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# Optimal strategic oil stockpiling and import tariffs: The case of China

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ABSTRACT

As two of the most important instruments for dealing with the issues of energy supply security, strategic petroleum reserves (SPRs) and oil import tariffs have been proven effective in developed countries. While China is currently building up its strategic oil reserves to ensure energy security, it is of great importance to investigate China's optimal oil stockpiling policies while taking into account the possibility of imposing an import tariff or quota, which can also be used for alleviating the energy insecurity of an oil-importing country. Employing a dynamic programming framework, this paper examines the optimal SPR policies and oil import tariffs or quotas for China and the interactions between the two instruments under different scenarios for the world oil market. The results show that the combination of optimal tariffs and SPR policies can substantially reduce the expected oil insecurity cost for China; the effect is larger when the probability that a disruption will continue is higher.


## 1. Introduction

The security of energy supply plays an important role in the industrialization and urbanization of developing countries. As one of the world's largest developing countries, China's energy consumption, especially oil consumption, has skyrocketed in the past two decades. In 2011, China's oil consumption reached 461.8 million tons, which is more than four times its oil consumption in 1990 (BP, 2012). With its rapidly increasing consumption of oil, China's dependency on foreign oil has also increased dramatically. In 1993, China became a net oil importer, with 6% dependency on foreign oil. As of 2012, this figure has increased to 58.7%. The growing dependency on foreign oil triggered a lot of concerns about China's oil supply security. Moreover, the majority of China's oil imports are from the Middle East, where the economies and politics are unstable, and this adds more risk to China's oil supply. If oil supply is ever interrupted, China's economic activities and social stability will be affected substantially. Therefore, it is of great importance to take effective measures to reduce China's vulnerability to oil supply disruptions and to ensure China's oil security.

Essentially, the oil insecurity problem emerges because of the potential imbalance between oil demand and supply, which implies that there are two main ways to deal with the oil insecurity problem. One way is to take measures on the supply side, such as building up strategic petroleum reserves (SPRs) to increase the oil supply when the world oil market is disrupted. The other way is to restrict oil demand, usually by an import tariff or quota policy, so as to mitigate the economic losses for an oil importing country during a supply disruption. In contrast to SPR policies, which reduce insecurity by holding inventories to smooth out the transition between different market situations, a tariff-quota arrangement lessens the insecurity of an oil-consuming country by preventing overdependence on foreign sources (Nordhaus, 1974).

After suffering severe damage from the oil crisis during the 1970s, most of the OECD countries have established SPRs to ensure their energy security. The United States is one of these developed countries and has detailed public information on its SPR size and stockpiling policies. The US started its SPR in 1977 and reached 590 million barrels in size in 1990, just before the outbreak of the Gulf War. After some further stockpile acquisitions during the early 2000s, the current size of the US SPR is maintained at around 700 million barrels (EIA, 2012a), as shown in Fig. 1.

The debate on the necessity for China to establish a SPR started right after China became a net oil importer in 1990s. The establishment of a SPR was approved by the Chinese government at the beginning of this century. The National People's Congress of China named the development of a SPR a primary goal in 2001. Phase I of China's SPR with four

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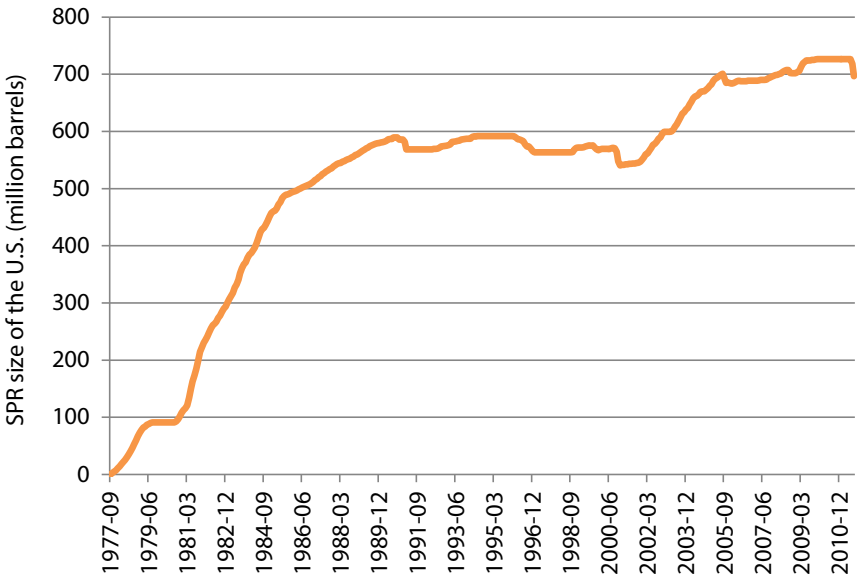


**Fig. 1.** Evolution over time of the US SPR.
Source: EIA (2013a).

reserve bases began in March 2004 and was completed by the end of 2008, providing a storage capacity of 103 million barrels. Phase II of China's SPR should be completed before the end of 2012, with a total capacity of 168 million barrels (Zhang, 2011).

The establishment of a SPR involves large costs in terms of facility construction, oil acquisitions and stockpile maintenance. Therefore, the trade-off between the benefit of a SPR and the cost of establishing it should be taken into account in the optimal SPR policy design, which includes the optimal SPR size, the best stockpile buildup/drawdown strategies, and so on. Even though SPR policy has been proven effective in dealing with oil supply disruption, it is not the only way to ensure energy security for oil consuming countries. As mentioned above, import tariff or quota policies can also be used for reducing an economy's vulnerability to oil shocks. However, as with the strategic oil stockpiling policy, a tariff/quota policy has costs. Because an import tariff or quota policy will raise the domestic oil price, it can reduce consumer surplus or social welfare. This implies that an optimal level of import tariff or quota should balance the trade-off between the benefit of reducing potential economic losses during a supply disruption and the cost of decreasing social welfare due to the higher domestic oil price.

Energy security and SPR policies have been widely analyzed since the oil crisis in the 1970s. The studies on SPR policies focus mainly on optimal SPR size and the best acquisition or drawdown strategies. Balas (1981) studied the optimal SPR sizes for oil consuming nations through a short-term interaction between oil importing nations and a politically motivated cartel that takes advantage of disruptions to inflict economic losses on importing nations. In that study Balas investigated the 'deterrence effect' of a SPR, which implies that the existing SPRs not only reduce economic losses during an oil supply disruption but also lessen the likelihood of a disruption. Chao and Manne (1983) established a multi-period dynamic programming model for obtaining optimal stockpiling and petroleum usage rates based on their analysis of the oil supply policies of the United States. Samouilidis and Berahas (1982) presented a decision tree model to evaluate different scenarios for SPR based on a cost function that includes procurement, maintenance, and shortage costs. Samouilidis and Magirou (1985) analyzed the optimal selection of the SPR size for a small country based on the work of Samouilidis and Berahas (1982). Oren and Wan (1986) presented a non-linear programming model for conducting a steady-state analysis on the optimal size, fill-up, and drawdown rates for SPR under a variety of different supply and demand conditions. Zweifel and Bonomo (1995) established a model that considers multiple risks to energy supplies to illustrate that the one-dimensional rules such as "an oil reserve for 90 days" turn out not only to be suboptimal but also suggest adjustments that make them even more suboptimal.

Because of the importance of import tariff/quota policies in designing energy security policies, some studies on SPR policies included consideration of import tariffs or quotas. Teisberg (1981) developed a dynamic programming model for the SPR of the U.S., which could be used to determine the optimal SPR size, acquisition and drawdown strategies for the U.S. in various scenarios, including the cases with and without import tariffs. Hogan (1983) extended Teisberg's model of U.S. stockpiling to a Stackelberg model to examine the interactions between two consuming countries, where one follows the other's lead. Murphy et al. (1987) presented a Nash dynamic game model of interactions between oil inventory and tariff policies for oil importing countries to analyze their SPR policies. Murphy et al. (1989) presented a dynamic game model for investigating public-sector and private-sector oil inventory policies in unstable world oil markets, taking into account the possible tariff policies employed by the government to limit oil imports.

Based on the experience of developed countries, China may also need to take into account import tariff/quota policies in its SPR policy design. It would be of great significance to get insight into the potential interactions between these different policies and their implications for China's energy security. Quantitative studies concerning China's SPR have increased rapidly in recent years due to greater concerns about China's oil supply security. Wei et al. (2008) conducted an empirical analysis of the optimal SPR size for China based on a decision tree model. Wu et al. (2008) presented an uncertain programming model for analyzing acquisition strategies for China's SPR. Zhang et al. (2009) analyzed the optimal size of China's SPR and the best acquisition and drawdown strategies for several scenarios based on a stochastic dynamic programming model. Fan and Zhang (2010) established a dynamic Nash game to model the possible mutual influences between the SPR polices of China and India in various cases. Bai et al. (2012a) examined the optimal path for China's SPR in several scenarios based on a dynamic programming analysis. Wu et al. (2012) also employed a dynamic