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Phasing out the U.S. Federal Helium Reserve: Policy insights from a world helium model☆

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ABSTRACT

This paper develops a detailed partial equilibrium model of the global helium market to study the effects of the recently decided rapid phase out of the U.S. Federal Helium Reserve (FHR), a vast strategic stockpile accumulated during the 1960s. The model incorporates a detailed representation of that industry and treats both helium producers and the FHR as players in a dynamic non-cooperative game. The goal of each player is assumed to be the maximization of discounted profit, subject to technical and resource constraints. We consider two alternative policies aimed at organizing the phase out of the FHR: the currently implemented one and a less stringent one whereby the FHR would be allowed to operate as a profit-maximizing agent during an extended period of time. Evidences gained from a series of market simulations indicate that, compared to the current policy, a less stringent policy mandate systematically increases the financial return to the U.S. federal budget, always enhances environmental outcomes as it lowers helium venting into the atmosphere, and also augments global welfare in three out of the four scenarios considered in the paper.

1. Introduction

The worldwide consumption of helium, a noble gas that combines a number of remarkable properties,[1] is growing rapidly. This natural element is used in a number of advanced technologies (e.g., leak detection, chromatography, welding under inert

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[1] Helium has the lowest boiling point of any substance, is the second-best gaseous conductor of heat and electricity, and is the second lightest element.

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conditions) and is a nearly non-substitutable input in a disparate set of activities including fiber-optic technology, electronic manufacturing (e.g., semiconductors, flat panels), rocket launching (to purge the fuel tanks), and cryogenics. Helium is also critically needed to cool magnetic resonance imaging (MRI) scanners, a now essential diagnostic tool for the medical community. During the years 2007–2013, that historically stable market experienced a series of noticeable supply shortages and unusually high prices.[2] Given the critical importance of that commodity for our modern societies, helium suddenly emerged as a source of political concern (NRC, 2010; Nuttall et al., 2012a; Glowacki et al., 2013) and the future availability of helium resources subsequently became the topic of a burgeoning literature authored by science and technology experts.[3] The present paper provides a complementary perspective as it details an economic analysis of the world helium market and examines the rationale of a U.S. government policy: the 2013 Helium Stewardship Act (HSA).

Helium is an exhaustible finite resource. Though helium is naturally present in the atmosphere, its concentration is so low that the cost of separating it from the air is prohibitive. Commercial helium is thus obtained as an optional by-product of a second exhaustible resource: natural gas. Helium can be separated from the gas streams extracted from a limited number of helium-rich natural gas deposits. If not separated, the helium in fuel gas is typically wasted as it dissipates in the atmosphere when the gas is burned without significantly increasing the atmospheric concentration of helium.

To conserve helium resources, a vast strategic stockpile – the Federal Helium Reserve (FHR) – was accumulated by the U.S. government as part of the country's cold war efforts during the 1960s. It was then expected that the revenues obtained from the sales of the stored helium during the 1970s would permit a recovery of the cost of the FHR by 1980 (Epple and Lave, 1982). However, that plan failed and the U.S. government had to wait until 1996 before being able to start reselling its reserve (NRC, 2000). In 2013, the U.S. Treasury debt accumulated through the helium program was finally paid back, yet nearly a third of the original stockpile still remained. As a result, that long-awaited debt repayment convinced the U.S. Congress to pass the 2013 HSA instructing the federal government to: (i) rapidly deplete the remaining inventory – the Act imposes the sale of a flow of helium, equal to the amount the FHR can produce, each year – and (ii) subsequently cease its commercial operations. Accordingly, the federal government's commercial operations are expected to cease in 2022.

The purpose of this paper is to examine the economics of this rapid phase out of the FHR. Deciding how much helium to extract from the remainder of the Federal Reserve requires answering more general questions about the allocation of helium resources over time, the potential future demand by helium-dependent technologies, the potential new sources that may become available in the future, and the nature of the strategic interactions among helium producers. To the best of our knowledge, such a methodologically sound analysis was not conducted to guide the provisions in the 2013 Act. The two main informal arguments that motivated the 2013 Act can be summarized as follows. First, because of the progressive depletion of the underground reservoir, the annual production capacity of the FHR is expected to gradually fall in the coming years, thereby providing an opportunity for a smooth phase out of the FHR. Second, new sources of helium, both foreign and domestic, will shortly become available, thereby limiting the need for FHR supplies in the near future. Nevertheless, it is not certain that the proposed extraction trajectory maximizes the present discounted value of the profits from federal sales nor that this is a socially desirable policy. As the federal sales represented approximately 30 percent of the global helium supplies in 2013 (USGS, 2015), one may wonder whether the rapid resource extraction pattern stipulated in the 2013 Act could artificially generate low prices, thereby blurring the functioning of the helium market and distorting the firms' decisions.

To investigate the extraction trajectory that should be considered by the U.S. federal government, we propose a computerized dynamic model of the international wholesale helium market aimed at evaluating helium production and investment strategies. This deterministic, discrete-time, finite-horizon oligopoly model is formulated as an open-loop, Nash non-cooperative dynamic game that is solved numerically. Using this model, a series of simulations under markedly different scenarios are conducted to determine the optimal resource extraction patterns for the FHR and quantify their economic impact on both the world helium market and the U.S. federal treasury. Overall, we believe that this multi-period model is a valuable tool for public decision makers, professionals, and scholars interested in the politically sensitive issues observed in the helium sector.

Our analysis highlights that the rapid resource extraction path falls short of the policy objective to maximize the "returns to the American taxpayers". Implementing a slower extraction pattern has the potential to bring about sizeable gains to the U.S. Treasury. Depending on the scenario, we found that the present discounted value of its future stream of net revenues would rise by between +25.5 percent and +61.0 percent. Another important finding is that such an augmentation is not necessarily obtained at the expense of the consumer surplus and is welfare-enhancing in three out of the four scenarios examined in this paper. Lastly, we observe that the rapid phase out of the FHR occasions a net waste of helium which is estimated to be on the order of 122.8–533.2 MMcf.

From a methodological perspective, the rich literature on dynamic-games (e.g., Dasgupta and Heal, 1979; Dockner et al., 2000; Long, 2011) typically focuses on parsimonious continuous-time models that are analytically tractable. In the present paper, we examine the market equilibrium of a detailed model for which an analytical solution is virtually out of reach but,

[2] "The price of helium, Inflated," The Economist, May 3, 2007.

[3] For example, Cai et al. (2010) report a joint research effort by scientists and industrial experts at Cambridge (UK) that culminated in the development of a detailed system dynamics model of the world helium industry. Another example is the analysis in Mohr and Ward (2014) which has its methodological roots in the geoscience literature.