



Evaluating the management of U.S. Strategic Petroleum Reserve during oil disruptions[☆]



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ABSTRACT

Numerous countries have set up strategic petroleum reserves (SPRs) in response to oil disruptions since 1970. While numerous studies model such programs, we found few that evaluate SPRs' historical performance. Thus, we evaluate the U.S. SPR's performance by comparing actual real costs with estimated real benefits. From 1976 to 2014, the real U.S. SPR cost was about \$219 billion real (2014\$) dollars, whereas the real benefit was only \$122 billion. Sensitivity testing suggests such negative net benefits are qualitatively robust. However, if world oil demand is extremely inelastic to oil price or GDP is elastic enough to oil price shocks, the estimated U.S. SPR net benefit is positive. Sensitivity testing around total real costs and benefits range from \$380 billion to \$80 billion. Limited testing of IEA coordinated drawdowns suggests that total U.S. benefits jump from \$122 billion to more than \$400 billion putting the SPR strongly in the black. Limited testing of private sector inventory changes was more disappointing and tentatively suggests private activities may at times have offset some of the government drawdowns. With 20-20 hindsight, initial experimentation found that better management could have significantly enhanced the value of the U.S. SPR, especially for the 1990-91 disruption.

1. Introduction

Nordhaus (1974) takes an early step to model strategic government reserves, taking the net consumer welfare loss to be the main economic damage of a supply disruption. As in the majority of subsequent studies, we will also include this loss. Further, economists have provided strong evidence that oil supply disruptions leading to oil price shocks reduce economic activity. This externality has been one of the strongest justifications for strategic stockpiles. In an early study, Tolley and Wilman (1977) considered such a cost in their modeling while other empirical studies that include such a cost on the negative correlation between oil price shocks and aggregate output or employment include: Rasche and Tatom (1977, 1981), Mork and Hall (1980), Hamilton (1983, 2003, 2009), Mork (1989), Balke et al. (2002) and Kilian (2008, 2009), Bohi (1989), Bohi and Toman (1996), and Mork (1994). Leiby (2007) sums up their insights on the mechanisms by which oil shocks could affect economic performance, i.e. external inflationary shocks, income transfer and potential output. Brown and Yucel (1999), Brown and Yucel (2002) and others have concluded that these GDP changes from price shocks are asymmetric and we will follow their lead. If the price shock is a sharp increase, there will be a negative effect on GDP,

whereas if there is a sharp decrease, there will be no increase in GDP.

Another fairly common externality in oil markets is termed the monopsony premium as suggested by Landsberg et al. (1979). Although individual companies may not be able to exercise monopsony power against the large oil exporters, governments of large importing countries could. The argument typically is that since large exporting countries are exercising monopoly power, countervailing policies, such as a tariff, could exploit buyer monopsony power to garnish some of these monopoly rents. We agree with Brown and Huntington (2015) and Brown (forthcoming 2018) that such a policy would further distort markets. To the extent that markets may be getting more competitive with non-disrupted supply more elastic, a monopsony premium may also have shrunk. Thus, we do not include a monopsony premium in our measure of externalities.

A non-quantifiable effect that we do not consider, but that would add to the benefits of the SPR, is its deterrence effect (Balas, 1981). If the SPR significantly blunts the damages from a disruption, it should lower the chances that a disruption would be used as a political weapon. Additionally, if a disruption limits actions related to other political objectives, the SPR would have an added value related to reducing this cost. Military costs relating to protecting oil supplies are

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sometimes cited as additional costs, but it is typically argued it is too hard to disentangle oil import insecurity costs from other military objectives (Leiby, 2007; Brown and Huntington, 2013, 2015). We, too, yield to this argument. One last omission we know of is the value of reducing market risk to risk-averse agents. We have found one paper that quantifies this value. Toman and Macauley (1986) assume a functional form for utility and use the Arrow and Pratt measure of risk aversion to provide a quantitative measure for this SPR benefit. They find this risk reduction benefit to be small and indicate it should get even smaller with the development of oil futures markets. Further, they highlight the difficulty and uncertainty in its measurement. For these reasons, we do not attempt any quantification of the risk reduction the SPR has provided.

As an international public good, the SPR can benefit other oil consumers by damping world oil prices during supply interruptions. The benefit for each country is in fact a joint effect of all market players. Hogan (1983) very nicely summarizes literature emphasizing these joint effects and the potential for free riding in both static and dynamic frameworks most often using game theory. He notes a range of outcomes depending on model assumptions and extends the analysis to include uncertainty. He finds that net gains to the U.S. to free ride are slightly positive, while the gains of joint optimization as opposed to a degeneration into no government stockpiling are ten times larger at \$171 billion in 2014 dollars. A little more recently, Murphy et al. (1985, 1987) use a Nash Cournot model and given inventory limits to find there are few benefits to cooperation over noncooperation. Their study points out that synchronized drawdown activity in response to disruptions is important for stockpilers best interests even if total drawdown is less than the collective optimum. We do not directly model cooperative government behavior as in these important early papers, but do our best to estimate the beneficial effects of the rest of the OECD's drawdown on the U.S.

Another issue considered is the role of private sector inventories, which can also be drawn down during disruptions. However, with negative externalities from an oil disruption, private inventory changes alone may not provide an optimal solution (Bohi and Toman, 1996). Further, private inventory behavior may even destabilize the market given different economic objectives, expectations, and asynchronous response in disruptions. With a two-player game model, Murphy et al. (1986, 1989) address public and private inventory interactions. They find that the private sector tends to release inventory rather than speculate and that private inventory change has a limited effect on optimal public policy. Again we do not explicitly model optimal behavior but rather do our best to measure the effects of private OECD stock behavior on the U.S.

Although potential economic damages from oil supply interruptions or sudden major oil price shocks can be limited through Strategic Petroleum Reserves drawdown, to establish and maintain such a huge inventory also costs taxpayers' considerable capital investment. Such costs include not only the carrying cost of the crude oil but also the cost and maintenance of the SPR facilities themselves. There have been arguments on the economic effectiveness of the SPR given the huge investments required. However, the proponents and opponents have not yet provided solid evidence or come to an incontrovertible conclusion.

Most of the proponents believe that the SPR benefits importers and consumers politically or economically. It has been taken as an effective tool to minimize consumer welfare loss. Hogan (1983) pointed out that oil stockpiling is the most visible and substantial measure of government activity in energy security policy. His early assessment is held by many. Of the many government programs and policies specifically enacted to deal with the energy crisis back in the 1970s, it is one of the few emergency measures that remains even to this day. Long gone are the government oil allocation schemes, the oil windfall profit tax, restrictions on under the boiler use of natural gas, oil price controls, and government ownership of a large synfuel project.

However, opponents doubt that the SPR has been executed

effectively and is worth its large expense. Taylor and Van Doren (2005) found that the SPR had cost taxpayers at least \$50.3 – \$62.04 billion (in 2014 dollars), or \$78.94 – \$97.19 per barrel of oil deposited in the SPR at that time. They argued its only releases in history were all too modest to produce significant benefits. In support, Considine (2006) estimated the effect of SPR stock sale on market price using a monthly econometric model, and found that sales from the SPR had minor impacts on market price and could be easily trumped by actions of other players in the game.

The United States, as one of the major IEA members, initiated its SPR program in the 1975 Energy Policy and Conservation Act. In 2009, the U.S. SPR was finally filled to its 727 million barrel design capacity. Its formidable size may make the SPR a significant deterrent to oil supply disruptions and a key tool of U.S. foreign policy. However, more recently the United States plans to sell 58 million barrels of crude oil from its SPR between 2018 and 2025. The proposed sale, which represents more than 8% of the now 690 million barrels in the U.S. SPR, is due to start in 2018 at an annual rate of 5 million barrels and rising to 10 million by 2023 (U.S. DOE, 2017).

This policy has again raised many public concerns, i.e. is the U.S. SPR worth its investment? Although many studies have made a case for such SPRs and tried to model such aspects as the optimal size of the SPR as well as the optimal fill and drawdown timing given various disruption patterns (Teisberg, 1981; Bai et al., 2014, 2016), we know of no attempt to evaluate whether such SPRs were a good investment and whether the government had abilities superior to those of private companies to manage a disruption. Our contribution in this paper is to provide the first step in such an evaluation by measuring an estimate of net benefits of the U. S. SPR over its history.

Our paper is organized as follows. In Section 2, we present the methodology to estimate the U.S. SPR's cost. In Section 3, we introduce the methodology to estimate the SPR benefit followed in Section 4 by the data used. Section 5 shows the results of the empirical study on the SPR benefit along with sensitivity testing. Section 6 concludes and offers some policy implications and suggestions for future work.

2. The U.S. SPR cost

With a capacity of over 700 million barrels, the United States now holds the world's largest stockpile of government-owned emergency crude oil known as the Strategic Petroleum Reserve. According to the U.S. Department of Energy, the government has paid about \$25.7 billion to maintain such a stock including \$5 billion for facilities and \$20.7 billion for crude oil (U.S. Office of Fossil Energy, 2017b). However, the numbers consider neither inflation over time, nor the opportunity cost of this huge investment. In this section, we measure the real SPR cost by adjusting the investment flow by the consumer price index (CPI) and include the opportunity cost or interest cost on the capital. As additional demand in the world market, the SPR acquisition may also drive up the world oil prices a bit, therefore causing some consumer welfare loss during normal periods (Huntington and Eschbach, 1987; U.S. DOE, 2015). We include this minor adjustment to cost as well.

The bulk of the cost data used to evaluate the SPR comes from the SPR report of the U.S. DOE (2016b), the U.S. Energy Information Agency online databases, and the International Energy Agency online databases. The U.S. DOE provides a budget account of appropriations for its SPR policy, which we divide into the following three SPR accounts with nominal total dollars spent as of 2014 shown in parenthesis:

- Oil account with the fiscal expenditure on crude oil (\$16.1 billion):
- Facilities account with the cost of development, operation, maintenance, and expansion (\$7.48 billion);
- Management account with the salaries and expenses necessary to plan and manage the program (\$0.64 billion).

In addition, we consider one final cost:

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