil producers, however, did not increase production despite considerable slack capacity in the market. If producers had thought that an SPR release was likely, the profit-maximizing response would be to quickly increase production in order to take advantage of the high prices that followed but that would presumably dissipate somewhat upon SPR release. The fact that no such thing occurred suggests that oil producers did not believe that the U.S. government would put its inventory onto the market, which further suggests that the reserve's ability to deter producers from squeezing supply at inopportune times is modest at best.[58]

In the final analysis, the deterrence value of the SPR depends on the government's willingness to use it and the extent to which disruptions are deterrable. As discussed below, most of the supply disruptions were triggered by exogenous events that were not deterrable by an SPR. Moreover, the executive branch has been so reluctant to use the SPR that whatever deterrence value it might theoretically hold is not that great in practice.

Fourth, and most importantly, the SPR might deliver macroeconomic benefits by dampening future oil price increases. To the extent that the main economic damage caused by oil price spikes is from secondary reactions in the economy and not from the price of oil itself, even expensive SPR inventories might be worth maintaining. Analysts at the Oak Ridge National Laboratory, for example, have argued that oil price spikes may have cost the U.S. economy an average of $90 billion annually between 1972 and 1991,[59] a total of $10.22 trillion between 1970 and 1999,[60] and that future supply disruptions might reasonably be expected to impose an average of $27.2 billion of annual costs on the economy.[61]

Those estimates and projections are highly speculative, however, for three reasons. First, there is an unresolved academic dispute about whether Federal Reserve monetary policy exacerbates the reductions in economic growth that accompany oil price shocks.[62] Briefly, some believe that if the Federal Reserve did not increase interest rates during oil shocks, economic output would not decline. Critics of this argument have replied that the Fed could theoretically keep rates constant, but the result would be higher future inflation.[63] Second, the effect of future oil supply interruptions depends on the value of other economic variables including excess world oil production capacity at the time of the supply interruption, the oil intensity of the United States economy, the size of world oil stocks at the inception of the supply interruption, and the level and volatility of oil prices prior to the supply interruption.[64] Third, we cannot easily predict the frequency and severity of future supply disruptions.

Now that we recognize the uncertainties involved in an SPR cost-benefit exercise, it is useful to consider the three most problematic assumptions found in the SPR cost-benefit literature.

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Excessive Fear of Supply Interruption

One cannot estimate the net benefits of an SPR without making some attempt to estimate the number of times it might be put to use.[65] Two studies did so by assuming that the future will look like the past.[66] All of the other studies in the literature either hypothesized the likelihood of future supply disruptions based on some other criteria or offered a single hypothesized disruption scenario for intense examination.

A brief review of the studies that have speculated about the likelihood of future supply disruptions can be found in Table 2.[67] To put those hypothesized disruptions in context, a loss of 10 percent of world supply would be the equivalent of losing Saudi Arabia. A loss of 15 percent of world supply would be the equivalent of losing Saudi Arabia, Kuwait, and Iraq. A loss of 20 percent of world supply would be the equivalent of losing those nations plus Iran. A loss of 25 percent of world supply would be the equivalent of losing Saudi Arabia, Kuwait, Iraq, Iran, and Venezuela.[68]

Table 3 identifies all of the significant supply disruptions in the international oil market since World War II.[69]

In a 50-year period we have experienced 12 supply crises with an average of 5.4 percent reduction in supply for each event, which translates into a 24 percent chance of such a disruption in any given year. A comparison of the data in Tables 2 and 3 suggests that most analysts expected that supply disruptions would be more frequent and more severe than has actually been the case.

Self-Liquidating Reserves

"Whatever one believes about the effects of oil prices on the economy," says Prof. Timothy Considine of Pennsylvania State University, "the effectiveness of the SPR depends critically on how it is actually used in a crisis."[70] Oil economist Philip Verleger concurs, "These stockpiles are of no use unless the oil is accessible quickly at the start of a disruption."[71] All of the published studies that quantify the net benefits of the SPR or optimal stockpile size assume that it will be used robustly and immediately at the onset of disruption. If it is not, then it is of very limited value.

Our experience with the SPR suggests that politicians are unlikely to order inventory releases as quickly and as robustly as economists would recommend. The first major release of SPR crude oil was on January 16, 1991, in response to the onset of military hostilities between the United States and Iraq. The release was quite modest in size (21 million barrels) and occurred five months after global markets lost access to Kuwaiti and Iraqi oil supplies. The SPR was deployed too late to reduce prices and any economic damage that those prices caused. The second major release was in September 2000, but it was not in response to a global supply disruption. On that occasion, President Clinton loaned 30 million barrels to private oil traders with the understanding that the borrowed oil plus a bonus percentage of like crude would be returned to the reserve in October 2001. That release was hotly controversial even within the Clinton administration and faced substantial political criticism. The third major release was in response to Hurricane Katrina, when the federal government sold 11 million barrels and loaned an additional 12.6 million barrels to oil traders.[72] None of those three releases were particularly large, and it's unclear what effect, if any, those releases had on oil prices.[73]

The government's reluctance to employ the SPR in the robust manner advised by economists is understandable. First, there is a value to delaying release until it's clear whether those reserves might be more beneficially used in response to some future shock.[74] Second, given that most politicians and the general public view the SPR as a means to combat actual physical shortages rather than high prices, it's unlikely that the executive branch will ever feel free to use the SPR in the uninhibited manner supported by most economists to combat oil price increases.[75] Third, because EPCA states that no draw down can be authorized absent a presidential declaration that a "severe supply interruption" exists, any decision to release will

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Table 2
Estimates of Hypothetical Future Supply Disruptions in the SPR Literature

Author	Year	Assumption
U.S. Dept. of Energy[1]	1979	Best estimate was that in any given year: • 31 percent chance of slack production capacity, • 33 percent chance of tight production capacity, • 10 percent chance of a 10 percent supply disruption, and • 5 percent chance of a 20 percent supply disruption.
William Hogan[2]	1981	Mid-range estimate that in any given decade there is 30 percent chance of a 5 percent loss of supply and a 5 or 20 percent chance of a 10 percent loss of supply.
James Plummer[3]	1981	Base scenario assumes that in any given year there is a 20 percent chance of a 5 percent supply disruption and a 10 percent chance of a 16.8 percent supply disruption.
Thomas Teisberg[4]	1981	Examined a scenario in which the U.S. experiences a 10 percent loss of supply for 1 year.
William Hogan[5]	1983	Posited that in any given year there is a 20 percent chance of a 10 percent loss of supply and a 10 percent chance of a 20 percent loss of supply.
Hung Po Chao & Alan Manne[6]	1983	Posited that in any given year there is a 20 percent chance of a 5 percent loss of supply and a 10 percent chance of a 16.8 percent loss of supply.
Schmuel Oren & Shao Hung Wan[7]	1986	Posited a loss of 30 percent of supply for 8 months once every 10 years.
Paul Leiby & Russell Lee[8]	1988	Considered 3 transition matrixes. In matrix 1: • 63 percent of the time the market will have slack capacity, • 20 percent of the time the market will be normal, • 10 percent of the time the market will experience a 7 percent supply disruption, • 5.5 percent of the time the market will experience a 10 percent supply disruption, and • 0.3 percent of the time the market will experience a 17 percent supply disruption. In matrix 2: • 28 percent of the time the market will have slack capacity, • 44.5 percent of the time the market will be normal, • 21 percent of the time the market will experience a 4.3 percent supply disruption, • 10.6 percent of the time the market will experience an 8.5 percent supply disruption, and • 1 percent of the time the market will experience a 17 percent supply disruption. In matrix 3: • 20 percent of the time the market will have slack capacity, • 37 percent of the time the market will be normal, • 23 percent of the time the market will experience a 4.3

Continued on next page

Table 2 *Continued*

Author	Year	Assumption
		percent supply disruption, • 14 percent of the time the market will experience an 8.5 percent supply disruption, and • 6 percent of the time the market will experience a 25 percent supply disruption
John Weyant[9]	1988	Examined two scenarios: a 10 percent loss of supply for 1 full year and a permanent 10 percent loss of supply.
Frederic Murphy, Michael Toman, & Howard Weiss[10]	1989	Examined a scenario in which the U.S. experiences a 20 percent loss of supply.
Energy Modeling Forum[11]	1996	Posited that in any given year there is a 5.3 percent chance of a 10 percent or greater supply disruption and a 2.5 percent chance of a 15 percent or greater supply disruption.

[1] U.S. Department of Energy, "An Analysis of Acquisition and Drawdown Strategies for the Strategic Petroleum Reserve," Draft Paper, Office of Oil Policy, December 17, 1979.
[2] William Hogan, "Import Management and Oil Emergencies," in *Energy and Security*, ed. David Deese and Joseph Nye (Cambridge, MA: Ballinger, 1981), pp. 261–301.
[3] James Plummer, "Methods for Measuring the Oil Import Reduction Premium and the Oil Stockpile Premium," *Energy Journal* 2, no. 1 (1981): 1–18.
[4] Thomas Teisberg, "A Dynamic Programming Model of the U.S. Strategic Petroleum Reserve," *Bell Journal of Economics* 12, no. 2 (Autumn 1981): 526–46.
[5] William Hogan, "Oil Stockpiling: Help Thy Neighbor," *Energy Journal* 4, no. 3 (1983): 49–71.
[6] Hung Po Chao and Alan S. Manne, "Oil Stockpiles and Import Reductions: A Dynamic Programming Approach," *Operations Research* 31, no. 4 (July–August 1983): 632–51.
[7] Shmuel Oren and Shao Hong Wan, "Optimal Strategic Petroleum Reserve Policies: A Steady State Analysis," *Management Science* 32, no. 1 (January 1986): 14–29.
[8] Paul Leiby and Russell Lee, "The Preliminary Results of the SPR Size Cost-Benefit Study," Oak Ridge National Laboratory, 1988.
[9] John Weyant, "Coordinated Stock Drawdowns: Pros and Cons," in Horwich and Weimer.
[10] Frederic Murphy, Michael Toman, and Howard Weiss, "A Dynamic Nash Game Model of Oil Market Disruption and Strategic Stockpiling," *Operations Research* 37, no. 6 (November–December 1989): 958–71.
[11] Hillard Huntington, Antje Kann, John Weyant, and Phil Beccue, "Quantifying Oil Disruption Risks Through Expert Judgment," Energy Modeling Forum, EMF-SR 7, April 1997.

The damage from any price increase will occur long before the SPR can be used to address it.

likely be delayed to avoid alarming allies, foreign oil suppliers, the general public, and other market actors. The implication is that the damage from any price increase will occur long before the SPR can be used to address it.[76] Thus, Timothy Considine concludes: "Part of the problem stems from the legislation governing the use of the SPR in an emergency. A more fundamental problem arises from vesting a political entity with the inherently complex task of allocating oil across time and space—a task that is probably best left to market forces."[77]

Although many economists who have long supported the existence of the SPR are today frustrated by the government's reluctance to release the oil, that reluctance should not have come as a surprise. Historically, government stockpiles have been hoarded during emergencies rather than used.[78] Jeffrey Williams and Brian Wright put it succinctly: "If the U.S. government's management of inventories of metals is any guide, the oil [in the SPR] may never be released."[79]

Table 3
World Oil Supply Disruptions

Date of Oil Supply Disruption	Duration (Months of Supply Disruption[1]	Average Gross Supply Shortfall (MBD)	World Production Prior to Disruption (MBD)[2]	Supply Shortfall[3] (%)
Nov. 1956–Mar. 1957 (Suez Crisis)	4	2	16.8	11.9
Dec. 1966–Mar. 1967 (Syrian Transit Fee Dispute)	3	0.7	32.96	2.1
Jun. 1967–Aug. 1967 (Six-Day War)	2	2	35.39	5.7
May 1970–Jan. 1971 (Libyan Price Dispute)	8	1.3	45.89	2.8
Oct. 1973–Mar. 1974 (Arab-Israeli War)	6	4.3	57.744	7.4
Nov. 1978–April 1979 (Iranian Revolution)	6	5.6	62.906	8.9
Oct. 1980–Jan. 1981 (Iran-Iraq War)	3	4.1	58.338	7.0
Aug. 1990–Jan. 1991 (Iraq Invasion of Kuwait)	5	4.3	60.487	7.1
Jun. 2001–Jul. 2001 (Iraqi Oil Export Suspension)	2	2.1	67.551	3.1
Dec.2002–Mar. 2003 (Venezuela Labor Srike)	4	2.6	68.595	3.8
Mar. 2003–Dec. 2003 (War in Iraq)	9	2.3	69.041	3.3
Aug. 2005–? (Hurricane Katrina)	?	1.4[4]	73.572[5]	1.9

Note: MBD=Millions of barrels per day. The time and magnitude of supply shortfall data is obtained from Figure 1, in International Energy Agency, "Fact Sheet IEA Stocks and Emergency Response" (http://www.iea.org/Textbase/papers/2004/factsheetcover.pdf). The disruption size for Syrian Transit Fee Dispute and for the Libyan Price Controversy, however, is from the Energy Information Administration, "Global Oil Supply Disruptions Since 1951," http://www.eia.doe.gov/emeu/security/Oil/distable.html. The magnitude of the supply shortfall is the peak gross supply loss excluding supply increases of other oil producing countries. Accordingly, the average daily supply loss over the disruption period is lower than the gross peak supply loss.

[1] The duration of oil supply disruptions since 1951 is from the Energy Information Administration's website (http://www.eia.doe.gov/emeu/security/Oil/distable.html). For the incidents not listed or listed differently in the above EIA website, the duration of disruption is calculated by authors according to time listed in the International Energy Agency, Fact Sheet "IEA Stocks and Emergency Response" (http://www.iea.org/Textbase/papers/2004/factsheet cover.pdf).

[2] Annual world crude oil production data are from Energy Information Administration website (http://www.eia.doe.gov/emeu/aer/txt/ptb1105.html). Monthly world crude oil production data are from Energy Information Administration, May 2005, Monthly Energy Revie, Table 11.b, "Crude Oil Production: Persian Gulf Nations, Non-OPEC, and World," http://tonto.eia.doe.gov/merquery/mer_data.asp?table=T11.01b. World oil production data for 1956 are from Oil and Gas Journal, April 1, 1957, p. 96, cited in James D. Hamilton, "What is an Oil Shock?" *Journal of Econometrics* 113 (2003): 390.

[3] Per e-mail from DOE staff, world crude oil production in the month prior to the disruption is used as the denominator in calculating the percentage of supply shortfall. Because monthly supply data prior to 1973 are not available, annual production data for the year 1956 and 1967 are used to calculate the percentage of supply shortfall caused by Suez Crisis and Six Day War.

[4] Energy Information Administration, "Short Term Energy Outlook," September 7, 2005, http://www.eia.doe.gov/emeu/steo/pub/contents.html.

[5] Figure from June 2005 (the most recent data available at the time of this writing). Energy Information Administration, "International Petroleum Monthly," http://www.eia.doe.gov/emeu/ipsr/t11c.xls.

Static Versus Dynamic Market Responses

The studies of the costs and benefits of an SPR assume minimal response from market actors in the face of a supply disruption or subsequent SPR releases. For example, few of the published studies consider the possibility that private inventories (which, as previously noted, are today approximately three times larger than public inventories) will release significant quantities of oil into the market as a

The benefits of the "too-little-too-late" release in 1991 and the modest releases of 2000 and 2005 have not exceeded the accumulated costs of the program.

response to a supply disruption. Likewise, most of the published studies assume a very minimal response of supply to high prices during a crisis. For example, if supply interruptions were to occur during a time of excess production capacity, the benefits of an SPR release would be minimal.

If market actors believe that a disruption will outlast the SPR, a release from the SPR would have little effect on price because inventory holders would outbid consumers for access to SPR oil.[80] In fact, the market response to the supply disruption of 1979 was an inventory increase as a hedge against even greater future disruptions rather than an inventory release as a response to the disruption.[81]

Finally, economists acknowledge that maintaining public stockpiles discourages the accumulation of private inventories and perhaps even public inventories abroad because foreign governments have an incentive to "free ride" off U.S. inventories given that a U.S. release would reduce oil prices everywhere in the world. How much oil is displaced by the SPR is unknown,[82] but most of the SPR benefits studies assume that a barrel of oil in the SPR equals one additional barrel of oil in the sum of (private and public) oil inventories. But, as Brian Wright and Jeffrey Williams argue:

> An extra barrel added to a strategic petroleum reserve does not in general mean that an extra barrel is available during an import disruption. This replacement effect, which can be very important, varies with the severity of the price ceiling that might be anticipated in response to some future price spike.[83]

If we don't know to what extent public inventories actually increase total inventory size, we can't with any certainty determine the benefits of an SPR or what the optimum size of an SPR might be. For example, if every barrel of the oil in the SPR reduces the size of private inventories by half a barrel, the benefits of an SPR are only one-half what they would be without offsetting effects.

SPR Benefits Reconsidered

Most of the academic literature pertaining to the SPR was published between 1970 and 1986. Thus, its assumptions about likely administrative practices, reserve release policies, future disruption events, and macroeconomic dynamics were speculative. The frequency and severity of oil shocks since then have been mild rather than severe, and the actual operation of the SPR has been infrequent. Thus, claims about the potential benefits of the SPR in the literature are too high. The benefits of the "too-little-too-late" release in 1991 and the modest releases of 2000 and 2005 have not exceeded the accumulated costs of the program. Accordingly, some economists who once supported the SPR—such as Philip Verleger—now argue for its elimination.[84]

Although it is possible that supply disruptions will occur more frequently in the future, nothing suggests that SPR release practices will change. In fact, the more uncertain oil supplies become in the future, the more likely that governmental officials will be reluctant to use the reserve.

Conclusion

Economists generally oppose government intervention in markets absent convincing evidence of clear and consequential market failures. Do oil market disruptions have such characteristics? The evidence is surprisingly weak. Thus the SPR is a bad program on this basis alone—there is no clear problem for it to solve.

For those unwilling to rule out the SPR on that basis, an examination of the revealed costs and benefits of the program should prove sobering. The cost of maintaining the SPR exceeds oil prices that we observe even during shocks. If it were shut down, we could avoid paying for it during good times and simply pay market prices during shocks. Instead we now pay both the costs of the SPR and market prices during shocks.

Economists who have supported the SPR have done so not because they fear the impact of high oil prices per se but because they

believe that there are large macroeconomic externalities associated with oil price shocks and that an SPR could minimize the impact of those externalities were it used frequently, robustly, and quickly during the *early* stages of oil price shocks.

Our analysis suggests that the SPR has not and probably never will be used in the manner prescribed by its economic supporters. The economic literature concerning the SPR, however, is uniformly supportive of the program. Why the discrepancy? There are likely two reasons.

First, supporters of the SPR limited their analytic attention to the reasons why private oil inventories might be too small in a laissez-faire world. Such analysis provided prima facie evidence for the economic merit of the SPR. "Government failure," however, received little if any serious attention; most economists simply assumed that the former problem was greater than the latter.[85] Experience with the program now strongly suggests that the opposite is true.

Second, economists by-and-large have lost interest in the SPR in particular and energy security issues in general after the oil price collapse of 1986. The literature thus represents analysis that is generally 20 or more years old. Accordingly, the disappointment that many economists now feel concerning the operation of the SPR has not found its way into the literature.

There is little reason to think that the program's dynamics will change in the future. The United States has had quite a bit of experience with the SPR by now and the experience is clear—the program costs more than the benefit it provides. Thus, instead of filling the reserve and expanding its capacity to 1 billion barrels or more, the federal government should cut its losses by selling the oil within the SPR and shutting the program down.

Notes

The authors would like to thank Timothy Considine, Richard Gordon, William Hogan, Andrew Kleit, Philip Verleger, and Benjamin Zycher for providing helpful comments concerning the manuscript prior to publication.

1. Those figures were accurate of August 18, 2005. U.S. Department of Energy's Office of Fossil Energy, http://www2.spr.doe.gov/DIR/SilverStream/Pages/pgDailyInventoryReportViewDOE_new.html. Sweet crude has low sulfur content and sour crude has high sulfur content.

2. For a summary of the legislative history of the SPR, see Robert Bamberger, "The Strategic Petroleum Reserve," CRS Issue Brief 1B87050, September 10, 1993.

3. Legally, a "severe energy supply disruption" is defined in Section 3 of the EPCA as that which the president of the United States determines "(A) is, or is likely to be, of significant scope and duration, and of an emergency nature; (B) may cause major adverse impact on national safety or the national economy; and (C) results, or is likely to result, from (i) an interruption in the supply of imported petroleum products, (ii) an interruption in the supply of domestic petroleum products, or (iii) sabotage or an act of God."

4. In pactice, the president has wide latitude to define a "severe energy supply emergency" in any way he likes. Timothy J. Considine and Kevin M. Dowd, "A Superfluous Petroleum Reserve?" *Regulation* 28, no. 2 (Summer 2005). EPCA dictates, however, that the president may not release oil from the SPR "(A) in excess of an aggregate of 30,000,000 barrels with respect to each such shortage; (B) for more than 60 days with respect to each such shortage; (C) if there are fewer than 500,000,000 barrels of petroleum product stored in the Reserve; or (D) below the level of an aggregate of 500,000,000 barrels of petroleum product stored in the Reserve."

5. The total amount of publicly controlled oil reserves in the United States, Japan, and Western Europe is approximately 1.3 billion barrels combined. Considine and Dowd, p. 21.

6. Calculation by authors based on data reported in Energy Information Administration, *Monthly Energy Review*, February 2005, http://www.eia.doe.gov/emeu/mer/pdf/pages/sec3_3.pdf and http://www.eia.doe.gov/emeu/mer/pdf/pages/sec11_3.pdf.

7. For a brief summary of the IEA's role during a supply disruption and its designated powers, see the Congressional Budget Office, "Rethinking Emergency Energy Policy," December 1994, pp. 6–7. For an extended discussion, see George Horwich and David Weimer, eds., *Responding to International Oil Crises* (Washington: American Enterprise Institute, 1988).

8. Despite three supply disruptions that passed the 7 percent threshold since the establishment of the IEA, the IEA only responded once: in 1991 at the onset of the Persian Gulf War, when it ordered mem-

ber states to release 2.5 million barrels of oil a day for a brief period of time. It did respond, however, to Hurricane Katrina in 2005, when world crude production dropped by 1.9 percent. In that case, the IEA ordered members to release a total of 2 million barrels of oil a day (or their equivalent in gasoline terms) for 30 days. "Fact Sheet on IEA Oil Stocks and Emergency Response Potential," International Energy Agency, http://www.iea.org/Textbase/Papers/2004/factsheetcover.pdf; and Justin Blum, "26 Nations to Release Petroleum Reserves," *Washington Post*, September 3, 2005, p. D1.

9. Alvin Alm, "Managing Oil Shocks," in *Oil Shock*, ed. Alvin Alm and Robert Weiner eds. (Cambridge, MA: Ballinger, 1984), pp. 15–16.

10. Carl Blumstein and Paul Komor suggest that a federally chartered SPR corporation be established and structured like the board of governors of the Federal Reserve System. De facto privatization of the oil within the SPR, however, would not entail privatization of the SPR. See Carl Blumstein and Paul Komor, "Another Look at the Strategic Petroleum Reserve: Should Its Oil Holdings Be Privatized?" *Journal of Policy Analysis and Management* 15, no. 2 (1996): 271–75.

11. Robert Bamberger and Lawrence Kumins, "The Strategic Petroleum Reserve and the Drawdown Dilemma," Report 90-492 ENR, Congressional Research Service, October 12, 1990. M. A. Adelman argues that the oil in the reserve should be available to buyers at all times, for the highest price being charged anywhere in the world plus the cost of a year's storage. See "Coping with Supply Insecurity," *Energy Journal* 3 (April 1982): 1–17. A regularized, periodic sale of SPR call options has also been advanced in Alm, and by James L. Plummer, "The Institutional Alternatives for Financing and Operating the Strategic Petroleum Reserve," in Alm and Weiner, pp. 20–25 and 173–75, respectively. A brief discussion regarding how such options might be institutionalized can be found in U.S. General Accounting Office, "Energy Security: Evaluating U.S. Vulnerability to Oil Supply Disruptions and Options for Mitigating Their Effects," GAO/RCED-97-6, December 1996.

12. Shantayanan Devarajan and R. Glenn Hubbard, "Drawing Down the Strategic Petroleum Reserve: The Case for Selling Futures Contracts," in Alm and Weiner, pp. 187–96.

13. It has been noted that to the extent to which SPR reduces the impact of oil price spikes, it constitutes a subsidy to oil consumers and thus should be funded directly by oil consumers rather than by the general public. For a review of the alternative funding proposals, see U.S. General Accounting Office, "Strategic Petroleum Reserves: Analysis of Alternative Financing Methods," GAO/RCED-89-103, March 1989.

14. Estimates concerning the "optimum size" of the SPR vary depending on micro- and macroeconomic assumptions as well as assessments regarding the likelihood of disruption and the degree to which public stockpiles might crowd out private stockpiles. U.S. Department of Energy, "Strategic Petroleum Reserve: Analysis of Size Options," DOE/IE-0016, February 1990.

15. Philip Verleger, *Adjusting to Volatile Energy Prices* (Washington: Institute for International Economics, 1993). Although futures contracts allow individual actors to hedge against risk, futures markets arguably make inventories even more important than they would be absent an oil futures market. Hossein Razavi and Fereidun Fesharaki, *Fundamentals of Petroleum Trading* (Westport, CT: Praeger, 1991), pp. 142–44.

16. See Horwich and Weimer; and Robert Willenborg, Christoph Tonjes, and Wilbur Perlot, "Europe's Oil Defenses: An Analysis of Europe's Oil Supply Vulnerability and Its Emergency Stockholding Systems," *Journal of Energy Literature* 10, no. 2 (December 2004): 3–49.

17. To our knowledge, the only two prominent energy economists who have vocally opposed the SPR are Richard Gordon of Pennsylvania State University and Robert Mabro, director of the Oxford Center for Energy Studies. Gordon identified the weaknesses of the market-failure arguments and foresaw the problems inherent in political management of the stockpile. Mabro, on the other hand, argued that consuming nations would be better served by encouraging the development of surplus oil production capacity than by the establishment of strategic oil reserves. See Richard Gordon, "The Economics of Optimal Self-Sufficiency and Energy Independence, Mineral Wars, and Soft Energy Paths," *Minerals and Society* 7, no. 2 (1983): 225–35; Richard Gordon, "Energy Intervention after Desert Storm: Some Unfinished Tasks," *Energy Journal* 13, no. 4 (October 1992): 5–9; and Robert Mabro, *A Dialogue between Oil Producers and Consumers: The Why and the How* (Oxford, UK: Oxford Institute for Energy Studies, 1991). For a critique of Mabro's case for a producer-consumer dialogue, see Philip Verleger, *Adjusting to Volatile Energy Prices*.

18. Chantale LaCasse and Andre Plourde, "On the Renewal of Concern for the Security of Oil Supply," *Energy Journal* 16, no. 2 (1995): 1–23, and Jeffrey Williams and Brian Wright, *Storage and Commodity Markets* (New York: Cambridge University Press, 1991), p. 413.

19. World oil production in 2004 totaled 26.46 bil-

lion barrels. Energy Information Administration, http://www.eia.doe.gov/emeu/mer/pdf/pages/sec11_3.pdf. The size of the SPR at the end of 2004 was 675.6 million barrels (a figure provided by Lynnette Lemat of the U.S. Department of Energy, personal correspondence, April 11, 2005. Available from the author upon request).

20. Considine and Dowd, p. 21.

21. For a review of the standard arguments pertaining to market failure, see Tyler Cowen, ed., *The Theory of Market Failure* (Fairfax, VA: George Mason University Press, 1988). For a discussion concerning other definitions of market failure (particularly asymmetric information between market actors and the economics of network industries), see Tyler Cowen, ed., *Market Failure or Success: The New Debate* (Northampton, MA: Edward Elgar, 2004).

22. Douglas Bohi and W. David Montgomery, *Oil Prices, Energy Security, and Import Policy* (Washington: Resources for the Future, 1982), p. 89. For a discussion concerning why this is so, see pp. 59–89.

23. Considine and Dowd, p. 21. Nonetheless, the drive to reduce inventory costs that today characterizes most sectors of the economy also governs inventory trends in the oil sector. For data on private oil inventory trends in OECD nations, see D. Kinder, "The Impact of Industry Stocks and the Futures Market on Oil Market Dynamics," Asia Pacific Energy Research Centre Background Report, 2002, fig. 8, p. 21.

24. Daniel Newlon and Norman Breckner, *The Oil Security System: An Import Strategy for Achieving Oil Security and Reducing Oil Prices* (Lexington, MA: Lexington Books, 1975); Frederic Murphy, Michael Toman, and Mark Goldstein, *Strategic Oil Stocks and Public-Private Interactions: A Dynamic Game Analysis* (Washington: Resources for the Future, 1984); Brian Wright and Jeffrey Williams, "The Roles of Public and Private Storage in Managing Oil Import Disruptions," *Bell Journal of Economics* 13, no. 2 (Autumn 1982): 345–46; and Jeffrey Williams and Brian Wright, *Storage and Commodity Markets*, pp. 417–28.

25. For a brief discussion of the political economy of oil price controls in the 1970s, see Peter VanDoren, *Politics, Markets, and Congressional Policy Choices* (Ann Arbor: University of Michigan Press, 1991), pp. 39–45. For a more robust examination, see Joseph P. Kalt, *The Economics and Politics of Oil Price Regulation* (Cambridge, MA: MIT Press, 1981).

26. Richard Gordon, "Energy Intervention after Desert Storm," p. 8. Given that Congress cannot bind future Congresses to contemporary policy decisions, it's difficult to imagine how the government could remove the fear that legislators might impose oil price controls in the future.

27. For a representative argument, see William Hogan, "Oil Stockpiling: Help Thy Neighbor," *Energy Journal* 4, no. 3 (1983): 49–71.

28. Jeffrey Williams and Brian Wright, *Storage and Commodity Markets*, p. 417.

29. Edwin Burmeister, "Is Price Stabilization Theoretically Desirable?" *in Stabilizing World Commodity Markets*, ed. F. Gerald Adams and Sonai Klein (Lexington, MA: Lexington Books, 1978), pp. 189–91.

30. Douglas Bohi and W. David Montgomery, *Oil Prices, Energy Security, and Import Policy*, pp. 90–94, 120–121. Philip Verleger has made the most powerful argument for this proposition. Verleger's proposed remedy is not an SPR but a stiff and predictably declining tax on crude oil to be implemented whenever supplies are disrupted. This would create strong incentives for inventory owners to release oil onto the world market when it could do the most economic good. Unfortunately, optimum release policies will usually be apparent after the fact, not before, which renders the Verleger Tax of limited use to policymakers. See Philip Verleger, *Oil Markets in Turmoil: An Economic Analysis* (Cambridge, MA: Ballinger, 1982), pp. 167–97. Richard Gordon maintains that Verleger overstates the role of the spot market in the oil economy and may very well be wrong to criticize actions by investors during past crises. Richard Gordon, "Energy Intervention after Desert Storm," p. 4.

31. Hans Landsberg et al., *Energy: The Next Twenty Years* (Cambridge, MA: Ballinger, 1979), p. 39. Richard Gordon goes further and contends that public inventory managers are actually less likely to competently manage inventories that private inventory managers. Richard Gordon, *Regulation and Economic Analysis: A Critique over Two Centuries* (Boston: Kluwer Academic Publishers, 1994), p. 107.

32. Models constructed by Williams and Wright demonstrate that a public subsidy to inventory holders is "the clear winner" compared with alternatives relating to publicly managed commodity stockpiles. Jeffrey Williams and Brian Wright, *Storage and Commodity Markets*, p. 445.

33. For discussions of alternative interventions, see Glen Sweetnam, "Stockpile Policies for Coping with Oil-Supply Disruptions," in *Policies for Coping with Oil-Supply Disruptions*, ed. George Horwich and Edward Mitchell (Washington: American Enterprise Institute, 1982), pp. 93–96; Alm, pp. 19–20; pp. 199–217; and Hans Landsberg et al., pp. 38–39.

34. Alvin Alm, William Colglazier, and Barbara Kates-Garnick, "Coping with Interruption," in

Energy and Security, ed. David Deese and Joseph Nye (Cambridge, MA: Ballinger, 1981), p. 330.

35. M. A. Adelman, *The World Petroleum Market* (Baltimore: Johns Hopkins University Press, 1972), p. 260.

36. There have actually been three attempts by Arab states to target embargoes against certain Western states; 1956 (targeted at Britain and France), 1967 (targeted at the United States, Britain, and West Germany), and 1973 (targeted at the United States and the Netherlands). All failed to reduce imports into the targeted countries. For a political and economic history of those embargo episodes, see A. F. Alhajii, "Three Decades after the Oil Embargo: Was 1973 Unique?" *Journal of Energy and Development* 30, no. 2 (2005), pp. 1–16.

37. Thomas Lee, Ben Ball Jr., and Richard Tabors, *Energy Aftermath* (Boston: Harvard Business School, 1990), p. 17.

38. Ibid., p. 30. See also Edward Fried, "Oil Security: An Economic Phenomenon," in *Oil and America's Security*, ed. Edward Fried and Nanette Blandin. (Washington: Brookings Institution, 1988), pp. 56–59.

39. Cited in Robert L. Bradley Jr., *The Mirage of Oil Protection* (Lanham, MD: University Press of America, 1989), p. 140.

40. Cited in M. A. Adelman, *Genie Out of the Bottle: World Oil Since 1970* (Cambridge, MA: MIT Press, 1995), p. 113.

41. Ibid.

42. Henry Kissinger, *Years of Upheaval* (Boston: Little, Brown, 1982), p. 873. As oil historian Daniel Yergin notes, "Henry Kissinger . . . had before 1973 known nothing about oil and precious little about international economics. Politics and grand strategy were what he relished. In the months after the embargo, he would tell aides, 'Don't talk to me about barrels of oil. They might as well be bottles of Coca Cola. I don't understand!' Yet once the oil weapon had been brought into play, this diplomatic acrobat would do more than anyone else to get the sword back into its scabbard." David Yergin, *The Prize* (New York: Simon & Schuster, 1991), p. 613.

43. Alvin Alm notes that "unless the shortage is extremely large or for political reasons the market is not allowed to work, the SPR would not be needed to offset physical shortages." Alm, p. 16. Chantale LaCasse and Andre Plourde point out that the only instance in which physical scarcity was actually a problem in the OECD nations was during the 1956 Suez Crisis, in which for a period of a few weeks, oil was in very short supply in Europe. Chantale LaCasse and Andre Plourde "On the Renewal of Concern for the Security of Oil Supply," pp. 13–14. The international oil market has evolved substantially since then, primarily due to the advent of spot markets and trading in oil futures. Both developments render physical shortage an extremely unlikely event. For an overview of those changes and how they have affected the market, see Razavi and Fesharaki.

44. Richard Gordon, "Energy Intervention after Desert Storm," p. 9.

45. The dollar figures come from Table 1. At the end of 2003 the SPR contained 638 million barrels of oil.

46. Producers are required to provide from 12.5 percent to 16.7 percent of the oil they produce to the U.S. government. The government can either acquire the oil itself or receive the equivalent dollar value. Federal policy has been to keep some of the oil for the SPR and to sell the rest. U.S. General Accounting Office, "Mineral Revenues: A More Systematic Evaluation of the Royalty-in-Kind Pilots Is Necessary," GAO-03-296, January 2003.

47. Estimating the opportunity costs associated with the SPR is contentious. Money not spent on the SPR would have been spent on something else. The rate of return that "something else" would have gained society would be the appropriate interest rate to apply to SPR expenditures. Those who believe that government would simply have spent SPR money on something else rather than leaving it to taxpayers—and that government expenditures result in little if any positive return—would apply an interest rate of zero. Those who are more optimistic about the rate of return on government expenditures or who believe that taxpayers might have otherwise been allowed to keep that money for private use would apply a steeper interest rate calculation, perhaps 7 percent.

48. The salt domes that harbor SPR's oil inventory apparently degrade substantially after fewer than a half-dozen significant drawdowns. Accordingly, facility depreciation costs could prove quite significant were the reserve used more often as most economists recommend. U.S. General Accounting Office, "Ranking Options to Improve the Readiness of and Expand the Strategic Petroleum Reserve," GAO/RCED-94-259, August 1994.

49. Figures calculated by authors on the basis of world crude production (Energy Information Administration, *International Petroleum Monthly*, July 2005, Table 1.1c), SPR additions over those years (Energy Information Administration, *Monthly Energy Review*, July 2005, Table 3.2b), and crude oil

domestic first purchase prices (Energy Information Administration, *Monthly Energy Review*, July 2005, Table 9.1). Lower-bound estimates assume an oil price demand elasticity of –0.1, whereas upper-bound estimates assume –0.06. The calculations could be improved, however, by matching the monthly fill rate with the average monthly spot price rather than using the average yearly price. In some months the fill rate is about double the annual average so the estimated price effects would be double those of our average calculations in those months. A more sophisticated analysis employing a monthly econometric model of the world crude oil market finds that SPR fill orders from November 2001 to March 2005 increased the price of crude oil by 20 cents per barrel. Timothy Considine, "Is the Strategic Petroleum Reserve Our Ace in the Hole?" Working Paper, July 14, 2004, p. 21. Available from authors.

50. Martin McGuire, "Provision for Adversity: Managing Supply Uncertainties in an Era of Globalization," *Journal of Conflict Resolution* 44, no. 6 (December 2000): 730–52.

51. For a review of the recent claims, see Robert Bamberger and Robert Pirog, "The Strategic Petroleum Reserve: Possible Effects on Gasoline Prices of Selected Fill Policies," Congressional Research Service, RL 32358, September 27, 2004; Petroleum Industry Research Foundation, "The SPR, the Royalty-in-Kind Program, and Oil Prices," August 2003; and Considine and Dowd, pp.18–25.

52. The standard reference is Edgar Browning, "The Marginal Welfare Cost of Taxation," *American Economic Review* 77 (1987): 11–23. William Niskanen calculates that for every $1.00 taxed, marginal costs range from $1.55—$4.43 depending on the sort of tax in question. William Niskanen, *Autocratic, Democratic, and Optimal Government* (Northampton, MA: Edward Elgar, 2003), pp. 37–38, note 4.

53. Per barrel costs equal the total divided by the SPR stock at the end of 2003—638 million barrels.

54. Hans Landsberg et al., p. 58; James McClure, "Preparing for Emergencies," in *Oil and America's Security*, ed. Edward Fried and Nanette Blandin (Washington: Brookings Institution, 1988), pp. 83–86; and Lucian Pugliaresi, "Policy Tests for Energy Security," in *Oil and America's Security*, ed. Edward Fried and Nanette Blandin (Washington: Brookings Institution, 1988), pp. 111–15.

55. David D. Kirkpatrick, "Some Senators on Panel Ask Angry Questions about Gasoline Pricing and Profits," *New York Times*, September 7, 2005, p. C5.

56. M. A. Adelman, *The Economics of Petroleum Supply*, pp. 509–25.

57. "The likelihood that a producer state will use the oil in an attempt to influence U.S. policy is directly related to its chances of success. The greatest benefit of a stockpile, like that of our nuclear arsenal, may be its mere existence." Alm, Colglazier, and Kates-Garnick, p. 326. Similar arguments are found in Nichols and Zeckhauser, pp. 66–96; and Vincent Crawford, Joel Sobel, and Ichiro Takahashi, "Bargaining, Strategic Reserves, and International Trade in Exhaustible Resources," *American Journal of Agricultural Economics* 66 (1984): 426–42.

58. M. A. Adelman, *Genie out of the Bottle: World Oil since 1970*, pp. 292–97.

59. David Greene and Paul Leiby, "The Social Cost to the U.S. of Monopolization of the World Oil Market, 1972–1991," ORNL-6744, Oak Ridge National Laboratory, March 1993. Figures in original are in 1994 dollars. Authors converted to 2005 (second quarter) dollars using ratio of GDP deflators in 2005 (second quarter) and 1994 (1.236).

60. The authors' median estimate was a total economic loss of $7 trillion in 1998 dollars, which we deflated by CPI to arrive at $8.27 trillion in 2005 dollars. David Greene and Nataliya Tishchishyna, "Costs of Oil Dependence: A 2000 Update," Oak Ridge National Laboratory, May 2000.

61. David Greene, Donald Jones, and Paul Leiby, "The Outlook for U.S. Oil Dependence," ORNL-6873, Oak Ridge National Laboratory, May 11, 1995.

62. For a nontechnical discussion, see James Surowiecki, "Oil Change," *New Yorker*, May 2, 2005, p. 46. For a more comprehensive treatment, see Donald Jones, Paul Leiby, and Inja Paik, "Oil Shocks and the Macroeconomy: What Has Been Learned since 1996," *Energy Journal* 25, no. 2 (2004): 1–32; and Robert Barsky and Lutz Kilian, "Oil and the Macroeconomy since the 1970s," National Bureau of Economic Research, Working Paper no. 10855, October 2004.

63. Charles T. Carlstrom and Timothy S. Fuerst, "Oil Prices, Monetary Policy, and the Macroeconomy," *Federal Reserve Bank of Cleveland Economic Commentary*, July 2005.

64. James Hamilton, "What is an Oil Shock?" *Journal of Econometrics* 113 (2003): 363–98; Kiseok Lee, Shawn Ni, and Ronald Ratti, "Oil Shocks and the Macroeconomy: The Role of Price Variability," *Energy Journal* 16, no. 4 (1995): 39–56; Congressional Budget Office, pp. 9–12; and U.S. General Accounting Office, "Energy Security."

65. Several studies have eschewed speculation about future supply disruptions and have instead used game theory analysis to examine the merits of the

SPR. Those studies assume that producers and consumers are rational actors and that the interplay between them dictates the occurrence of supply disruptions. See, for instance, Albert Nichols and Richard Zeckhauser, "Stockpiling Strategies and Cartel Prices," *Bell Journal of Economics* 8, no.1 (Spring 1977): 66–96; Egon Balas, "The Strategic Petroleum Reserve: How Large Should it Be?" in *Energy Policy Planning*, ed. B. A. Bayraktar et al. (New York: Plenum Press, 1981); and Kofi Nti, "Competitive Procurement under Demand Uncertainty," *Management Science* 33, no. 11 (November 1987): 1489–1500. Experience suggests, however, that supply disruptions are nearly always triggered by exogenous events outside the control of either producers or consumers. While producers frequently restrain production in the aftermath of such events in order to maximize revenue, the stylized models offered by game theorists do not comport well with past disruption events. See M. A. Adelman, *Genie out of the Bottle: World Oil Since 1970*.

66. U.S. Department of Energy, "Strategic Petroleum Reserve"; and Paul Leiby and David Bowman, "The Value of Expanded SPR Drawdown Capability: SPR Drawdown Capability Study, Final Report, Draft 2," Oak Ridge National Laboratory, October 18, 2000, pp. 16–17.

67. In some of the studies reviewed in this subsection, supply disruptions were measured in millions of barrels a day. We have converted those estimates into percentage terms based on global production at the time those estimates were made.

68. Energy Information Administration; http://www.eia.doe.gov/emeu/ipsr/t22.xls.

69. There are several ways that analysts might measure the extent of oil supply disruptions, none of which is obviously best. The EIA and analysts from Oak Ridge National Laboratory use the average world crude supply loss over the duration of the event relative to the supply just before the disruption. The IEA divides gross peak crude supply losses (rather than average) by pre-shock supply and disregards increased production and inventory releases that occur during disruptions. We use the IEA method because it is most similar to the measures used by the studies reviewed in this section even though IEA's methodology arguably overstates the impact of market disruptions.

70. Considine and Dowd, p. 19.

71. Philip Verleger, *Oil Markets in Turmoil*, p. xxix.

72. U.S. Department of Energy, "DOE Approves Bids for 11 Million Barrels of Strategic Reserve Crude Oil," Press Release, September 14, 2005, http://www.fe.doe.gov/news/techlines/2005/tl_spr_2005drawdown_bids.html.

73. John Lichtblau argues that the prospect of release from the SPR prior to the start of the Persian Gulf War in 1991 was a significant factor in the collapse of world oil prices in January 1991. John Lichtblau, "Oil Imports and National Security: Is There Still a Connection?" *Energy Journal* 15 (Special Issue, 1994): 329–46. Alan Reynolds argues that President Clinton's release of oil from the SPR in September 2000 also had a major impact on world crude oil prices. Alan Reynolds, "Federal Oil Hoarding," Cato Commentary, June 2, 2004, http://www.cato.org/pub_display.php?pub_id=2677. A monthly econometric model of the world crude oil market constructed by economist Timothy Considine, however, casts doubt on such claims. Timothy Considine, "Is the Strategic Petroleum Reserve Our Ace in the Hole?" Working Paper, July 14, 2005, pp. 20–21. Available from authors.

74. Optimal release strategy is always clearer after the fact than it is before. Considine and Dowd, p. 20.

75. The only oil economists that we are aware of who support conservative use of the SPR are employed at the Petroleum Industry Research Foundation. PIRF believes that global crude oil price signals should be allowed to do their job without government interference in commodity markets except when the market is characterized by extreme backwardation—a condition in which the price of oil futures is significantly lower than the existing spot market price. Most recently, the market was characterized by backwardation in 1990–91 (during the buildup for Operation Desert Storm), the Spring and Summer of 2000, and early 2003 in the midst of domestic turmoil in Venezuela, which resulted in the temporary loss of Venezuelan oil production. See Petroleum Industry Research Foundation, "Using the SPR: Issues and Lessons from Recent History," December 2004.

76. Plummer; and Alm, Colglazier, and Kates-Garnick, p. 331.

77. Considine and Dowd, p. 18.

78. Joseph Nye, David Deese, and Alvin Alm, "A U.S. Strategy for Energy Security," in *Energy and Security*, p. 402.

79. Jeffrey Williams and Brian Wright, *Storage and Commodity Markets*, p. 411.

80. Douglas Bohi and Michael Toman, *The Economics of Energy Security* (Boston: Kluwer Academic Publishers, 1996), p. 126, and Douglas Bohi, "Searching for Consensus on Energy Security Policy," in *Making National Energy Policy*, Hans Landsberg, ed. (Washington: Resources for the Future, 1993), pp. 57–58. Those scenarios are given a strong foundation of plausibility

by R. Glenn Hubbard and Robert Weiner, "Inventory Optimization in the U.S. Petroleum Industry: Empirical Analysis and Implications for Energy Emergency Policy," *Management Science* 32, no. 7 (July 1986): 773–790. "Our simulations support the view that a supply disruption is accompanied by substantial inventory accumulation." Nonetheless, the stylized model used by the authors lead them to conclude that oil releases from public reserves are unlikely to be entirely absorbed by private stockpiles and that releases slightly dampen speculative stockpiling.

81. Philip Verleger, *Oil Markets in Turmoil*, pp. 89–122. Verleger criticizes oil companies for not acquiring even greater inventories than they actually did during that period.

82. Jeffrey Williams and Brian Wright—who both believe that public inventories have a significant effect on the decisions of private inventory holders—observe, "These questions about the displacement of private storage can never be fully answered empirically, for it is difficult to estimate from the behavior of one regime how the system would have evolved in another." Jeffrey Williams and Brian Wright, *Storage and Commodity Markets*, p. 438. For another criticism of the conventional view that displacement of private inventories is a minor problem, see Philip Verleger, *Adjusting to Volatile Energy Prices*, pp. 130 and 203–04, and Newlon and Breckner.

83. Brian Wright and Jeffrey Williams, "The Roles of Public and Private Storage," p. 352.

84. Jim Efstathiou Jr., "Bush Should Sell U.S. Oil Reserve, Says an Early Advocate of It," *Bloomberg News*, August 26, 2005.

85. This should not surprise; it is the rule rather than the exception among academic economists. For a discussion, see Charles Wolf, *Markets or Government: Choosing between Imperfect Alternatives* (Cambridge, MA: MIT Press, 1991).

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