



# How Does ANWR Exploration Affect OPEC Behavior? —A Simulation Study of an Open-loop Cournot-Nash Game

Zili Yang\*

*Department of Economics, The State University of New York at Binghamton, P.O. Box 6000,  
Binghamton, NY 13902-6000, United States*

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## Abstract

Exploring petroleum reserves in the Alaskan Arctic National Wildlife Refuge (ANWR) has been proposed to reduce the dependence on foreign oil and to ease the energy shortage in the United States. To investigate the impacts of the ANWR exploration on strategic behavior of OPEC members, a calibrated dynamic model of oligopolistic competition and cartel collusion in the U.S. petroleum market is built in this paper. Numerical simulations on an open-loop game are used here to examine the scope and magnitude of strategic interactions between OPEC's decisions and ANWR exploration. The simulation results show that OPEC's strategic postures have much stronger effects on the U.S. petroleum market than the ANWR exploration. The simulations in this paper indicate that preventing cartel collusion by OPEC is more effective than the ANWR exploration in alleviating short petroleum supplies of the United States in the near future.

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## 1. Introduction

Petroleum supplies to the United States have experienced numerous shocks in the past three decades. After the 1989 Gulf War, the real price of petroleum has been stable for ten years. However, world oil price suddenly surged from about \$10 per barrel in March to more than \$20

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\* Tel.: +1 617 777 4726; fax: +1 617 777 2681.

E-mail address: [zlyang@binghamton.edu](mailto:zlyang@binghamton.edu).

per barrel in December during 1999. In early 2003, oil prices climb to over \$30 per barrel range. The Iraqi War and rapid growth of Chinese economy sent world oil price over \$60 per barrel in 2005. Negative impacts of high oil prices have permeated into the U.S. economy. Temporary interruption of oil production in the gulf caused by hurricane Katrina shows that the U.S. economy and consumer confidences are vulnerable to oil supply shocks.

After Bush came to the office in 2001, proposals of exploring new domestic oil reserves in environmentally sensitive areas, such as the Alaskan Arctic National Wildlife Refuge (known as ANWR) and offshore reserves in California and Mexican Bay, receive revived attentions. Opening the ANWR for exploration is one of the key components in the Bush administration's new energy plan. Some people argue that such exploration activities can reduce the dependency of the U.S. economy on the OPEC oil imports, others say not. Under strong pressure from high oil prices, the Congress passed the Energy Bill in 2005 that opens ANWR for oil production. Such measures represent long-standing viewpoints of the Bush administration. Not surprisingly, the energy policies of the Bush administration are controversial. Whether the ANWR oil productions, at the expenses of potential environmental damages, can effectively reduce the demand for oil imports and stabilize the oil price, is the crucial question to be answered.

The United States has relied heavily on foreign oil in the past. The OPEC countries are major suppliers to the U.S. market. In 2004, the U.S. produced 5.419 million barrels per day (MMBD) of crude oil, and consumed 20.731MMBD of oil products. 57.8% of total consumption was imported. The share of OPEC members were 47.4% in the total imports (EIA, 2005). Because of its importance to the U.S. and world economy, strategic behavior of OPEC, especially its cartel (or lack of) structure, has been studied extensively (for example, see Adelman, 1993, 1995; Griffin, 1985; Alhajji and Huettner, 2000; Gulen, 1996). Independent studies suggest that the OPEC has been a successful cartel in the recent past.

Modeling the U.S. energy system is a complicated task. To assess and forecast energy supply and demand, U.S. Department of Energy has maintained a large-scale general equilibrium model, called "National Energy Modeling System" (NEMS), for many years (EIA, 2001). Many smaller energy modeling endeavors have been undertaken in academia to address a variety of energy issues. Representative works include a series of researches presented at the Energy Modeling Forum, sponsored by Stanford University (EMF, 1982, 1992), among others.

ANWR exploration poses an interesting, yet challenging problem for energy modeling. It will take several years before potential ANWR oil field forms a sizeable production capacity. Can these new domestic supplies available a decade later affect the OPEC's behavior in the near future? The answer to this question seems not simple or clear-cut. Conventional general equilibrium and econometric modeling approaches are inadequate for dealing with strategic behavior of energy suppliers. Characterizing interactions between the OPEC behavior and the ANWR exploration in an open-loop dynamic game, is an appropriate method for modeling this type of intertemporal strategic interactions. The dynamic Cournot-Nash game has been used to characterize exhaustible resource industries and to address strategic aspects of the OPEC behavior vs. the U.S. economy, such as in Salant (1976), Karp and Newbery (1991), Ulph and Folie (1980), Griffin and Neilson (1994). Oligopoly, as a prevailing market structure in exhaustible resource industries, has also been studied extensively and is summarized in major texts (see Dasgupta and Heal, 1979; Hartwick, 1989). These succinct and stylized game-theoretic models are very useful for resolving certain theoretic and/or policy issues of exhaustible resources. However, game-theoretic models need to be calibrated with the data from the real world to answer policy issues directly.

In this paper, we develop an open-loop Cournot-Nash game model of an exhaustible resource industry that supplies the U.S. petroleum market. The OPEC members, other foreign oil producers,

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