Cost-benefit analysis alone rarely plays decisive roles in the resolution of important policy issues. Although cost-benefit analysis speaks to aggregate economic efficiency, the pluralistic and decentralized political systems of Canada, the United States, and most of the other Western democracies give voice to the organized interests that expect to be winners and losers. Lest aspiring analysts despair, however, they should realize that sound cost-benefit analysis can make important contributions to better policy by informing national and international leaders and by giving support to partisans whose interests happen to be consistent with aggregate economic efficiency. Thus, cost-benefit analysis may serve as a political resource as well as a normative guide.

In this chapter we look at the role cost-benefit analysis had in influencing decisions concerning the size of the Strategic Petroleum Reserve (SPR) program, a fundamental element of U.S. energy policy since the oil price shocks of the 1970s. Our story illustrates the use of cost-benefit analysis to evaluate programs whose future benefits are inherently uncertain. It also illustrates the process of doing quantitative analyses in bureaucratic settings and the role that such analyses can play in influencing political decisions. We hope to be both encouraging and sobering to aspiring analysts about the potential usefulness of their technical skills.

Background: Energy Security and the SPR

After the Second World War, the United States became a net importer of crude oil. In 1959, the United States instituted mandatory quotas on oil imports to limit its growing dependence on foreign sources and to support higher prices for domestically produced oil. Throughout the 1960s, the Texas Railroad Commission stabilized domestic prices by regulating the quantity of oil produced in Texas, the major oil-producing state. Thus, even though U.S. dependence on foreign oil continued to grow, the United States was not directly vulnerable to changes in the world oil market because the Texas Railroad Commission could adjust domestic production to compensate for shifts in import levels.

The picture had changed by the early 1970s. As countries asserted sovereignty over their natural resources during the 1960s, the international oil companies, anticipating eventual loss of control over oil reserves, favored high rates of current production that led to falling real prices. The years of falling real oil prices and a growing world economy contributed to a steady growth in world oil consumption. By the time national governments had achieved direct control over their domestic oil production, they were in a favorable position to exercise some market power through

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1For a more detailed discussion of the U.S. stockpiling program, see David L. Weimer, The Strategic Petroleum Reserve: Planning, Implementation, and Analysis (Westport, CT: Greenwood Press, 1982). Our account here draws heavily on this source.

the Organization of Petroleum Exporting Countries (OPEC).

Meanwhile, in the United States two factors were contributing to greater dependence on imported oil and greater vulnerability to swings in the world market. Ceilings on wellhead prices of domestic crude oil had come into effect as part of the general wage and price controls instituted in August 1971 by President Richard Nixon. Although the ceilings had provisions to encourage the development of new oil fields, their overall effect was to slow the growth in domestic oil production and thereby increase import levels. By this time, the Texas Railroad Commission was allowing wells to produce at their maximum efficient rates, and therefore it no longer controlled excess capacity that could be used to increase domestic production rapidly.

Recognizing that a large fraction of oil supplied to the world market originated in the politically unstable Middle East, a small but growing number of analysts and political leaders in Congress and the executive agencies began to worry about the increasing vulnerability of the United States to disruptions of the world oil market. By the summer of 1973, there were several proposals that the U.S. establish petroleum stockpiles. For example, the National Petroleum Council, an industry advisory group to the Department of Interior, raised the possibility of protecting the United States from supply disruptions by storing ninety days of oil imports in salt dome caverns by 1978. Senator Henry Jackson held hearings before the Interior and Insular Affairs Committee on legislation he had introduced that would establish government-owned petroleum stocks. Although administration witnesses offered cautious support for the idea of creating petroleum reserves, they argued that more time was needed to study the options.

Events did not allow much time for quiet study. On October 6, 1973, Egypt attacked Israeli positions along the Suez Canal. Led by Saudi Arabia, the Organization of Arab Petroleum Exporting Countries (OAPEC) tried to use the "oil weapon" in support of Egypt. When the United States began to resupply arms to Israel through bases in The Netherlands, OAPEC embargoed oil shipments to the two countries. More significantly, OAPEC members reduced their total oil production so that total world supply fell by about 5 percent in the last quarter of 1973 and the first quarter of 1974. The result was a quadrupling of oil prices. The spot price of Mideast light crude, for example, went from $2.70 per barrel in the third quarter of 1973 to $13.00 per barrel in the first quarter of 1974. This price shock triggered a deep recession that extended well into 1975. The "policy window" for energy security was clearly open.

Initiation of the SPR Program

In response to the Arab oil embargo, President Nixon announced Project Independence, a national effort to achieve energy self-sufficiency by the end of the decade. An interagency task force, eventually headed by the newly created Federal Energy Administration (FEA), began to analyze ways of implementing Project Independence. The task force eventually realized that reducing U.S. vulnerability to disruptions in the world oil market was a much more appropriate

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goal than self-sufficiency. Yet most of the report was devoted to modeling domestic supply and demand to predict future import levels. Relying heavily on the earlier National Petroleum Council analysis, the Project Independence Report nevertheless suggested that petroleum stockpiles of a billion barrels or more might be justified on grounds of economic efficiency.

The creation of a strategic petroleum reserve was one of the few recommendations of the Project Independence Report included by the new Ford Administration in its legislative proposals of January 1975. Of all the proposals, it received the warmest reception in Congress. The Energy Policy and Conservation Act (P.L. 94-163), which was passed and signed into law in December 1975, gave the FEA administrator one year to submit to Congress a plan for the implementation of a Strategic Petroleum Reserve program that would have 150 million barrels of petroleum in storage within three years and eventually store up to 1 billion barrels. Although there was a presumption in the legislation that the SPR would hold about ninety days of petroleum imports (then about 500 million barrels) within seven years, the details of program design and implementation were left to the FEA administrator.

**Basic Program Structure**

The SPR plan, which was submitted to Congress in December 1976, called for 150 million barrels of oil to be in storage by December 1978, 325 million barrels by December 1980, and 500 million barrels by December 1982. The choice of 500 million barrels was the result of a compromise with the Office of Management and Budget (OMB). OMB analysts favored a smaller reserve. Although FEA analysts believed that a larger reserve could be justified on efficiency grounds with reasonable assumptions about the likelihood of future disruptions, they did not wish to reopen the issue with OMB.

The SPR plan identified salt dome caverns and mines as the most desirable storage facilities. They were expected to be much cheaper than the major alternatives: steel tanks, floating tankers, and shut-in wells. The writers of the plan anticipated that about 200 million barrels of salt dome storage capacity could be purchased from firms that had created caverns as a by-product of brine production and salt mining. Additional capacity would be created through solution mining (making caverns by dissolving salt with fresh water), which permitted new caverns to be filled with oil as they were being created. The salt dome formations were conveniently located along the Gulf Coast near existing transportation facilities so that oil taken out of storage could be easily distributed.

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6Storage on the form of surge capacity from shut-in oil wells is the most expensive of the alternatives. For each barrel of surge capacity, about eight barrels of proven reserves must be shut in. To have the capacity to increase production by 1 billion barrels per year would require 8 billion barrels of proven reserves, or about 25 percent of total U.S. proven reserves. Furthermore, transportation facilities and production crews would have to be kept at the ready. Whereas new solution-mined caverns were expected to cost between $1.35 and $2.15 per barrel (actual costs turned out to be closer to $3.00 per barrel) and new steel tanks between $8 and $12 per barrel, in situ storage was estimated to cost between $45 and $100 per barrel. Strategic Petroleum Office, "Strategic Petroleum Reserve Plan," December 15, 1976, Table IV-1, at p. 75.
The SPR plan was generally well received in Congress. The only major criticism came from a few senators who wanted the plan to include the storage of petroleum products in regional locations as well as the storage of crude oil along the Gulf Coast. The FEA administrator under the new Carter Administration was able to deflect this criticism by promising further study. Consequently, the Senate and House allowed the plan to go into effect without amendment in April 1977.

Implementation Problems

The SPR program appeared to get off to a good start. Within one week of the plan's going into effect, three of the major sites for solution mining were acquired. Within a few months, oil was being injected into caverns at one site; by the end of the year, oil was being injected at all three sites and a conventionally mined site had been acquired. Soon, however, problems arose that frustrated efforts to keep the program on schedule and under budget. In 1979, when oil purchases were stopped in response to the increases in price growing out of the Iranian revolution, only 92 million barrels were in storage. The resulting general perception of failure, and some of the specific reasons for it, left the program vulnerable to later attempts to limit its size.

Here we briefly sketch some of the major sources of implementation failure at the outset of the SPR program.\(^7\)

**Problems Inherent in Program Design.** The SPR plan was overly optimistic about how much existing storage capacity could be purchased and immediately put to use. Several caverns did not have as much capacity as expected. The capacity that was available required the disposal of a barrel of brine for each barrel of oil put in storage. Deep wells, which would eventually be replaced by planned pipelines to the sea, proved inadequate for disposing of the brine. The deficit of existing capacity, which necessitated more solution mining of new capacity, greatly exacerbated the problem of brine disposal—the mining of each barrel of new capacity produces seven barrels of brine as a by-product.

The SPR plan also failed to anticipate the difficulty of initiating and monitoring the large number of contracts—eighty-five major construction contracts alone during the first year—with a small staff based in Washington, D.C. The task was overwhelming. The eventual solution, a limited privatization of the contracting function, was to hire a prime contractor that in turn contracted for the necessary construction services and materials. Nevertheless, the initial contracting problem slowed implementation, contributed to cost overruns, and diverted attention from building a management infrastructure.

Should these problems have been foreseen by program planners? Undoubtedly, the limited technical experience of the planners contributed to their overly optimistic assumptions about the availability and feasible rate of developing storage capacity. But without taking time to do field experiments, it is not obvious how they could have made better estimates. In contrast, if they had prepared detailed implementation scenarios, then they might have anticipated the difficulty of administering so many contracts with such a small staff in an organization with no prior experience in procuring construction services.

Unrealistic Expectations. James R. Schlesinger, who later became secretary of the new Department of Energy, served as President Jimmy Carter's chief energy adviser in the early days of the new administration. He viewed reliance on Middle Eastern oil as a serious weakness in the U.S. defense posture. He also believed that the then "soft" world oil market would become "tight" in the early 1980s, so it would be better to accumulate oil for the reserve sooner rather than later. He therefore convinced the president that development of the SPR should be accelerated by two years and its ultimate size increased to 1 billion barrels.

These decisions were made, however, without consulting the SPR office about their feasibility. The SPR staff argued for a more modest acceleration; but Schlesinger insisted on changing the schedule so that 250 million barrels would be in storage by the end of 1978 and 500 million barrels by the end of 1980. So, at a time when the SPR Office was straining to keep the implementation on the old schedule, it had to divert scarce managerial resources to devise a plan for meeting a more ambitious one. The plan was transmitted to Congress in May as an amendment to the original SPR plan.

Aside from using scarce managerial resources at a critical stage in the implementation, the acceleration decision forced the SPR office to take a number of gambles in order to meet the new schedule. For example, to avoid delays in deliveries of oil, purchases were made in anticipation of facilities being completed. When they were not ready, demurrage charges had to be paid for the unaccepted deliveries. The acceleration decision also contributed to a loss of credibility that hurt the program in its future efforts to secure needed resources. Thus, because of the failure to consider the feasibility of implementation, the acceleration decision actually decelerated the program. The decision to expand the size of the SPR to 1 billion barrels opened the bureaucratic battles that we discuss later in the chapter.

Lack of Organizational Support. When the SPR office was located within the FEA, it enjoyed a favored position. The head of the SPR office was an assistant administrator who reported directly to the FEA administrator. This access enabled the SPR office to obtain fast decisions from the administrator and elicit his support in securing cooperation from other agencies and other units within the FEA. For example, when the magnitude of the contracting problem became apparent, the administrator helped set up a special procurement board to expedite the signing of construction contracts.

All this changed with the creation of the Department of Energy (DOE) in October 1977. Instead of reporting directly to the FEA administrator, the director of the SPR office now reported to a deputy assistant secretary, who reported to an assistant secretary, who reported to the undersecretary, who reported to a deputy secretary, who reported to the secretary. No longer was it possible to get fast decisions. Furthermore, each substantive office within the department competed for the attention of the new hierarchy.

Three serious problems arose. First, the SPR office could not easily mobilize the DOE leadership to intervene with other agencies, such as the Environmental Protection Agency and the Army Corps of Engineers, whose procedures for issuing environmental and water use permits were slowing construction. Second, when the DOE was created by merging the FEA, the Federal Power Commission, and the Energy Research and Development Administration, the number of employees exceeded the limit for the new agency. The response was a department-wide hiring freeze—just at the time that the SPR office needed to add personnel with experience in contract...
administration. The director of the SPR office had to devote staff time to making special requests for new hires. Third, all procurement responsibilities were transferred to what had been the procurement office of the Energy Research and Development Administration. Its cumbersome procedures were designed to handle procurements for large and complex research and development projects. Contracts that the FEA would have processed in weeks or months now took as long as nine months. Indeed, a critical six-month period passed with virtually no contracts for the SPR being let.

These problems highlight the importance of considering organizational structure in designing new programs. Perhaps many of the problems could have been avoided if the SPR office had been established as either an independent agency or a unit reporting directly to the secretary. The necessity of winning support within the large DOE bureaucracy also became relevant in later battles with OMB over funding for program expansion.

Reprise of SPR Origins. The SPR program failed to meet either its original or accelerated schedule. At the end of 1978 only 68.5 million barrels were in storage—far less than the 150 million barrels called for by the old schedule or the 250 million barrels called for by the accelerated schedule. The 500-million-barrel mark was not reached until 1986, four years later than under the original schedule and six years later than under the accelerated schedule. The implementation problems that led to these delays had been largely solved by 1980. But were (and are) the objectives of the SPR program appropriate? It is to this question that we turn next.

Analytical Approaches to the Size Issue
The intuitive logic behind stockpiling is simple: buy oil when prices are low (in normal markets) and sell oil when prices are high (in disrupted markets). Such speculation has the potential for generating profits, suggesting the possibility of private stockpiling. Why, then, should the government be involved in oil stockpiling? In other words, what market or government failure justifies publicly owned oil stocks? There are three major rationales for public stockpiling: two based on market failure and the other based on government failure.8

First, stockpiling involves external effects. Firms do not bear the full costs and benefits of their stockpiling decisions. When firms purchase oil stocks, they increase the world demand for oil, which may in turn increase the price. While the stockpilers must pay the higher price, so, too, must all buyers of oil. The economic costs of the higher prices, however, are external to the profit calculations of the stockpilers. Thus, the social costs of building stocks may be higher than the private costs. With respect to drawdowns that reduce price, the social benefits may be higher than the private benefits. Also, the mere existence of a large stockpile may provide political benefits, such as the deterrence of purposeful disruptions, that do not show up in the profits of private stockpilers. In general, we expect the positive externalities to be greater than the negative externalities. The reason is that stock accumulations usually occur gradually, so that small price increases with negligible economic effects result; drawdowns are likely to occur during price

shocks, when even small price reductions can have noticeable economic benefits.9

Second, if firms are risk averse, then they may forgo stockpiling that reduces social risk. For an individual firm, stockpiling in anticipation of a major price shock is like gambling—if the price shock occurs, the firm profits; if it does not, the firm suffers a loss. Therefore, from the firm's perspective, stockpiling is like gambling—a sure payment is made in return for the small probability of a big gain. From the social perspective, however, stockpiling is like insurance—a sure payment is made in return for avoiding the small probability of a big loss.

Third, because of government price controls and mandatory petroleum allocations in the recent past, firms may anticipate the possibility that the government will prevent them from selling speculative stocks at market prices during future oil price shocks. In other words, past government actions have undermined the credibility of property rights to stockpiled oil. We can think of this as having created an institutional common property resource problem: because firms are not able with certainty to exclude others from using their stockpiled oil when it is most valuable, they will undersupply speculative stocks. Therefore, too little oil will be privately stockpiled for use during oil supply disruptions.

These rationales suggest the desirability of a public role in oil stockpiling. But how big a role? Assuming that stockpiling is to be supplied directly by government, how big should the stockpile be? How quickly should it be built? And under what circumstances should it be used? The cost-benefit framework helps us begin to answer these questions.

**Impacts of a Stockpiling Program**

As shown in Table 17.1, we divide the impacts of a public stockpiling program into four categories: expenditure, direct market, political, and collateral effects.

(Table 17.1 about here)

**Expenditure Effects.** The most visible costs of an oil stockpiling program are the outlays that must be made to secure storage facilities and purchase oil. Estimates of the costs of building storage facilities can be based on engineering data or on the costs of similar facilities built in the past. Estimating the cost of oil requires projections of future prices, including the effects of the purchases themselves. Because purchases generally will not be made in disrupted markets, such projections can take the form of assumptions about long-run rates of price growth (or decline).

When the government sells oil from the stockpile, it realizes revenue. Large sales will depress the price of oil—the intended effect when stocks are used to counter a price shock caused by a disruption of the world oil market. We may assume that the program will be terminated at some future date by selling facilities and any remaining stocks at projected prices. These revenues constitute the anticipated scrap value of the program.

(Figure 17.1 about here)

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9The major exception occurs in situations in which firms attempt to build their stocks once disruptions have already begun. Such behavior may be consistent with the maximization of profits if firms anticipate higher prices in the future, but it contributes to the magnitude of the price shock that the economy suffers.
Market Effects. The left-hand panel of Figure 17.1 illustrates the market effects of a drawdown of stocks during a disruption of the world oil market. Prior to the disruption, the world price of oil is $P_0$, the price at which the supply schedule $S_{WN}$ and the demand schedule $D_{WN}$ intersect. A disruption, which suddenly removes supply from the market, shifts the supply schedule to $S_i$. This shift causes price to rise to $P_1$. (The sudden jump in price from $P_0$ to $P_1$ is the oil price shock.) A drawdown of oil stocks shifts the supply curve back to the right. A drawdown of size $\Delta$ shifts the postdisruption supply schedule horizontally to the right by $\Delta$ units to $S_{WD} + \Delta$ so that price $P_2$ results. Thus, the drawdown keeps the postdisruption price from rising all the way to $P_1$. The difference between $P_1$ and $P_2$ is the source of the economic benefits of the drawdown for net oil importers like the United States.

A purchase of oil for the stockpile shifts the demand schedule in the world market to the right. If the supply schedule is horizontal over the range of the shifting demand schedule, then the purchase does not cause the price to rise. If the supply schedule is upward sloping, however, the shift in demand does cause price to rise. This rise in price results in economic losses for net oil importers that can be measured in the same way as the economic losses caused by the oil supply disruption.

Political Effects. A large stockpile may deter embargoes and politically motivated reductions in supply. The larger the stockpile, the more political opponents must reduce supply in order to impose any particular level of economic loss on importers. As long as the exporting countries anticipate that they also will suffer economic losses by reducing supply, the existence of a large stockpile will deter somewhat the use of supply disruptions for political purposes.

A large stockpile also expands the range of options that the United States can pursue in carrying out domestic and foreign policy. Because a stockpile drawdown provides "breathing space" between the time when supplies from an exporting region are disrupted and the time when the full impact of the resulting price increase is felt, diplomatic initiatives can be launched in a less politically volatile domestic environment than otherwise. If the disruption coincides with, or leads to, military intervention, the stockpile will enhance operational flexibility by reducing the costs to the United States and its allies of temporary damage that they might inflict collaterally to oil-producing facilities. In terms of domestic policy, drawdowns may lessen the political panic that can lead to price controls and mandatory allocations of the sort that exacerbated the economic costs of disruptions during the 1970s.\(^\text{10}\)

Collateral Effects. Public stockpiling may discourage private stockpiling. The existence of a large stockpile controlled by the government may displace stockpiling that would otherwise be done by the private sector. Firms will expect government drawdowns during disruptions to reduce the price at which their own stockpiles could be sold. Although this price-reducing effect will tend to lower the size of private stockpiles, the marginal reduction is likely to be small if firms already anticipate that price controls and mandatory allocations of private stockpiles will be reimposed during disruptions large enough to trigger use of the government stockpile. Indeed, if firms believe that larger government stockpiles reduce the

\(^{10}\)For a discussion of the impact of the U.S. regulations during the 1970s, see Horwich and Weimer, *Oil Price Shocks*, pp. 57–110.
likelihood that price controls and allocations will be reimposed, increasing the size of the government stockpile may actually encourage private stockpiling. Overall, the displacement of private stockpiling is probably insignificant.

A large U.S. stockpile may also discourage the stockpiling efforts of foreign governments. Because oil consumers worldwide gain from drawdowns of the U.S. stockpile, other importing nations may take a "free ride" on large U.S. stocks. If this happens, then each barrel added to the U.S. stockpile will result in less than a barrel in net additions to world stocks. A factor that constrains free riding is the International Energy Agency. Its members, including the United States, Canada, Japan, Germany, and most of the other countries in Western Europe, have agreed to hold minimum levels of petroleum stocks for use during supply disruptions. Even without such an agreement, fear that the United States may fail to use its reserves is likely to restrain countries somewhat from free riding.

The standard approach for taking account of these displacement effects in cost-benefit analyses is to assume that the public stockpile has a smaller effective, than physical, size. So, for example, if analysts believed that private stocks would be reduced by one barrel for each five barrels put in the public stockpile, then a 500-million-barrel reserve would have an effective size of only 400 million barrels.

Quantifying Costs and Benefits

We can employ the standard tools of economics to quantify the budgetary and market impacts of a stockpiling program. Unfortunately, the political and collateral effects are not as easily quantified. It is probably reasonable to assume that the displacement effects of a U.S. stockpiling program are small. Although the political benefits cannot be quantified, they nevertheless may be important, especially to a president who must make politically sensitive decisions, such as those concerning the resupply of Israel during a Middle East war or the use of military force to aid the government of Saudi Arabia against foreign-supported insurgents or an Iraqi invasion. In excluding political benefits from our cost-benefit analysis, we understate the net benefits of stockpiling. As we discussed in Chapter 16, the cost-benefit analysis becomes one component of a larger multigoal analysis.

We must also consider the issue of standing. As we have already mentioned, acquisitions and drawdowns affect the price of oil in the world oil market. One approach is to measure the costs and benefits accruing not just to the United States but also to its allies that import oil at the world price. Instead, the standard practice for analysts in the U.S. government has been to measure only costs and benefits accruing domestically. In other words, they give standing in their cost-benefit analyses only to U.S. residents.

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**Changes in Social Surplus.** We return to Figure 17.1 to illustrate the measurement of the benefits of drawdowns and the costs of acquisitions.

The right-hand panel shows the effect of the rise in price from $P_0$ to $P_1$ on the U.S. oil market. At the predisruption price $P_0$, $q_{D0}$ is domestically consumed (point $e$ on the U.S. demand schedule, $D_{US}$) and $q_{S0}$ is domestically produced (point $a$ on the U.S. supply schedule, $S_{US}$). The difference between domestic consumption and domestic production equals the level of imports prior to the disruption. When the price rises to $P_1$, domestic consumption falls to $q_{D1}$ and domestic production rises to $q_{S1}$. The resulting loss in social surplus equals the area of trapezoid $abde$; the area of triangle $def$ represents the consumer surplus lost because less is being consumed; the triangle $abc$ represents the real resource costs of increasing domestic production; and the area of rectangle $bdfc$ represents the additional amount that consumers must pay to foreign suppliers for the imports that they continue to consume.

The postdisruption price with a drawback of size $\Delta$ is only $P_2$. The social surplus loss of a rise in price from $P_0$ to $P_2$ equals the area of trapezoid $aghe$, which is smaller than the social surplus loss without the drawdown by the area of trapezoid $bdhg$. Thus, the avoided social surplus loss from the drawdown equals the area $bdhg$ (which is shaded in the figure). Applying the rule developed in Chapter 12, we see that the benefits of the drawdown equal the realized revenue ($\Delta$ times $P_2$), plus the change in social surplus in the primary market (area $bdhg$).

Oil acquisitions that increase world price also cause a social surplus loss in the U.S. domestic oil market. Imagine that the rise in price from $P_0$ to $P_1$ had been caused by a very large oil purchase. It would cause the same loss in social surplus as the disruption. To calculate the costs of the acquisition, we would add expenditures for the purchased oil to the change of social surplus in the domestic market. Only if price did not rise as a result of the oil purchase would the cost of the acquisition just equal the budgetary cost.

What information is needed to calculate these direct social surplus changes? To locate the positions of the supply and demand schedules, we need projections of price, world consumption, domestic consumption, and domestic supply for the period of time during which the stockpiling program is to be in existence. Such long-run projections are typically based on historical trends. To measure the effect of supply interruptions on price, we need estimates of the price elasticities of supply and demand in the world oil market; to measure social surplus losses we need estimates of the price elasticities of supply and demand in the U.S. oil market. Econometric analyses of historical or cross-national data provide reasonable ranges for these elasticities.

**Adjustment Costs.** The social surplus analysis assumes that the economy can move from one equilibrium to another without cost. While this is a reasonable assumption for moderate price changes, it may not be for steep price changes in a commodity, such as oil, that is a basic input to important sectors of the economy. The higher price of oil requires that relative prices throughout the economy change to achieve efficient allocation at the new equilibrium. Not all prices are perfectly flexible, however. Nominal wages, for instance, tend to be downwardly sticky, so that during a large price shock we may see greater involuntary unemployment rather than an immediate fall in wages. Although inflation may eventually permit an appropriate adjustment by reducing real wages, the short-term consequences may be greater inefficiency than estimated by the direct changes in social surplus.

Similarly, sharp oil price shocks induce immense transfers in wealth from domestic consumers to domestic and foreign oil producers; this shifts demand schedules throughout the
economy. Uncertainty about the new composition of demand can slow investment needed to produce a capital stock consistent with the new relative prices. Delayed investment and reduced aggregate consumption can lead to recession. The inefficiency of idle resources during recession and the loss in future output caused by delays in current investment are not reflected in the direct changes in social surplus.

In light of these adjustment costs, do cost-benefit analyses based on direct changes in social surplus have any systematic biases? Because adjustment costs grow disproportionately with the size of the price shock, direct measures of social surplus changes contribute more to an underestimation of the benefits of drawdowns than an underestimation of the costs of acquisitions. Therefore, cost-benefit analyses based on direct social surplus changes in the oil market generally underestimate the true net benefits of stockpiling.

**Macroeconomic Simulations.** Given that an oil price shock sets in motion price changes throughout the economy, a dynamic model of the entire economy would provide an attractive tool for estimating the full economic costs of oil price shocks and thereby the costs and benefits of stockpiling. Large-scale macroeconomic models employ hundreds of interrelated equations to represent various sectors of the economy and their interactions. A variety of these models are used in government and business for predicting GNP, inflation, unemployment, and other measures of aggregate economic performance. For example, the Department of Energy relied on the commercial forecasting models developed by Data Resources Incorporated (DRI) and Wharton Econometric Forecasting Associates in many evaluations of the SPR.

To measure the benefits of a stockpile drawdown, an analyst would employ the following procedure: First, specify a disruption scenario—the price path of oil over a number of three-month periods. Second, using the specified price path of oil, simulate the response of the economy and measure the present value of GNP over a period of several years. Third, specify a new price path of oil that reflects the assumed drawdown and measure the present value of GNP. Fourth, interpret the difference in the present value of GNP as the benefit of the drawdown.

Aside from the limitations of GNP as a measure of social welfare, already discussed in Chapter 7, two important practical problems inherent in this procedure make it analytically unattractive.12

First, the most commonly used macroeconomic models are not well designed to estimate the effects of supply-side shocks like oil supply disruptions. The models focus primarily on aggregate demand with only implicit accounting of supply flows; thus, they often produce internally inconsistent results that must be corrected with ad hoc procedures. Also, the econometrically estimated relationships in the models may not hold for large disruptions beyond the range of historical data.

Second, the great complexity of the models, and the numerous assumptions that must be made in using them to simulate something extraordinary like an oil price shock, provide a great

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12Exactly offsetting shifts in domestic consumption and exports would not change GNP. Yet the social surplus of U.S. residents would go down—foreigners now consume goods that they previously consumed. The measure of changes in economic efficiency should be the sum of changes in GNP and changes in foreign claims on GNP. For a comparison of GNP and social surplus welfare measures, see Horwich and Weimer, *Oil Price Shocks*, pp. 8–14.
opportunity for modelers to manipulate the results. For example, small changes in assumptions about government monetary and fiscal policies can have large effects on the estimated costs of disruptions. Because numerous ad hoc corrections are needed to achieve internal consistency, even well-trained macroeconomists may have difficulty in finding inappropriate assumptions hidden in the complexity. Given that the cost of using such models is high (in terms of both human and computer time), it is often not feasible to test the sensitivity of all major assumptions. All these features invite analytical abuse by those already committed to policies.

Dealing with Uncertainty

Uncertainty about the timing, frequency, duration, and magnitude of oil supply disruptions provides an interesting challenge for anyone wishing to do a cost-benefit analysis of a stockpiling program. If no disruption occurs, or if one occurs before significant stocks can be accumulated, then the stockpiling program will almost certainly involve net costs. But this possibility must be weighed against the possibility that a drawdown during a major disruption will yield huge benefits that greatly exceed the costs of building the stockpile.

We briefly discuss here the two major approaches that have been used to deal with uncertainty in cost-benefit analyses of the SPR: scenario/break-even analysis and dynamic stochastic programming.

Scenario/Break-Even Analysis. Early cost-benefit analyses of the SPR were based on specified scenarios of program development and future market conditions. Each analysis compared two scenarios with identical program schedules: a disruption scenario with a specified supply interruption and a base-case scenario without it. After measuring the costs and benefits incurred under each scenario, the analysts then calculated how likely the scenario with the supply interruption would have to be for the program to barely pass the cost-benefit criterion with zero expected net benefits. For example, the scenarios might call for the addition of 60 million barrels of oil to the SPR in each of the next five years. The disruption scenario might then call for the drawdown of all 300 million barrels in response to a major supply interruption (say, the loss of 6 million barrels per day to the world market for a period of six months) in the seventh year. The base-case scenario might assume that oil would be held for another ten years and then sold. If the present value of the costs of acquiring and storing the oil under the base-case scenario equaled $C$, and if the present value of benefits from the drawdown during the disruption equaled a larger amount $B$, then the break-even probability, $P_b$, would equal $C/B$.\(^{13}\) If the decision maker believes that the probability of an interruption similar to the one in the disruption scenario is greater than

\[^{13}\text{The break-even probability solves the following equation for zero net expected benefits:} \]

\[0 = p_b (B - C) + (1 - p_b) (0 - C)\]

where $B$ is the present value of benefits if the interruption occurs and $C$ the present value of costs. Of course, this simple formulation implies a world with only two contingencies: the supply interruption in the scenario occurs and the supply interruption in the scenario does not occur. It also assumes that the costs of developing the reserve are identical with and without the supply interruption, or $B$ is adjusted to make the costs equal. For example, $B$ would equal the drawdown benefits plus the present value of the avoided costs of future acquisitions and minus the present value of forgone scrap value.
the break-even probability, then he would conclude that the proposed program schedule offered positive net expected benefits.

The scenario/break-even approach oversimplifies the stockpiling problem in a number of important ways. It does not allow for uncertainty over the timing, magnitude, and duration of disruptions. It ignores the possibility of there being more than one disruption over the life of the program. In considering the break-even probability, decision makers must subjectively account for these limitations in determining how large a probability to assign to the occurrence of the disruption. In addition, the scenario/break-even methodology provides little insight into the optimal timing of acquisitions and drawdowns.

(Figure 17.2 about here)

**Simple Decision Analysis**

Decision analysis provides a framework for expressing the various dimensions of uncertainty in terms of combinations of simple risks. The basic tool of decision analysis is the decision tree. Figure 17.2 illustrates a very simple decision tree that corresponds to a stylized break-even analysis. The tree consists of two types of nodes connected by lines representing outcomes. The square at the left of the tree is a decision node, where we begin by making one of two choices: adopt the proposed stockpiling program or do not adopt it. If we do not adopt it, then we move to the lower circle representing a chance node, which leads to a disruption (an economic cost of 100) with probability \( p \) and no disruption (an economic cost of zero) with probability \( 1 - p \). If instead we decide to adopt the proposed stockpiling program, then we pay for the program (an economic cost of 10) and move to the upper circle, which leads to a disruption (an economic cost reduced to 60 by drawdown) with probability \( p \) and no disruption (an economic cost of \(-8\) because of liquidation of stocks) with probability \( 1 - p \).

To calculate a break-even probability, we compare the expected value of stockpiling with the expected value of not stockpiling. These expected values are shown in the dashed box of Figure 17.2. By equating the expressions for the expected values and solving for \( p \), we find that stockpiling offers positive net expected benefits if the probability of disruption is greater than 1 in 16.

Now imagine that we let the tree grow decision nodes at the end of each of the chance branches. We could interpret the resulting structure as representing two successive time periods. It would be possible to have no disruption over the two periods, one disruption lasting one period, or one disruption lasting the entire two periods. As we add more and more periods, the tree allows for the possibility of even more patterns of disruption. Thus, by constructing a multiperiod decision tree, we create a model that incorporates a large number of scenarios involving disruptions of varying length and frequency.

Also imagine that we expand the chance nodes to include several levels of disruption. Now the tree permits the possibility of scenarios with the magnitude of a disruption changing over time. We can allow for flexibility in the schedule of the stockpiling program by modifying the

\[ \text{For an application of decision analysis within the context of cost-benefit analysis, see Anthony E. Boardman, David H. Greenberg, Aidan R. Vining, and David L. Weimer, Cost-Benefit Analysis: Concepts and Practice, 2nd ed. (Upper Saddle River, NJ: Prentice Hall, 2001), 156–91.} \]
decision nodes to have multiple choices about increments and decrements to stocks.

(Figure 17.3 about here)

Figure 17.3 shows a close-up of a small portion of an expanded decision tree for the stockpiling problem. As shown, we enter period \( t \) under normal market conditions with 50 million barrels of oil already in the stockpile. We are then faced with the decision of how much oil to acquire or drawdown. Eleven possible decisions are shown. They range in 10-million-barrel increments from drawing down the entire stockpile (−50 million barrels) to adding another 50 million barrels. If we add, say, 20 million barrels, then we move to the chance node with 70 million barrels in the stockpile. Now one of five possible market conditions occurs: a slack market in which some oil could be purchased without driving up that price; a normal market in which purchases drive the price up somewhat; a minor disruption; a moderate disruption; and a major disruption. The market condition and the stockpile size define the entering state at the beginning of period \( t + 1 \).

The decision tree for a stockpiling problem with, for instance, fifteen time periods, five market states, and stockpile increments of 10 million barrels would be literally impossible to draw or solve by hand. Fortunately, a general solution method called stochastic dynamic programming can be applied with the aid of a computer.

**Stochastic Dynamic Programming.** If we were to solve a decision tree by hand, we would start at the last period, calculating expected values over the outcomes of the last chance nodes. We would then replace the chance nodes with these expected values and prune off all but the chance node with the largest expected value for each decision node. We would then discount the dominant nodes back to the previous period. Continuing this process of taking discounted expected values and pruning off dominated chance nodes, we would eventually work back to the decision node in the initial period. As a result of this pruning process, we would be able to select the decision in the initial period that had the largest present value of expected net benefits. Reading through the pruned tree from the first to last period would give us the optimal strategy for any sequence of market conditions.

Stochastic dynamic programming employs a similar solution method, identifying the optimal sequence of drawdowns and acquisitions for any scenario of market conditions. Constraints on the allowable size of the stockpile in each period can be incorporated to model proposed schedules of storage capacity development. To compare alternative schedules, the stockpiling model would be solved for each schedule separately. The schedule offering the largest present value of expected net benefits would be selected as most efficient.

What assumptions must be made to employ stochastic dynamic programming? First, for each alternative program we require a specification of a schedule of storage capacity availability and the present value of the costs of providing it. Second, assumptions about prices, quantities, and elasticities for the world and U.S. oil markets are necessary for each period so that costs and benefits can be calculated. Third, a social discount rate must be selected. Fourth, the probabilities of each market condition arising in each period contingent on the market condition of the previous period are needed for calculating expected values. For example, given a normal market in the current period, what is the probability that the next period will also have a normal market?
The first three of these categories include the sorts of assumptions that we normally make in doing cost-benefit analysis. Therefore, we have fairly standard approaches for making them. Assumptions about the probabilities of market conditions are much more subjective. If we allow only two possible market conditions, for example, then we can easily do sensitivity analysis by varying the two assumed probabilities. For a model with five market conditions, however, sixteen independent probabilities must be specified. The greatest weakness in the stochastic dynamic programming approach is the difficulty analysts face in selecting these probabilities and communicating their significance to clients.

Stochastic dynamic programming was first applied to the oil stockpiling problem by Thomas J. Teisberg, then a member of the economics faculty at the Massachusetts Institute of Technology. He worked with policy analysts in the DOE to develop a model that became the standard tool for evaluating economic costs and benefits of alternative stockpiling policies. In the story that follows, we look at the role played by this model in the debate between the DOE and the Office of Management and Budget over the appropriate size of the SPR.

The Role of Analysis in the SPR Size Controversy

The Energy Policy and Conservation Act mandated the creation of an SPR of between 150 million and 1 billion barrels, with a strong presumption that the SPR would be sufficient to replace 90 days of petroleum imports (then about 500 million barrels). Although work completed by the Institute of Defense Analyses suggested that a much larger SPR was economically justified, the billion-barrel figure was selected as a round number larger than the largest size that the administration anticipated recommending to Congress in the SPR plan. The lower level of 150 million barrels represented an estimate by the FEA of the amount of existing salt dome storage capacity that it could obtain for the program. The presumed size of 500 million barrels, consistent with the National Petroleum Council recommendation, was selected by President Ford as a compromise between the positions of the OMB and the FEA. Presaging later battles, the OMB had argued for a smaller SPR to reduce program costs, while the FEA had argued for the greater security that would be provided by a larger reserve.

The SPR plan submitted by the FEA to Congress in December 1976 included a cost-effectiveness analysis in support of the 500-million-barrel size. The analysis concluded

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16 This section is based on Hank C. Jenkins-Smith and David L. Weimer, "Analysis as Retrograde Action: The Case of Strategic Petroleum Reserves," *Public Administration Review* 45(4) 1985, 485–94, which provides a full documentation of sources. Parts are reprinted with permission from *Public Administration Review*, 1985, by the American Society for Public Administration, 1120 G Street, N.W. Washington, D.C. All rights reserved.


18 The analysis employed an estimated relationship between oil import reductions and GNP. It is summarized in Randall Holcombe, "A Method of Estimating the GNP Loss from a
that under optimistic assumptions about import levels and the likelihood of disruptions, a reserve of 500 million barrels or larger was cost-effective. Agreement in favor of the 500-million-barrel size was tenuous, however. Analysts at OMB wanted to limit the size to 200 million barrels, but they could not gain sufficient support to override the legislative presumption for 500 million barrels. For their part, most FEA analysts believed that a larger size could be justified on economic grounds, but they decided not to press their case in view of anticipated opposition from OMB.

**The Billion-Barrel Initiative**
Development of the National Energy Plan, which called for expansion of the SPR to 1 billion barrels, was tightly controlled by James R. Schlesinger, President Carter's chief energy adviser. His staff tapped the agencies and departments for information but remained secretive about policy options. Operating efficiency was selected over "the more time-consuming process of consensus building." The National Energy Plan draft was circulated within the administration for comments only a short time before President Carter released the final version on April 29, 1977. Consequently, OMB career staffers concerned with the SPR did not have time to convince their new director to seek presidential reconsideration of the billion-barrel goal included in National Energy Plan. In bureaucratic slang, Schlesinger had successfully "rolled" OMB on the SPR issue.

OMB found an opportunity to blunt the billion-barrel initiative during the preparation of the administration's FY 1979 budget proposals in the fall of 1977. Schlesinger, as secretary of the newly created Department of Energy, had requested funding for construction of the second 500 million barrels (Phase III would take the SPR to about 750 million barrels and Phase IV to 1 billion barrels) of storage capacity. When OMB cut these funds, Schlesinger appealed to the president.

Schlesinger presented his case to the president at a White House meeting with the OMB director. OMB staffers, armed with flipcharts, began to make the case that a reserve size larger than 500 million barrels was unjustified. They were cut short by President Carter, however, who stated that the size of the SPR was not at issue: he was still committed to an ultimate reserve size of 1 billion barrels. The real issue was how much would be spent in FY 1979 for Phases III and IV. As a compromise, the president allowed planning funds to be included for only Phase III.

The results of this meeting might be viewed as a Pyrrhic victory for Schlesinger. He secured presidential reaffirmation of the billion-barrel goal. (Congress endorsed the expanded goal by approving an amendment to the SPR plan the following June.) In the process, however, OMB staffers, who would be involved in future budget fights over the SPR, were embarrassed in front of the president. It is possible that the incident influenced their attitudes toward the SPR program.

In these initial rounds, then, DOE analysts under Schlesinger had successfully mounted an initiative to expand the SPR size. Persistent opposition from OMB had been temporarily overcome. Given widespread support within both Congress and the administration, as well as the repeated analytic justification for a large SPR, how can the continued opposition of OMB be explained?

OMB analysts had legitimate reasons to question the analytical justification for the larger SPR size. The analysis presented in the SPR plan was unsophisticated in the way it measured the benefits of drawdowns and dealt with uncertainty. Within the analytical framework employed, ample room existed for disagreement over assumptions about future conditions. These assumptions, in turn, were critical to estimates of future SPR benefits. Thus, at this stage of the controversy, OMB opposition on analytical grounds was clearly defensible.

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Institutional factors may also have contributed to opposition by OMB staffers. OMB is responsible for the overall budget and is concerned with limiting expenditures wherever possible. The SPR made an attractive target for several reasons: First, its benefits are diffuse, with no strong constituency to oppose budget cuts; its aggregate benefits may be large, but no politically active group anticipates a large enough share to make it worthwhile to take political action. Second, the SPR resembles an insurance policy in that the costs are certain but the full benefits accrue only from events that may not occur. Because the initial costs for SPR facilities and stock purchases are relatively large, those who are most responsible for the budget may be willing to accept higher levels of risk for reduced premiums. Third, the costs must be borne today while the benefits result sometime in the future. Those responsible for this year's budget may have a higher subjective discount rate than other decision makers. Thus the institutional mission of OMB, coupled with the diffuse benefits and high start-up costs of the SPR, made the initiative to expand the SPR a particularly attractive target for budget cutters.20

Analytical Trench Welfare, Round One: 1978

In February 1978, OMB organized an interagency task force to study contingency planning issues. It consisted of personnel from the Office of Contingency Planning in the Policy and Evaluation Office of DOE, the Special Studies Division for Natural Resources, Energy, and Science in OMB, and the Council of Economic Advisers (CEA). DOE agreed to consider alternatives for implementation of the expanded reserve, implicitly reopening the size issue. By mid-April, participants reached tentative agreement on the assumptions that would be employed to measure the macroeconomic costs of oil supply disruptions. With these assumptions, DOE and CEA analysts used the Wharton and DRI macroeconomic models to estimate a relationship between reductions in oil imports and quarterly losses in GNP. The relationship was used by DOE analysts in a cost-benefit analysis of the fourth 250 million barrels (Phase IV) of the SPR. When OMB analysts discovered that the DOE analysis supported implementation of Phase IV, they began to attack the assumptions used—including some to which they had previously agreed. Although DOE made a number of concessions on assumptions, Phase IV still appeared to be justified. Finally, OMB presented its own analysis arguing against Phase IV in a memorandum to the president.

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Secretary Schlesinger prepared to argue the issue with OMB during meetings on the FY 1980 budget. Schlesinger had been informed by his staff that OMB had argued that the probability of a severe disruption (the loss of approximately 60 percent of Persian Gulf exports for six months) would have to be between 10 and 25 percent per year over twelve years to justify Phase IV. With CEA concurrence, Schlesinger presented the DOE case that a yearly break-even probability of only 1 percent would justify Phase IV. When OMB agreed (its figures had been for the entire twelve-year period), Schlesinger seemed to be thrown off balance. Rather than threaten to take the issue to the president, he agreed not to press for Phase IV planning funds for FY 1980 and to recommend that the issue of ultimate size be referred to the National Security Council. One OMB analyst who attended the meeting believes that OMB would have backed down if Schlesinger had demanded a meeting before the president in which he would have asked the secretaries of defense and state if they would be willing to assume that the probability of a major disruption would be less than 1 percent per year. Perhaps Schlesinger might have taken this approach if his analysts had not focused his attention on the apparent discrepancy between DOE and OMB conclusions.

Round Two: 1979
In January 1979, OMB began to pressure DOE to participate in another joint study of the economic costs and benefits of implementing the billion-barrel goal. DOE analysts who had been involved in the previous joint study argued against participation. They believed that the OMB analysts would not be satisfied with any analysis that supported SPR expansion. But institutional relationships within the federal bureaucracy make it difficult for a department to refuse an OMB request. Beyond its influence in a given budgetary dispute, OMB must be dealt with on numerous budget issues, and the costs of not cooperating can extend beyond the particular issue involved. DOE committed about twenty staff-months of professional time and approximately $80,000 for consultants to the project.

The first project task was to complete simulations of the macroeconomic effects of disruptions based on the DRI and Wharton macromodels. Although initially agreement was reached on a set of assumptions to be used, the OMB and CEA representatives continually required modifications of assumptions. This was frustrating for the DOE analysts who had to implement them, particularly because it appeared to them that OMB staffers were consistently looking for ways to make disruptions appear less costly and, hence, the SPR less valuable.

DOE completed a first draft of the study report in October 1979. It assumed that the first 550 million barrels of the SPR would be drawn down only for disruptions involving losses to the United States of over 1 billion barrels per year. It also assumed that private industry would draw down its stocks by 125 million barrels during a severe disruption. The expected benefits from SPR drawdowns were estimated for a number of disruption scenarios and their assumed probabilities of occurrence. The report concluded that the economically desirable reserve was 2.1 billion barrels or larger.

OMB staff participating in the study project were outraged. OMB had been preparing to argue not only against Phase IV but also against Phase III on grounds that new capacity should not be added while existing capacity was not being filled. (In light of the long lead time needed to construct storage facilities, the OMB position seemed to assume that the then-current tight market conditions caused by Iranian production reductions would prevail for five or six years.) Also, the revelations over the preceding year of cost overruns and schedule delays encountered during the
implementation of Phases I and II made the SPR an even more tempting and perhaps more vulnerable target for budget cuts.

Focusing on the least certain (and, therefore, most vulnerable) techniques and assumptions included in the analysis, OMB raised four major objections to the draft report. First, the use of assumed probabilities for the disruption scenarios was attacked as arbitrary. DOE countered by arguing that, although arbitrary, the probabilities were viewed as conservative by most experts consulted. Second, OMB wanted the GNP loss function to be estimated on the basis of more accommodating monetary and fiscal assumptions that would yield lower real GNP losses but higher inflation rates. DOE responded that the more extreme the monetary and fiscal policy assumptions made, the more suspect the results of the macroeconomic models. Third, OMB objected to the assignment of a salvage value to SPR oil. DOE analysts thought it was obvious that the sale of remaining assets at the termination of the program should be counted as benefits. Finally, OMB argued that SPR drawdowns would not replace lost imports barrel per barrel—an objection that DOE analysts had to admit as valid. (Note that in Figure 14.1, the price effect of a drawdown depends on the price elasticities of supply and demand in the world market. Drawdowns of the SPR do not replace lost imports barrel for barrel.)

After it became clear that OMB was attempting to cut funds for Phase III from the budget, the DOE analysts decided to redo their analysis with a set of assumptions that OMB would not be able to attack. Successfully accomplished, such a move would reduce the opportunity for further delays based on demands for better analysis. The resulting new study, which even included an arbitrary across-the-board reduction of 25 percent of benefits to reflect possible inefficiencies in SPR use, found that expansion of the SPR to 750 million barrels was justified if one believed that the probability of a disruption of moderate size (less than 2 million barrels per day for one year) was greater than 3.5 percent per year.

This effort was to no avail. Not only did OMB cut funding for implementation of Phase III from the FY 1980 supplementary budget and the FY 1981 budget, but the DOE leadership decided not to appeal the decision to the president. Schlesinger, until then the strongest SPR supporter among the DOE leadership, was no longer secretary. The new secretary, Charles W. Duncan, and his assistant secretary for policy and evaluation, William Lewis, were not yet familiar with the issue. The remaining leadership in the past had emphasized long-run energy policy, such as conservation, over contingency planning measures, such as the SPR. Consequently, there was no one to lead a fight against OMB cuts. In fact, DOE Undersecretary John Deutch agreed to yet another joint OMB/DOE study to be conducted in 1980 for the FY 1982 budget decision on Phase III.

**Round Three: 1980**

While the Office of Contingency Planning was struggling with OMB over the 1979 study, the Office of Oil, also under the assistant secretary for policy and evaluation, was developing a methodology for investigating the optimal timing of oil acquisitions and drawdowns and of capacity expansions. Recognizing the weakness of methods previously used to handle the uncertainty about supply interruptions in prior studies, Lucian Pugliaresi, director of the Office of Oil, encouraged economist Thomas Teisberg to work on the problem.

Teisberg developed a stochastic dynamic programming formulation of the stockpiling problem. For each year of the SPR program, his model determines the oil acquisition or drawdown, subject to technical constraints, that minimizes the discounted sum of expected future
net social surplus losses. Uncertainty is converted to risk by assuming probabilities of moving from each market condition to each of the other possible market conditions in future periods. Using the model to look ahead, at some point the stockpiling reaches a size at which additions are no longer optimal. This plateau level is an indication of the "optimal" stockpile size for planning purposes.

In December 1979, Glen Sweetnam, Steven Minihan, George Horwich, and other staff members in the Office of Oil completed a major study of acquisition and drawdown analyses using the Teisberg model. Over a range of assumptions, the plateau level was found to vary from 800 million to 4.4 billion barrels. More importantly, the study suggested that large net benefits were associated with rapid expansion of the SPR toward the plateau.

The new assistant secretary for policy and evaluation intensively reviewed the Office of Oil study and concluded that it employed a more appropriate methodology than that used in the joint OMB/DOE studies. He argued in a memorandum that future joint studies with OMB be based on modifications and extensions of the Teisberg model rather than on macroeconomic simulations.

Introduction of the new modeling technique added a fresh element to the struggle over the size of the SPR. On the one hand, the new technique was widely recognized as a more appropriate approach to the problem of public stockpiling than previously used methods. At the same time, however, introduction of the Teisberg model created opportunities for OMB to demand analysis as a delaying tactic.

In the spring of 1980, representatives from OMB and CEA objected to the use of the Teisberg model on a variety of grounds. Though some of the criticisms struck DOE analysts as gratuitous, and most of the others could easily be handled by revisions of the model, the most serious and fundamental objection concerned the probabilities assumed in the model. OMB complained that the assumed matrix of probabilities of going from each market condition to each of the others was "...so complex and theoretical as to have no meaning to policy-makers." The DOE analysts admitted that the Teisberg model appeared complex, but argued that it was conceptually straightforward. They argued further that it provided a method to deal with uncertainty that was much more systematic than the scenario approach.

A compromise of sorts that permitted use of the Teisberg model was reached at a July meeting of the DOE assistant secretary for policy and evaluation, the OMB assistant director for natural resources, energy, and science, a council member of CEA, and their respective staffs. The assistant secretary for policy and evaluation made it clear that DOE would include an analysis based on the Teisberg model in its FY 1982 budget request. He indicated that his staff would modify and run the model as requested by OMB but would not attempt to find mutually acceptable assumptions. He also committed $100,000 in contractor support (the former undersecretary had promised up to $1 million for the study) and four person-months of staff time to assist OMB and CEA in the proposed macroeconomic simulation study.

The DOE analysts provided energy projections and other advice as requested by OMB, but they refused to be drawn into battles about assumptions. Within a short time, it became apparent

that the assumptions made by CEA and passively agreed to by OMB were going to yield results even more supportive of SPR expansion than the 1979 joint study. OMB and CEA never completed the proposed macroeconomic simulation study.

In the meantime, DOE had modified the Teisberg model to focus explicitly on the Phase III question. The results were presented in October at an OMB hearing on the SPR budget. Perhaps because the macroeconomic analysis had not turned out as they had expected, OMB finally expressed an interest in analyses from the Teisberg model. The analyses were completed with the understanding that DOE did not necessarily endorse the assumptions that OMB had requested.

To summarize the debate through 1980, the presidential decision in 1977 to expand the SPR to 1 billion barrels was not based primarily on economic analysis. In 1978, OMB forced DOE to evaluate the economic benefits of the expanded reserve with a somewhat more sophisticated methodology. Although the resulting analysis supported the expansion, OMB cut planning funds for Phase IV and secured agreement from DOE to reconsider the size issue in the next budget cycle. During 1979 OMB analysts attempted to force DOE to agree to combinations of assumptions in the previously used macroeconomic simulations that would lead to results not supporting expansion of the SPR. Even though fairly conservative assumptions were employed, the results favored expansion. Nevertheless, OMB delayed funding of Phase III from FY 1980 to FY 1982. In 1980, OMB analysts again attempted to draw DOE into a battle over assumptions in the macroeconomic approach. Failing, they reluctantly expressed interest in the stochastic dynamic programming model that DOE intended to use in support of its FY 1982 budget request.

Apparent Resolution

By mid-November 1980, it had become clear that OMB would not oppose funding in the Carter Administration's FY 1982 budget request for implementation of Phase III. Did analysis finally carry the day? Perhaps. In light of the extended fight over Phase III, however, a more plausible explanation is that analysis was a secondary factor. Most likely, the OMB staff anticipated that the assistant secretary for policy and evaluation, who enjoyed the confidence of the secretary, would recommend that the issue be taken to the president if Phase III funding was not included in the FY 1982 budget proposal. Unlike the previous two years, it appeared that the DOE leaders were confident of their analysis and willing to take OMB to the mat. At the time, the SPR program had begun to reestablish its managerial credibility, undercutting implied arguments that it could not handle implementation of Phase III. Finally, with hindsight, one cannot help but wonder if the presidential election were not a factor. As it turned out, President-elect Ronald Reagan appointed David Stockman, a strong congressional supporter of the SPR, as director of OMB. It may be that the career staff at OMB anticipated this possibility and did not wish to be seen by the new administration as being responsible for further delay of the SPR program. In fact, during the early months of the Reagan Administration, the same OMB staffers who had led the fight against expansion of the SPR throughout the Carter Administration directed a joint study with DOE of options for accelerating Phase III. Thus, it appears that changing political factors, as much as analysis, resolved the debate over the appropriate size of the SPR.
But analysis played an important role in several ways. First, if any of the cost-benefit studies conducted during the period of controversy had failed to find that expansion of the SPR was justified on economic grounds, then OMB would almost certainly have been able to stop Phase III. Second, without the Teisberg model, the Office of Oil staff probably would not have been able to convince the new assistant secretary to support SPR expansion. Absent his willingness to take the question of Phase III funding to the president, something usually done only for the most important issues, OMB might have continued to stall. Finally, the introduction of the Teisberg model drew attention to acquisition and drawdown strategies. One result was the consideration of acceleration options. Another was the later development within the Reagan Administration of a policy calling for early use of the SPR to counter oil price shocks.

Postscript
The SPR currently has capacity for holding 700 million barrels; it actually held 610 million barrels of crude oil in mid-2003. It is currently being filled with oil taken as in-kind royalties from oil leases on the outer continental shelf. The SPR can drawdown approximately 4.1 million barrels per day of crude oil for three months, with a declining rate in subsequent months. In coordination with the German Erdölbevorrantungsverband and the Japan National Oil Corporation, approximately 8.7 million barrels per day could be drawn down from government controlled strategic reserves at the outset of a supply disruption. In early 1991, an SPR drawdown of 17 million barrels was initiated to moderate prices during the first Gulf War.

Conclusion
Our story of the controversy over the size of the SPR should be both encouraging and sobering for aspiring analysts. It should be encouraging because it shows that participants in policy debates do consider the results of formal analyses to be important—at least sometimes—and because it demonstrates that new analytical insights can make a difference. It should be sobering because it shows analysis to be a political resource that can be abused.

The opportunity for abuse is especially great in situations where no consensus exists about the reasonableness of analytical assumptions. Political decision makers rarely have the time, inclination, or expertise to resolve analytical disputes. So when analysts disagree about assumptions and methods, analysis is unlikely to play a decisive, or perhaps even an informative, role. From a practical perspective, analysts should be prepared for attacks on their assumptions and methods by advocates of opposing policies. They should anticipate such attacks in choosing models, gathering supporting evidence, and eliciting support from neutral experts. From an

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23 Indeed, many complex simulation models have hidden assumptions that even experienced analysts have difficulty discovering. The situation is further clouded because there is relatively little effort expended in validating models—even those regularly used by government offices and consultants. See Constance F. Citro and Eric A. Hanushek, eds., Improving Information for Social Policy Decisions: The Uses of Microsimulation Modeling, Vol. I (Washington, DC: National Academy Press, 1991).
ethical perspective, analysts should remember their responsibility to the value of analytical integrity in deciding whether to attack the analysis of others.

For Discussion

1. Analysts almost unanimously agree that strategic petroleum reserves should be used early during an oil supply disruption. The president, however, may hesitate initiating a drawdown out of concern that the disruption will outlast the reserves. Can you think of any institutional designs that might be employed to increase the changes of the use of the reserves at the outset of a supply disruption?

2. Imagine that you were an energy security analysts in the early 1970s. How might you expand the cost-benefit analysis of the strategic petroleum reserve into a multigoal analysis?
Table 17.1
Impacts of a Public Oil-Stockpiling Program

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expenditure Effects</strong></td>
<td>Outlays: oil purchases storage facilities</td>
<td>Measured in benefit-cost analyses</td>
</tr>
<tr>
<td></td>
<td>Revenues: oil sales</td>
<td></td>
</tr>
<tr>
<td><strong>Direct Market Effects</strong></td>
<td>Costs: price effects of purchases</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Benefits: price effects of drawdowns</td>
<td></td>
</tr>
<tr>
<td><strong>Political Effects</strong></td>
<td>Deterrence against purposeful disruptions</td>
<td>Not monetized</td>
</tr>
<tr>
<td></td>
<td>“Beathing space”: foreign policy domestic policy</td>
<td></td>
</tr>
<tr>
<td><strong>Collateral Effects</strong></td>
<td>Stockpiling displacement: private sector other countries</td>
<td>Adjustments to effective size of public stockpile</td>
</tr>
</tbody>
</table>
Figure 17.1
Measuring the Direct Economic Benefits of an SPR Drawdown

World Oil Market

- $S_{WN}$ — Normal supply
- $S_{WD}$ — Distrupted supply
- $\Delta$ — SPR drawdown

U.S. Oil Market

- Social surplus loss due to disruption: abde
- Social surplus loss with drawdown $\Delta$: aghe
- Benefit of drawdown (avoided loss): bdhg
A Simple Decision Tree for Stockpiling Problem

- **Cost of stockpile**: 10
- **Economic costs**
  - Disruption (p): 60
  - No disruption (1-p): -8

**EV(stockpiling)** = -10 + 8(1-p) - 60p = -2 -68p
**EV(no stockpiling)** = 0(1-p) -100p = -100p

Stockpile if p > 1/16

- **Disruption (p)**: 100
- **No disruption (1-p)**: 0
A Sample Node in the Expanded Decision Tree for the Stockpiling Problem

Figure 17.3

Period t-1

Entering state: normal market; 50 mmb in storage

+50 mmb
+40 mmb
+30 mmb
+20 mmb
+10 mmb
hold
-10 mmb
-20 mmb
-30 mmb
-40 mmb
-50 mmb

Period t

Slack market
Normal market
Minor disruption
Moderate disruption
Major disruption

Period t+1

Entering state: moderate disruption; 70 mmb in storage