Modeling of Optimal Oil Production and Comparing with Actual and Contractual Oil Production: Iran Case

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Introduction

- The Iran Oil Project, initiated in 2007, aims to find the inefficiencies and their possible sources in Iranian oil and gas policies.
- Iran's buy-back service contracts have been recognized as one of the possible sources of these inefficiencies.
- The goal of this study is to make recommendations for improving policies toward more socially desirable ways of developing oil and gas fields in Iran by considering the constraints that International Oil Companies and the National Iranian Oil Company face in Iran.
- Under this broad name 3 subprojects are underway:
  - **Sub Project 1:** Studying the buy-back service contracts in Iran thoroughly
  - **Sub Project 2:** Modeling of optimal oil production and comparing with actual and contractual (buy-back) oil production: Iran Case
  - **Sub Project 3:** Building a structural econometric model of dynamic strategic decision-making in Iran using insights from game theory

Modeling of Optimal Production

- Based on Hotelling's theory of optimal nonrenewable resource extraction, the goal is to study the optimal production of Iran's oil and gas fields which have been developed under buy-back service contracts.
- Soroosh and Nowrooz calibrated models are used to simulate the production trajectory over the life time of the fields.

Figure 1: Soroosh Platform [Image courtesy of www.japex.co.jp]

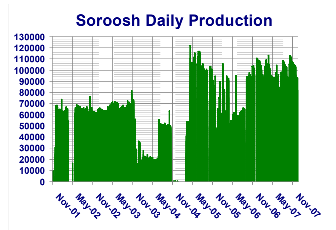

Figure 2: Source: National Iranian Oil Company

Background Information

Oil fields	Soroosh and Nowrooz
Location	Offshore Persian Gulf (Iran)
Type of contract	Buy-Back Service Contract
Contractor	Shell Exploration B.V.
Effective date of contract	November 1999
Final production date (contract)	June 2004
Final production date (actual)	July 2005
Contract objective	Final output of 100,000 and 90,000 barrels per day from Soroosh and Nowrooz respectively
Participating interest	Shell Exploration B.V. 70% JJI S&N B.V. 20% OIEC 10%
Capital Cost	$806 million

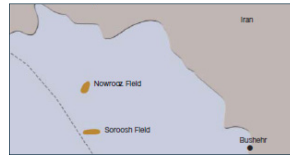

Figure 3: Soroosh and Nowrooz Oil Fields in the Persian Gulf

Methodology

The producer's optimal nonrenewable resource extraction problem is to choose the extraction profile to maximize the present discounted value of the entire stream of per-period net benefits, given initial stock and the relationship between extraction and stock remaining, and subject to the constraints that both extraction and stock are nonnegative (Lin 2008).

$$\max_{\{Q(t)\}} \int_0^\infty (G(S(t),Q(t)))e^{-rt}dt$$

$$s.t.$$

$$\dot{S}(t) = -Q(t); \qquad p(t)$$

$$Q(t) \geq 0, \quad S(t) \geq 0, \quad S(0) = S_0$$

where:

- ***S(t)*** is the state variable and represents the stock of oil remaining in the ground.
- ***Q(t)*** is the extraction flow rate (units of oil per units of time).
- ***S_0*** is the initial stock of reserve.
- ***G(.)*** is the net benefit, and equals to total benefits minus total costs.
- ***p(t)*** is called shadow price of the reserve in the ground which is the co-state variable associated with stock *S(t)*.
- ***r*** is the competitive interest rate.

Assumptions

- Perfect Competition Scenario:

$$G(S,Q) = U(Q) - C(S,Q)$$

- Total benefit U:

$$U(Q(t)) = \int_0^{Q(t)} D^{-1}(x)dx,$$

- Price clears the market:

$$P = D^{-1}(Q)$$

- Cost Function (Chakravorty et al. 1997):

$$C((S_0 - S(t)), Q) = c_1 e^{c_2(S_0 - S(t))}Q + c_0$$

where c_1 and c_2 are constants

- Constant marginal utility of income
- No Externalities
- Isoelastic Demand
- Elasticity of Demand = -0.05
- Interest Rate = 0.05
- Oil produced in each period will be sold at that period.

Figure 4: Soroosh Wellhead Platform 2 [Image courtesy of www.etech-group.co.uk]

Data

Price: Annual average of the weekly Iran Heavy oil price between 2001 and 2007 from Energy Information Administration

Production: Soroosh daily production from 2001 as reported by NIOC

Preliminary Results

The model generates solution between 2001 and 2160 when there is no more oil in the ground in Soroosh field. As it can be seen in figure 5, the model simulates an increasing price trajectory between 2080 and 2160.

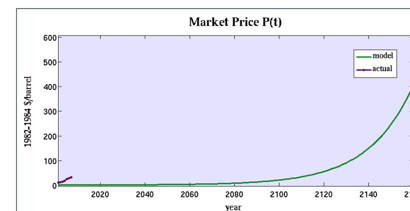

Figure 5: Simulated vs. actual market price trajectory

Also, the model simulates production increase up to 70,000 barrels per day to maximize the objective function. The objective of the contract to produce 100,000 barrels per day in Soroosh oil field has also been shown on figure 6.

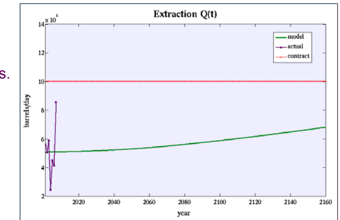

Figure 6: Simulated vs. actual and contractual extraction trajectory

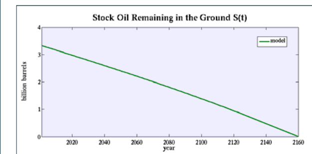

Figure 7: Simulated stock of oil remaining in the ground

Discussion Future Works

- The methodology used to study Soroosh oil field should also be applied to Nowrooz and other fields with buy-back service contracts to let us understand the optimal production aspect of these contracts.
- Since there are differences between optimal, actual and contractual production, the next step is to quantify the inefficiencies resulting from these differences.
- Financial aspect of buy-back service contracts is another area that should be incorporated to the results of the optimal production analysis.

Figure 8: Nowrooz Platform [Image courtesy of www.japex.co.jp]

References

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