

# ***Government Leasing Policy and the Multi-Stage Investment Timing Game in Offshore Petroleum Production***

C.-Y. Cynthia Lin, University of California at Davis, (530) 752-0824, cclin@primal.ucdavis.edu  
Wayne W. Leighty, University of California at Davis, (530) 635-7632, wwleighty@ucdavis.edu

## **Overview**

In order to maximize profits, petroleum-producing firms make decisions that are dynamic and strategic in nature, and that take into account constraints imposed by the regulatory and institutional environment. This paper describes our research modeling, estimating and analyzing the efficiency of the decisions of petroleum-producing firms in the Gulf of Mexico and Alaska, and examining the impact of government policy on these decisions.

Petroleum production is a multi-stage process involving sequential investment decisions. The first stage is exploration: when a firm acquires a previously unexplored tract of land, it must first decide whether and when to invest in the drilling rigs needed to begin exploratory drilling. The second stage is development: after exploration has taken place, a firm must subsequently decide whether and when to invest in the production platforms needed to develop and extract the reserve. Because the profits from petroleum production depend on market conditions such as the oil price that vary stochastically over time, an individual firm producing in isolation that hopes to make dynamically optimal decisions would need to account for the option value to waiting before making either irreversible investment. After investments in drilling rigs and production platforms have been made, the third stage of production is extraction.

The dynamic decision-making problem faced by a petroleum-producing firm is even more complicated when its profits are affected not only by exogenous market conditions, but also by the actions of other firms producing nearby. When firms own leases to neighboring tracts of land that may be located over a common pool of reserve, there are two types of externalities that add a strategic (or non-cooperative) dimension to firms' investment timing decisions and may render these decisions socially inefficient.

The first type of externality is an information externality: if tracts are located over a common pool or share common geological features so that their ex post values are correlated, then firms learn information about their own tracts when other firms drill exploratory wells or install production platforms on neighboring tracts. The information externality is a positive one, since a firm benefits from its neighbors' information.

A second type of externality is an extraction externality: when firms have competing rights to a common-pool resource, strategic considerations may lead them to extract at an inefficiently high rate. The extraction externality is a negative one, since it induces a firm to produce inefficiently.

Owing to both information and extraction externalities, the dynamic decision-making problem faced by a petroleum-producing firm is not merely a single-agent problem, but rather can be viewed as a multi-agent, non-cooperative game in which firms behave strategically and base their exploration and development policies on those of their neighbors.

In this paper, we summarize the previous work of Lin (2007) on whether a firm's investment timing decisions and profits in the Gulf of Mexico depend on the decisions of firms owning neighboring tracts of land. Do the positive information externalities and negative extraction externalities have any net strategic effect that may cause petroleum production to be inefficient? We then describe our ongoing research analyzing the efficiency of petroleum production in Alaska.

## Methods

A structural econometric model of the multi-stage investment timing game in offshore petroleum production is developed and used to analyze strategic behaviour in exploration and development decisions in the Gulf of Mexico.

To analyze petroleum production in Alaska, we develop a dynamic model of the unit operators' production decisions.

## Results

The results from the structural econometric model do not indicate that externalities from exploration have any net strategic effect. A firm's profits from development does not depend significantly on the exploration decisions of its neighbor. In contrast, externalities from development do have a net strategic effect. A firm's real profits from developing increase when its neighbor develops, perhaps because this is a signal to the firm that the neighbor's exploratory efforts were successful, and therefore that there may be deposits present.

Results also show that the importance of strategic interactions depends on tract size. As expected, strategic interactions are more likely to take place on smaller tracts, where the externalities are more acute. When the tract size is large enough, the net strategic effects of the externalities from both exploration and development disappear. Also as predicted by theory, the relative importance of the extraction externality from exploration with respect to the information externality is greater on small tracts than on large tracts; on large tracts, the two externalities cancel each other out.

The results suggest that, by selling predominantly large tracts, the federal government has minimized inefficiencies in petroleum production that may have resulted from non-cooperative strategic interactions.

## Conclusions

In the Gulf of Mexico, inefficiencies may arise when individual petroleum-producing firms make their exploration and development investment timing decisions, as positive information externalities and negative extraction externalities may lead them to interact strategically with firms owning neighboring tracts of land. In Alaska, the efficiency of petroleum production may be influenced by tax and leasing policies and contract structures.

Our research investigating the effects of institutions and government policy on how energy firms make strategic decisions is important for several reasons. First, our work examines and quantifies the sources of existing inefficiencies in energy markets. Second, our examination of how institutions and policy affect the degree of strategic interaction and the extent of the inefficiencies will enable us to design institutions and policy that lead to socially desirable outcomes that incorporate such socially desirable objectives as efficient petroleum production, environmental protection, energy security, and the desire to transition to alternative sources of energy.

## References

Lin, C.-Y.C. (2007). Do firms interact strategically?: A structural model of the multi-stage investment timing game in offshore petroleum production. Working paper. University of California at Davis