

Oil Service Contracts- Lecture A

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Not for Publication and Distribution



Introduction - Background

- MIT post Doc research associate in transportation economics
- Developed expertise in energy economics and policy
- Done extensive work on petroleum economics and economics of oil contracts.
 - Published
 - Three papers on the topic of oil service contracts
 - A working paper on Iraq technical service contracts.

Introduction - Motivation

- In this morning lectures we will be talking about oil contracts and in particular oil service contracts as it pertains to Iran and Iraq.
- The discussion on Iraq TSC is relevant:
 - TSCs have some common features with Iran petroleum contracts.
 - TSCs represent major differences with Iran BBSC.

Introduction - Motivation

- The question is how legal/policy restrictions might have affected (could affect) the overall efficiency of the contracts.

Introduction - Motivation

- My work has been on methods
 - To measure the overall efficiency of the contracts
 - To investigate potential sources contributing to any deviation from optimal outcomes.
- Showing how we used the technique to investigate the efficiency of an Iranian BBSC and an Iraqi TSC

Outline – Lecture A

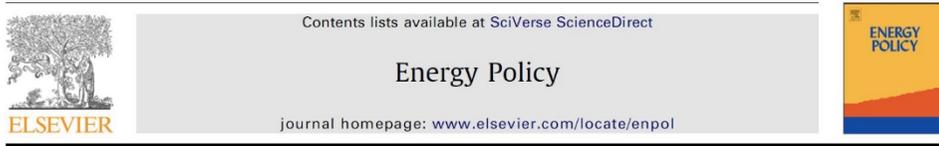
- What is an oil service contract?
 - Differences from an oilfield service contract
- Status of oil service contracts globally
- Iran's BBSCs Study
 - Economic Efficiency
 - Risks Factors to International Oil Companies

Outline – Lecture B

- Iraq TSC
- Discussion

Readings

Energy Policy 42 (2012) 181–190



Do Iran's buy-back service contracts lead to optimal production? The case of Soroosh and Nowrooz

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ABSTRACT

We model the dynamically optimal oil production on Iran's offshore Soroosh and Nowrooz fields, which have been developed by Shell Exploration through a buy-back service contract. In particular, we examine the National Iranian Oil Company's (NIOC) actual and contractual oil production behavior and compare it to the production profile that would have been optimal under the conditions of the contract. We find that the contract's production profile is different from optimal production profile for most discount rates, and that the NIOC's actual behavior is inefficient—its production rates have not maximized profits. Because the NIOC's objective is purported to be maximizing cumulative production instead of the present discounted value of the entire stream of profits, we also compare the NIOC's behavior to the production profile that would maximize cumulative production. We find that even though what the contract dictates comes close to maximizing cumulative production, the NIOC has not been achieving its own objective of maximizing cumulative production.

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On the rate of return and risk factors to international oil companies in Iran's buy-back service contracts^{*}

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Q4
Q48

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ABSTRACT

We analyze the rate of return (ROR) and risk factors faced by Shell Exploration, an international oil company (IOC), in its Soroosh and Nowrooz buy-back service contract in Iran. In particular, based on our models of cash flow, we analyze the buy-back contract specific risk factors that can contribute to a reduction in the rate of return for the international oil company. Our cash flow models resemble the cash flow of buy-back service contracts before the Iranian government changed the way it determined the capital cost ceiling and pre-defined the oil price in these contracts in 2008–2009. Our actual and contractual cash flow models reveal that Shell Exploration's actual ROR was much lower than the contractual level. Furthermore, we find that among the risk factors that we considered, a capital cost overrun has the greatest negative effect on the IOC's ROR. Moreover, we show that there is a potential for modifying the contracts in order for the IOC to face an actual ROR closer to the contractual ROR even if the contract faces cost overrun or delay, without exceeding the maximum contractual ROR that the National Iranian Oil Company is willing to give.



CASE STUDY

Oil and gas service contracts around the world: A review[☆]

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ABSTRACT

This paper reviews the energy strategy and oil and natural gas fiscal systems of eight major oil or natural gas producing countries which have either adopted a variation of a service contract or have shown interest in this framework as an alternative to production sharing contracts over the period 1990–2014. In particular, we look at each country's variation of service contract, and examine how these variations of service contracts are different from each other. A service contract is a long-term contractual framework that is used by some host governments to acquire the international oil companies' expertise and capital without having to hand over the field and production ownership rights to them. Our review suggests that the new interest in service contracts might be explained partially by heightened sovereignty concerns and the political environment on one hand, and the need for international oil companies' capital and know-how in developing oil and natural gas fields in the host countries on the other. In our review, we also explore some of the drawbacks of service contracts including the potential for economically inefficient outcomes. In addition, we look at some possible solutions for improving the economic efficiency of service contracts.

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On the Economic Efficiency of Oil Production Contracts: A Dynamic Model of the Rumaila Oil Field in Iraq¹

Abbas Ghandi and C.-Y. Cynthia Lin Lawell

Abstract

We develop a dynamic model of oil production and well drilling to analyze the economic efficiency of oil production contracts. As technical service contracts, buy-back contracts, and production sharing contracts each impose different sets of constraints, our theory model suggests that it may be possible to increase the efficiency of one type of contract by combining it with features of another. We apply our model to the Rumaila oil field in Iraq, which is under development through a technical service contract. According to the results of our application to Rumaila, production sharing contracts tend to be the most efficient, followed by technical service contracts. Buy-back contracts tend to be the least efficient of the three. The efficiency of a technical service contract can be increased by increasing the contractual plateau production target so that the production cap is less stringent; or, when additional factors that impose an implicit cost ceiling and constrain production are present, by combining a technical service contract with features from production sharing contracts such as using a fixed price gross revenue condition. On the other hand, combining a technical service contract with features from buy-back contracts can decrease efficiency. The Rumaila technical service contract is predicted to result in a deadweight loss of 14.2% relative to the first-best, which is higher than the deadweight loss due to the terms of the contract alone. In addition to the terms specified in the contract itself, additional factors that we examine that might affect the efficiency of the Rumaila technical service contract include an implicit cost ceiling and production constraints.

Keywords: Iraq; technical service contract; buy-back contract; production sharing contract; oil production; dynamic optimization; Hotelling; service contract

JEL Classification: Q4, Q48

Lecture A: Oil Service Contracts

- A service contract is a long-term contractual framework that governs the relation between a host government and international oil companies (IOCs) in which
 - the IOCs develop or explore oil or natural gas fields on behalf of the host government in return for pre-determined fees.
 - In most cases the host government does not hand over the control of the extracted or subsoil or sub-surface resources to the IOCs.
 - The term service contract can also refer to oilfield service contracts.

Lecture A: Oil Service Contracts

- Service contract can also refer to oilfield service contracts.
- There are oilfield service firms, such as Halliburton, Schlumberger and Baker Hughes, that provide oilfield services and that may specialize in services such as drilling.
 - These firms are awarded oilfield service contracts to fulfill particular jobs as part of broader development or exploration plans
 - Saudi Aramco, Mexico Pemex

Lecture A: Oil Service Contracts Global Review

Iran	Buy-Back Service Contract First Generation (First Signed in 1995)	Buy-Back Service Contract Second Generation (First Announced in 2004)	Buy-Back Service Contract Third Generation (First Signed in 2009)	Iran's New Plans for More Attractive Contracts Including Variations of Iraq's Technical Service Contracts or Potentially Production Service Contracts (2014)
Kuwait	Service Contract (First Signed in 1992)	Operating Service Contract (First Announced in 1999)	Enhanced Technical Service Agreement (First Signed in 2010)	Oil Field Service Contract (2013)
Venezuela	Operational Service Agreements (First Round Auctioning in 1991)	Operational Service Agreements (Second Round Auctioning)	Operational Service Agreements (Third Round Auctioning in 1997)	Service Agreements were Converted into "mixed enterprise" Frameworks with Majority Stakes for PDVSA (2006-7)
Mexico	Multiple Service Contract (First Announced in 2001)	Incentive-Based Multiple Service Contract (First Announced in 2009)	Incentive-Based Multiple Service Contract (Second Round Licensing in July 2012)	Integrated Exploration and Production Service Contract (Third Round Licensing in July 2013)
Bolivia	Operations Contract (First Announced in 2006)	Operations Contract (First Bidding Round in 2012)	Additional Incentives Introduced to the Operations Contract (April 2012)	Additional Incentives Introduced for Exploration Operations Contract (May 2013)
Ecuador	Service Contract (First Announced in 2007)	Incremental Production Contract (First Signed in February 2012)	New Licensing Round on 13 Exploration Blocks (December 2013)	Integrated Specific Service Contracts over 16 Mature Fields for Enhanced Oil Recovery (Jan 2014)
Iraq	Producing Field Technical Service Contract (2009)	Development and Production Technical Service Contract (2009)	Technical Service Contract (Third Round Auctioning in 2010)	Technical Service Contract (Fourth Round Auctioning in 2012)
Turkmenistan	Risk Service Contract (First Announced in 2008)			

Lecture A: Oil Service Contracts Global Review

	Iran BBSC	Iraq TSC	Venezuela OSA (1st & 2nd)	Venezuela OSA (3rd)
Capital Cost Decision Interaction	No leverage for the IOC	IOC/NOC	IOC/NOC	IOC/NOC
Produced Crude Ownership	Iran	Iraq	Venezuela	IOC/Venezuela
Oil Field Operator	Iran	Joint Company	IOC	IOC
Remuneration	Fixed in accordance to the IOC Rate of Return in the Project	Per Barrel Production	Per Barrel Production	Based on the Project Rate of Return
Who Bears the Risk	IOC	IOC/NOC	IOC/NOC	IOC/NOC

Buy Back Service Contracts

- In a buy-back service contract:
 - An International Oil Company (IOC) develops an oil or natural gas field.
 - When production starts, the field is handed over to the National Iranian Oil Company.
 - IOC's repayment rates are based on specific percentages of the production of the field, and an agreed upon rate of return.
- By using the buy-back service contract, the NIOC:
 - benefits from the IOCs' technical and financial capabilities.
 - meets Iran's strict constitutional provisions restricting foreign oil companies' involvement in Iranian oil and natural gas projects.

Buy Back Service Contract

- **Contract's objectives vs efficient outcomes**
 - To examine the NIOC's actual and contractual behavior and to compare with the optimal under the conditions of the contract, we model:
 - » The dynamically optimal oil production on Iran's offshore Soroosh and Nowrooz fields
 - » The optimal production if the producer were to maximize cumulative production, as the NIOC purports to do
- **Contract's risk factors**
 - To analyze the IOC's rate of return and risk factors, we model:
 - » The cash flow of Iran's Soroosh and Nowrooz buy-back service contract (separate paper)

Lecture A: Ends

The Iran Dynamic Optimal Project

- To examine the NIOC's actual and contractual behavior and to compare with the optimal under the conditions of the contract, we model:
 - The dynamically optimal oil production on Iran's offshore Soroosh and Nowrooz fields
 - The optimal production if the producer were to maximize cumulative production, as the NIOC purports to do.
- To analyze the IOC's rate of return and risk factors, we model:
 - The cash flow of Iran's Soroosh and Nowrooz buy-back service contract (separate paper)

Optimal Production Modeling: Review the Theory

- The NIOC's optimal control problem for Soroosh and Nowrooz fields would be to choose an extraction profile to maximize the present discounted value of the entire stream of per-period net profit as shown mathematically here:

$$\text{Max}_{\{Q_t\}} \sum_{t=0}^T \beta^t \{P_t * Q_t - C(S_t, Q_t)\}$$

- β : discount factor
- P_t : exogenous price
- Q_t : extraction rate (control variable)
- S_t : stock of oil remaining in the ground (state variable)
- $C(S_t, Q_t)$: cost function

Optimal Production Modeling: Review the Theory

- subject to:

$$Q_t \leq Q_{max}$$

$$Q_t \geq Q_{min}$$

$$ABS(Q_t - Q_{t-1}) \leq Q_f$$

- Q_{max} : maximum feasible level
- Q_{min} : based on terms of the contract
- Q_f : set at 10,000 b/d

To solve this dynamic optimization problem numerically, we formulate it using the following Bellman equation

$$V(S_t) = \text{Max}_{\{Q_t\}} \{P_t * Q_t - C(S_t, Q_t) + \beta(V(S_{t+1}))\}$$

Optimal Production Modeling: Review the Theory

$$V(S_t) = \text{Max}_{\{Q_t\}} \{P_t * Q_t - C(S_t, Q_t) + \beta(V(S_{t+1}))\}$$

$v(S_t)$: value function

- It is a function of state variable. It yields maximum amount of the objective function at time period t .
- In order to find this value, the optimal policy function, which is an optimal choice of extraction (control), considering stock in the ground (state) in time t , should be computed.
- Among possible solutions for the Bellman equation, we have used numerical backward induction.

Year/Perspective Versions of the Model (Soroosh)

- Our optimal production models require inputting exogenous price estimates which change each year.
- In order to account for the effects of such price estimate changes on the optimal production paths, we have defined three distinct year/perspective versions of the model for each of the two fields.
- These stages represent different actions in different time period when you are in different phases of the contract

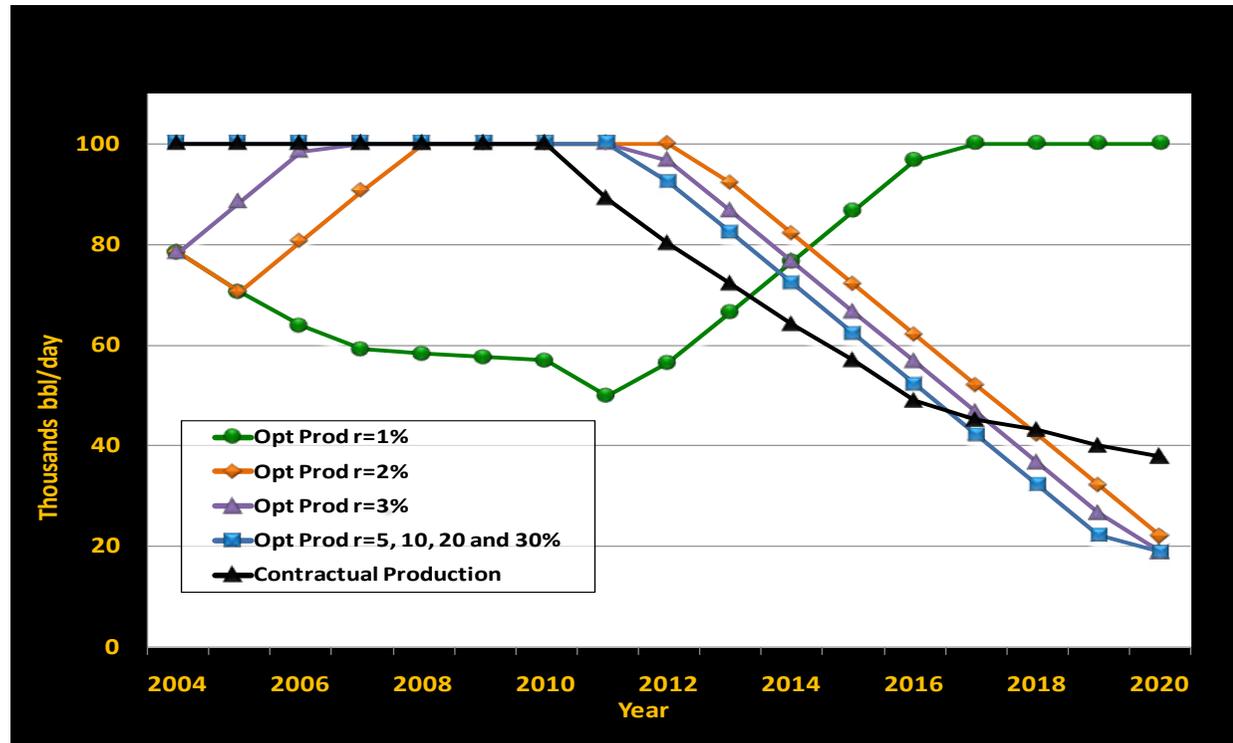
Year/Perspective Versions of the Model (Soroosh)

- We make unique conclusions based on each of the optimal results.
- For example, optimal production paths from the 1999 perspective are compared with the contractual path, which enables us to argue about the efficiency in contractual production decisions in 1999, since the contract was signed in 1999.
- Model versions from the perspective of 2009 for the two fields examine the optimality considerations in all the years of exploitation until 2009 based on information available in 2009.

Year/Perspective Versions of the Model (Soroosh)

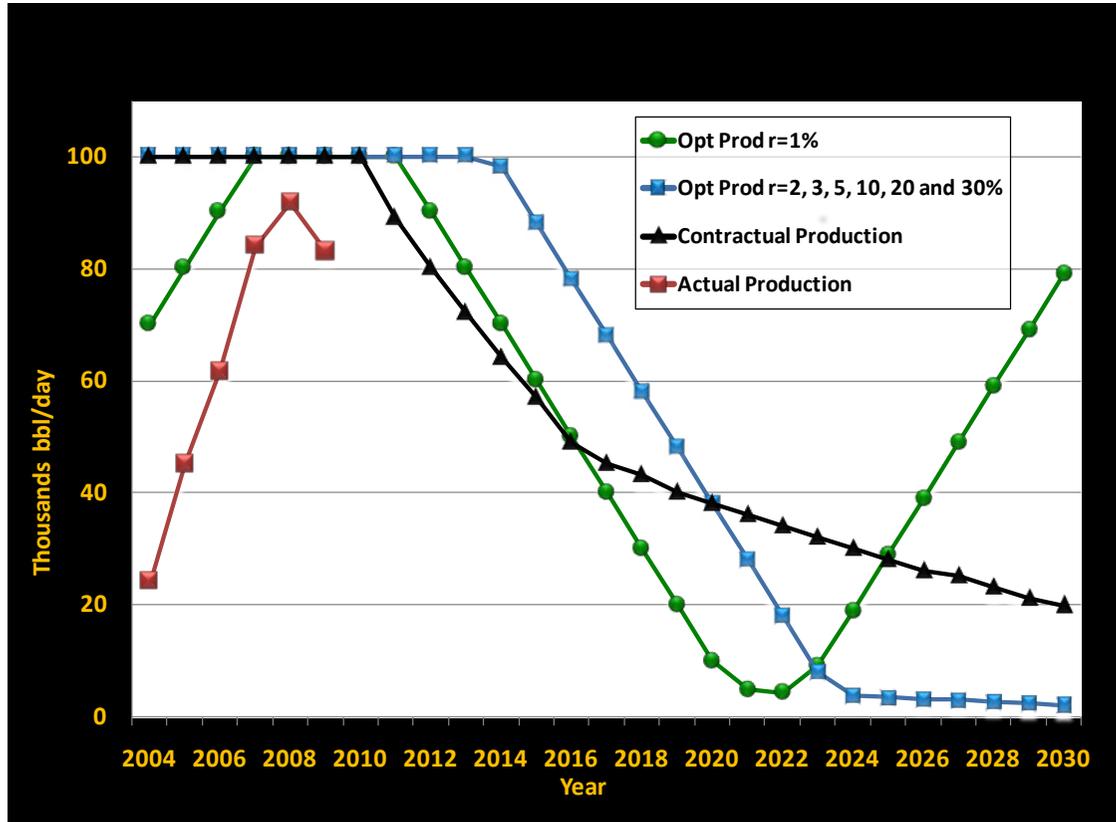
Phase/Period	Until 1999	1999-2004	2004-2009
Contract Status	Negotiations	Development	Actual Production
Model Perspective Features			
The year the price estimate was formed	1999	2004	2009
Last year of time horizon	2020	2025	2030

Optimal Production Results (1999 Perspective)



- Optimal Production when profit is maximized, from the perspective of the year 1999 for time horizon 2020.
- The IOC/NIOC decision on the contractual production path for each field does not match any of the optimal production paths.

Optimal Production Results (2009 Perspective)



- Optimal production when profit is maximized, from the perspective of the year 2009 for horizon 2030.
- The actual production levels of the fields, after they are handed over to the NIOC, have been far below the contractual and optimal production paths.

Conclusion

- We conclude that:
 - The NIOC is producing inefficiently.
 - The contract does not dictate what is optimal for most discount rates.
- However, if the objective is to maximize cumulative production:
 - The contract's production path is close to the optimal for each field.
 - The actual production path suggests that the NIOC has not been achieving its own objective of maximizing cumulative production on either of the two fields.

Discussion

- Reasons for low level of production
 - The terms of the contracts (the NIOC operatorship)
 - Once production of the field of the contract starts, the field is handed over to the NIOC.
 - The NIOC may lack the technology and expertise needed to determine the optimal production levels.
 - The crude share arrangements based on the cash flow calculations (marketing/customer issues) of the buy-back service contracts

Options for the Extra Crude

- To sell Shell the extra crude at the new actual higher price
 - Price dispute
- To process the crude domestically and either to use the crude domestically or to export the refined crude.
 - limitations on domestic refining capacity
- To try to market the extra crude independently.
 - Followed this option
 - limited storage facilities
 - Production disruptions

BBSC Risk Factors Review

- How much can the inherent risk due to the nature of buy-back service contract affect the IOC's actual ROR? In order to answer this question, we:
 - Model Shell Exploration's contractual and actual cash flow
 - Analyze the risk factors that lead to reduction in the IOC's rate of return.
 - Propose modifications in order for the IOC to face a lower degree of risk

BBSC Risk Factors Review

- Risk factors include:
 - Capital cost
 - Time profile of capital expenditures
 - Operating and maintenance cost
 - Delay in construction
 - Reduction in the
 - Oil price
 - Contractual production level
 - LIBOR
 - Remuneration not being realized
- We study these factors and their effects on the rate of return.
- We argue that in addition to existence of inefficiencies, the IOC may face high risk in the buy-back service contracts.

IOC Rate of Return

- The unique nature of buy-back service contract
 - The IOC does not share in the profit.
 - The IOC is not operator of the developed fields.
- How much the contract specific risk factors could affect the IOCs actual ROR?
 - A low ROR and high risks may avert the IOC from investment
- Modelling Shell contractual and actual cash flow in its Soroosh and Nowrooz buy-back service contract allows us to:
 - Compare the contractual and actual rate of returns
 - Analyze the buy-back specific contributing risk factors that lead to reduction in the IOCs rate of return
 - Propose a risk-sharing cash flow modeling in which the NIOC shares some risks with the IOC

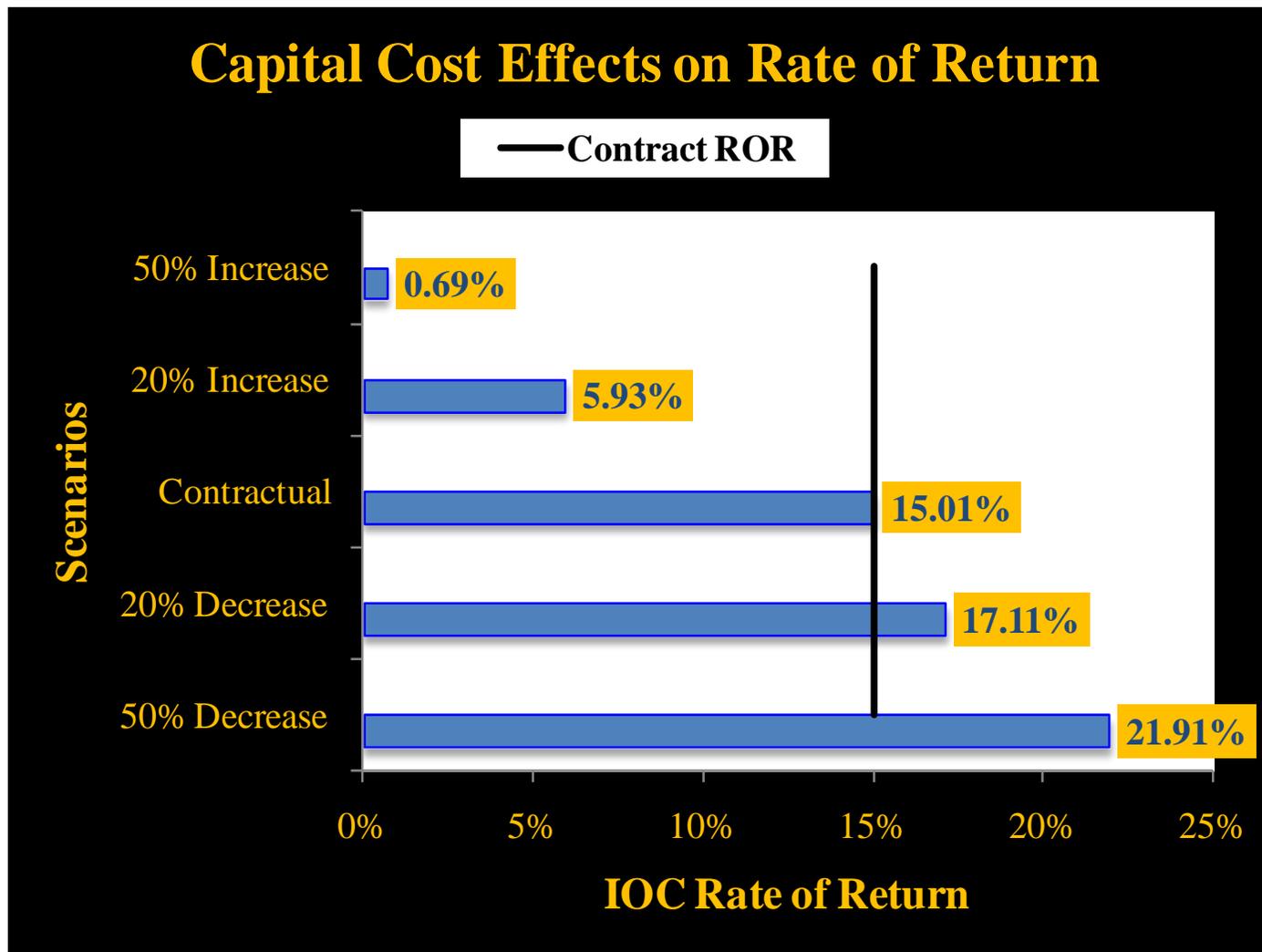
IOC Rate of Return- Results

Scenarios	Shell Rate of Return
Contractual	15.01%
Actual	0.53%

Based on our contractual and actual models of cash flows, Shell has ended up with significantly low rate of return in its Soroosh and Nowrooz buy-back service contract with Iran.

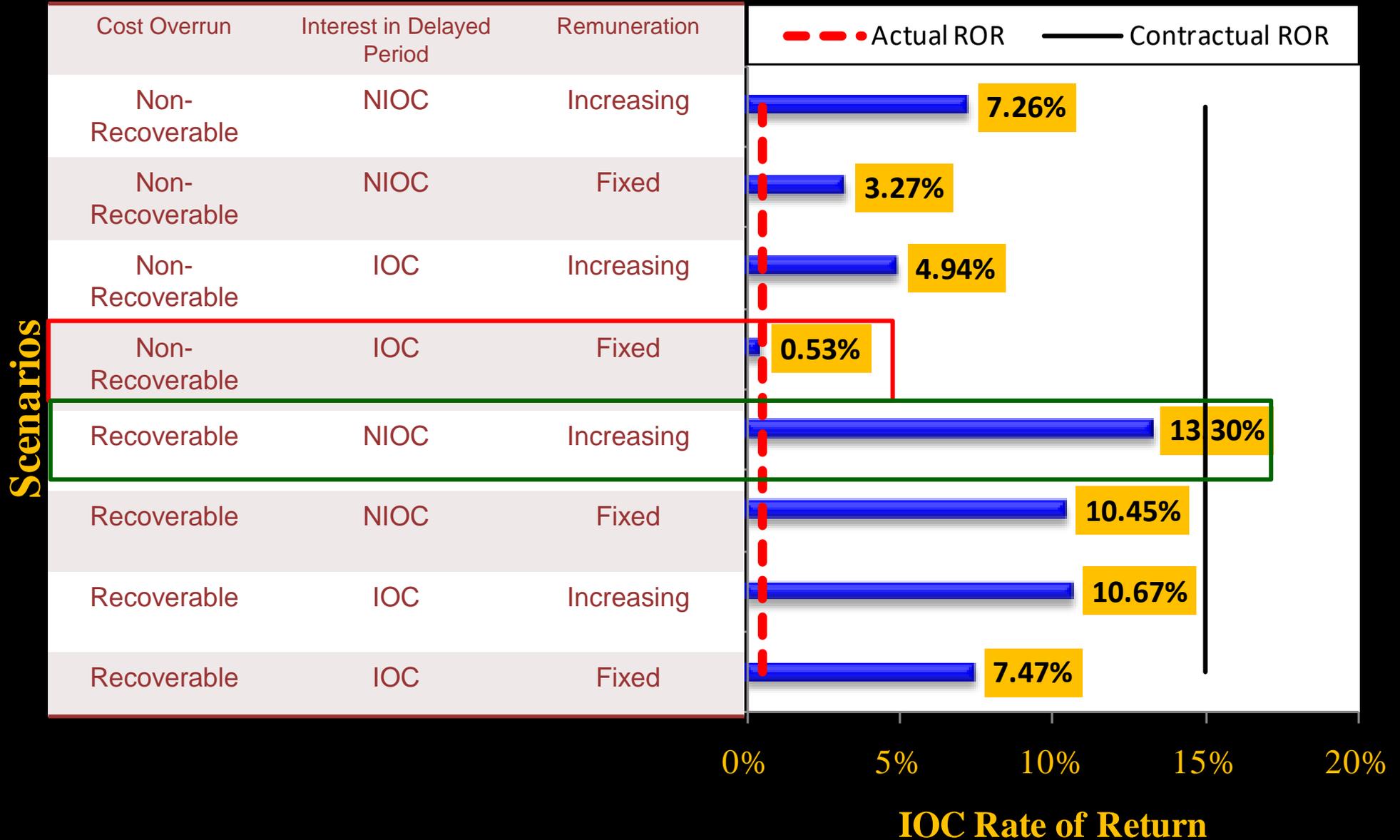
IOC Rate of Return- Results

- This chart shows just the effects of capital cost changes on the rate of return holding other things constant.



IOC Rate of Return- Results

Risk-Sharing Scenarios Rate of Returns



IOC ROR: Conclusion

- The IOC in a buy-back service contract may face very high degrees of risk.
- All the risk factors are capable of reducing the IOC rate of return, and therefore, we indeed recognize them as risk factors.
- We find that capital costs have the largest effect on ROR but more in terms of levels rather than percentages.
- Our model of risk-sharing cash flow suggests that there is a potential for modifying the contracts to better share the risk.

BBSC Proposed Modifications 2011

- Consider a limited open ROR policy:
 - As rewards for the IOCs who could fulfill certain objectives in favor the project
- Put a lower bound on the IOC's ROR:
 - The NIOC and the IOC could agree on detailed procedures to follow in cases of any or all of the risk factors are in effect.
 - Assess the optimal degree of risk-sharing between the NIOC and the IOC

BBSC Proposed Modifications 2011

- Offer different types of risk-sharing contracts to different IOCs:
 - Not all the IOCs are the same regarding their ability of carrying out complicated oil and natural gas exploration and development projects.
 - The NIOC could offer a risk-sharing contract as a reward for the IOCs that carry the exploration successfully.

Outline – Lecture B

- Iraq TSC
- Discussion

Lecture B: Iraq TSC

- available at:
 - aghandi.mit.edu



Lecture B: Iraq TSC-Project Motivation

- A service contract in Iraq
 - Might not be the most suitable option
 - Not the IOCs preferred business models
- There is a potential to make a strong argument for the Iraqi government to
 - Consider other contractual frameworks
 - Modify its technical service contract framework

Lecture B: Iraq TSC Paper Summary

- Develop a dynamic model of oil production and well drilling to analyze the economic efficiency of oil production contracts
 - technical service contracts, buy-back contracts, and production sharing contracts
- Structured Theoretical Model
 - to consider other contracts of interest
 - EX. Iran new IPC framework
- Numerical Solution

Lecture B: Iraq TSC Paper Summary

- Theory model
 - that it may be possible to increase the efficiency of one type of contract by combining it with features of another
- Apply our model to the Rumaila oil field in Iraq
- Numerical solution
 - TSC, BBSC and Production Sharing

Lecture B: Iraq TSC-Why Rumaila

- We choose to apply our model to the Rumaila oil field for several reasons
 - First, the Rumaila oil field is a large oil field: once reaching the plateau production target in its technical service contract, Rumaila will be the second largest producing field in the world after Saudi Arabia's Ghawar oil field
 - Second, the Rumaila oil field is under development through a technical service contract, and the literature to date on technical service contracts has been sparse

Lecture B: Iraq TSC-Why Rumaila

- Third, the Rumaila oil field is in Iraq, an important and increasingly important oil producing country. Iraq has replaced Iran as the second largest crude oil producer among OPEC members (EIA, 2013), and oil production in Iraq is estimated to reach an astonishing 10.5 million barrels per day by 2035
- Fourth, the Constitution in Iraq allows the Iraqi government to choose from a range of possible contracts with IOCs, including service contracts and production sharing contracts
- Fifth, an analysis of the efficiency of oil production contracts is also potentially of use to policy-makers in Iraq

Lecture B: Iraq TSC Paper Contribution

- We analyze the economic efficiency of oil production contracts using a dynamic model
- The first paper to date
 - to analyze the economic efficiency of technical service contracts
 - to compare technical service contracts, buy-back contracts, and production sharing contracts
 - to analyze novel combinations of features of these three types of contracts.

Lecture B: Iraq TSC Paper Summary Findings

- Production sharing contracts tend to be the most efficient
 - followed by technical service contracts
- Buy-back contracts tend to be the least efficient of the three.
- The Rumaila technical service contract is predicted to result in a deadweight loss of 14.2% relative to the first-best, which is higher than the deadweight loss due to the terms of the contract alone
 - Deadweight loss
 - First-best

Lecture B: Iraq TSC Paper Summary Findings

- The first-best outcome arises when the IOC does not face any additional constraints imposed by contracts and makes dynamically optimal decisions as if it were the sole owner of the field.

Lecture B: Iraq TSC Paper Summary Findings

- To measure any inefficiencies introduced by contracts, we define the deadweight loss DWL^X of contract X as the percentage lower the present discounted value $v_t^X(\cdot)$ of the entire stream of per-period profit from that contract is relative to the present discounted value $v_t^{FB}(\cdot)$ of the entire stream of per-period profit under the first-best:

$$DWL^X = \frac{v_t^{FB}(\cdot) - v_t^X(\cdot)}{v_t^{FB}(\cdot)} \cdot 100$$

- We say that a contract is “more efficient” if its deadweight loss is lower and “less efficient” if its deadweight loss is higher.

Lecture B: Iraq TSCs

Round	# Pre-qualified bidders	Important Dates	Bid Projects' Scope	Outcome
1	35	June 30, 2009 results announced.	To develop 6 oil and 2 non-associated natural gas fields	One contract was awarded (Rumaila). Three other oil contracts were signed later.
2	9	December 12, 2009 results announced.	To develop 10 oil fields	Seven contracts were awarded. Three contracts did not have any bidders.
3	13	October 20, 2010 results announced.	To develop 3 non-associated natural gas fields including two from the first round	Three fields were awarded to two international consortia
4	46	Promotional Conference: August 2011 Final Tender: November 2011 Bidding Event: May 2012	To explore 12 oil and natural gas blocks	

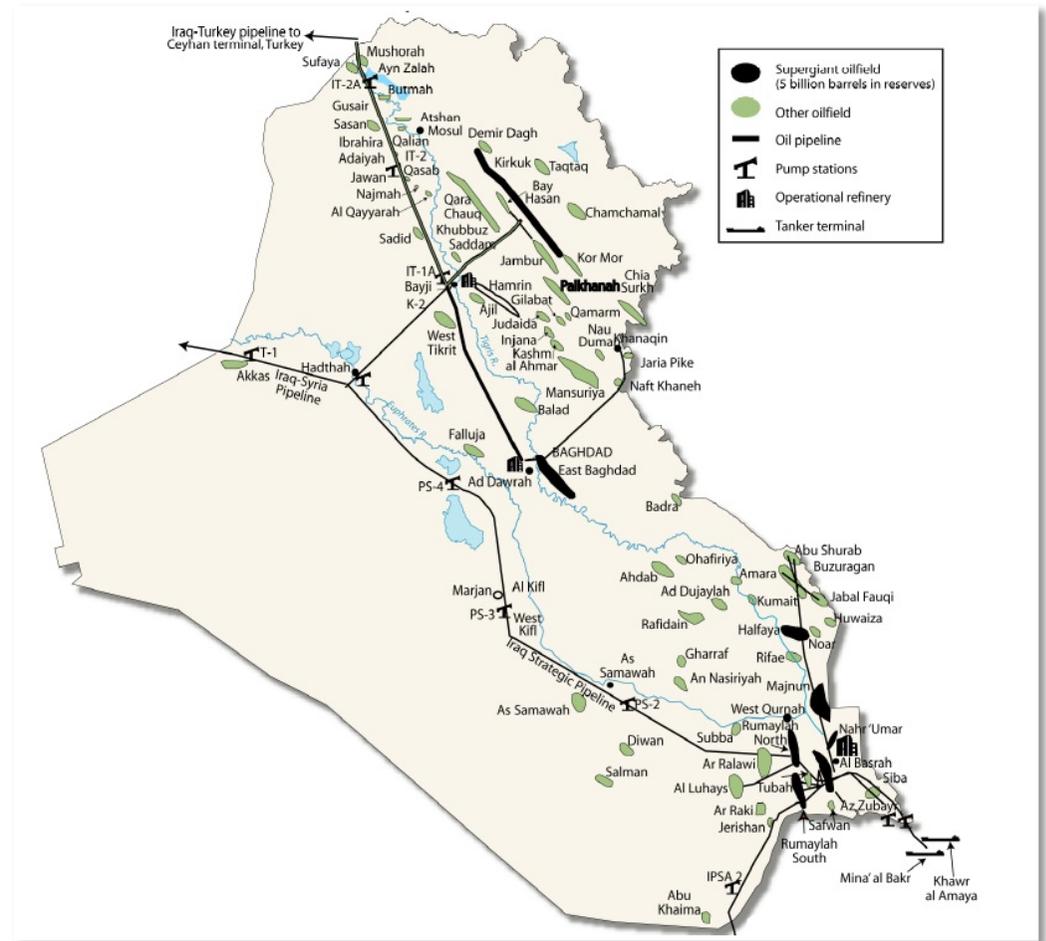
Lecture B: Iraq TSC

- First two rounds (development)
 - Bid on per barrel remuneration based on plateau production target
- Third round (natural gas)
 - Bid on per barrel oil equivalent remuneration fee
- Fourth round (exploration)
 - Bid on fees in return for their exploration activities

Lecture B: Iraq TSCs

- Producing Field Technical Service Contract
 - Fields with production prior to the contracts
- Development and Production Technical Service Contract
 - Fields without production prior to the contracts
- Main Differences of two contracts are in
 - The IOCs cost recovery speed
 - Cash flow mechanism

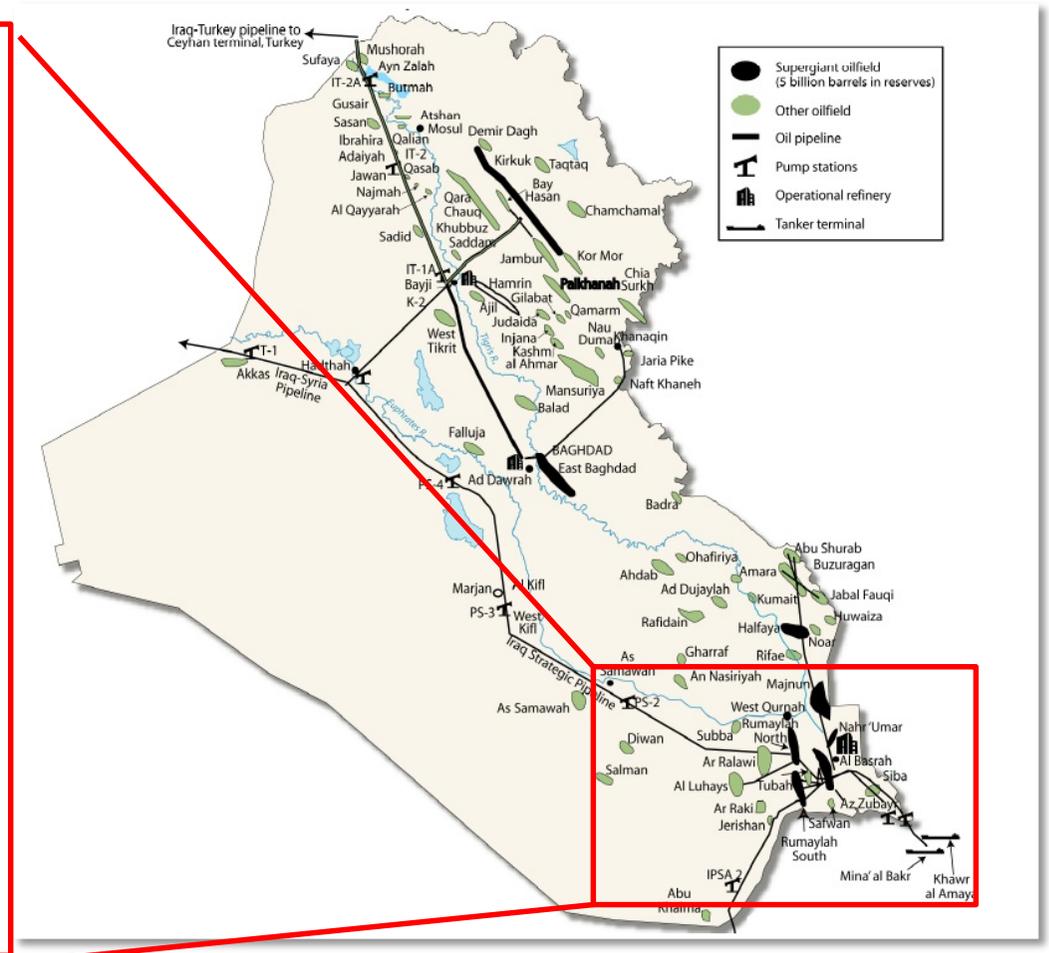
Iraq Oil Map



Source: Adapted from U.S. Energy Information Administration (EIA), Energy Situation Analysis Report, June 26, 2003.

Lecture B: Iraq TSCs

Iraq Oil Map



Source: Adapted from U.S. Energy Information Administration (EIA), Energy Situation Analysis Report, June 26, 2003.

Lecture B: Iraq TSC-Rumaila Oil Field

- First post-war awarded contract in the first round auctioning in 2009
- BP-led consortium
- A producing field technical service contract
- 2009 baseline production at 1 million barrels per day
- The plateau production target at 2.85 million barrels per day
- Rumaila will be second largest producing field in the world after Saudi Arabia's Ghawar.

Lecture B: Rumaila TSC Review

- Rumaila Producing Field Technical Service Contract
 - \$2 per barrel bid remuneration based on plateau production target
 - BP 38%, CNPC 37%, Iraq State Oil Marketing Organization (SOMO) 25%
 - Rumaila Operating Organization (ROO) is the joint company
 - Manages the field rehabilitation and expansion
 - Is staffed from Iraq's national South Oil Company

Lecture B: Rumaila TSC Project-Scenarios

- In order to account for the realities that the IOC and the Iraqi government face in implementing the Rumaila technical service contract (TSC), and to account for factors that could affect the overall economic efficiency of the Rumaila TSC.
 - **TSC Optimal**
 - **TSC Optimal, Cost Ceiling**
 - **TSC Actual Optimal**
 - **TSC Actual Optimal, Cost Ceiling**
 - **Buy-Back Optimal**
 - **Production Sharing Optimal**

Lecture B: Rumaila TSC Project-Constraints

	TSC Optimal	TSC Optimal, Cost Ceiling	TSC Actual Optimal	TSC Actual Optimal, Cost Ceiling	Buy-Back Optimal	Production Sharing Optimal
Production cap based on contract	X	X				
Production cap based on Deutsche Bank estimates (more stringent)			X	X		
Cost ceiling		X		X		
Cost reduction not recoverable					X	
Wells predetermined					X	
Gross revenue instead of price						X

Lecture B: Rumaila TSC Project-Data

- Discount rate: scenario based on 10%-20%
- Price Estimates
 - Calibrated price forecasts based on
 - the EIA's 2010 reference price
 - Basra Light Europe Delivery
- Production data
 - Deutsche Bank production estimates
 - Represents the most likely production scenario to be realized by 2030
- Reserve Estimates
 - 16 billion barrels of recoverable reserves
 - World Energy Outlook Special Report: IEA Iraq Energy Outlook

Lecture B: Iraq TSC Cost Function

- Gao, Hartley and Sickles' (2009) annual cost function has the following five main components:

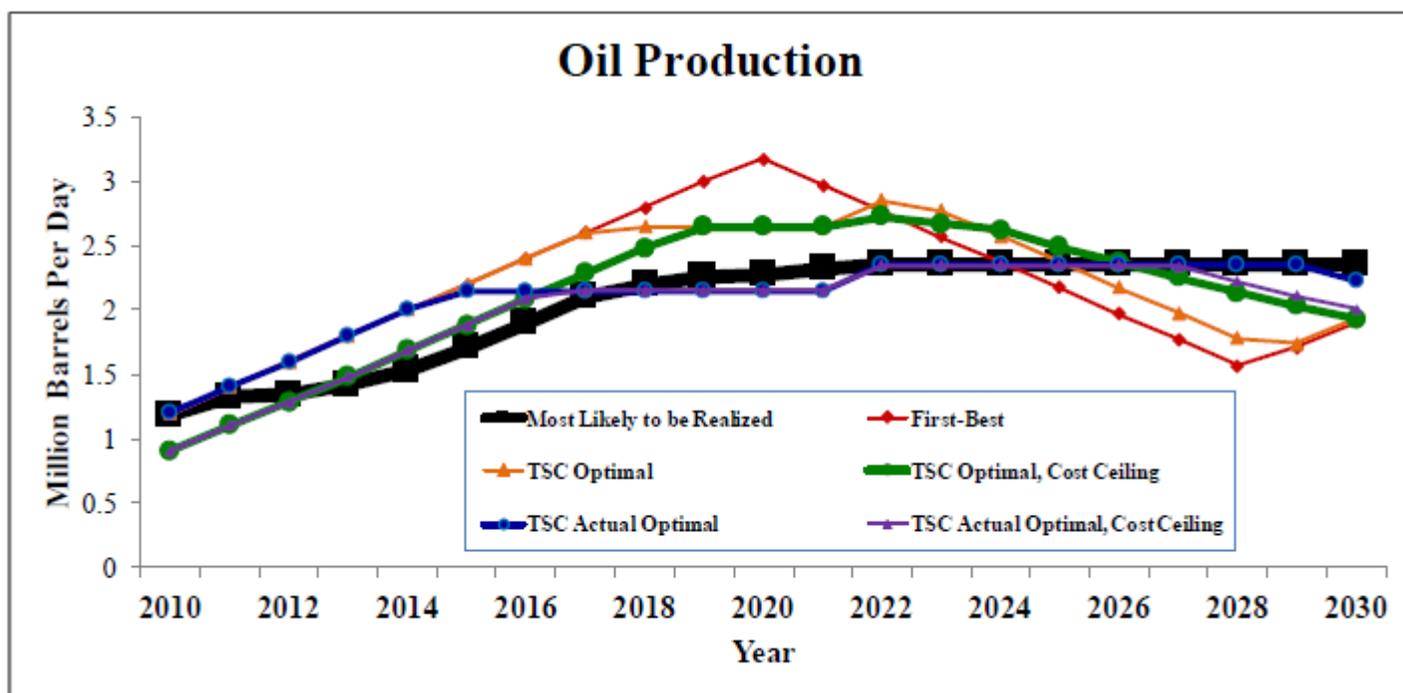
$$c(q_t, n_t, N_t) = c_I q_t + c_O(q_t) + c_W(W(q_t, n_t, N_t)) + c_N(N_t) + c_n n_t$$

- c_I is the surface infrastructure maintenance cost per barrel
- $c_O(\cdot)$ is the variable operating cost
- $c_W(\cdot)$ is the water injection cost
- $W(\cdot)$ is the water injection rate (in million barrels per day),
- $c_N(\cdot)$ is the maintenance cost for old wells
- c_n is the cost of a new well

Lecture B: Iraq TSC-Results

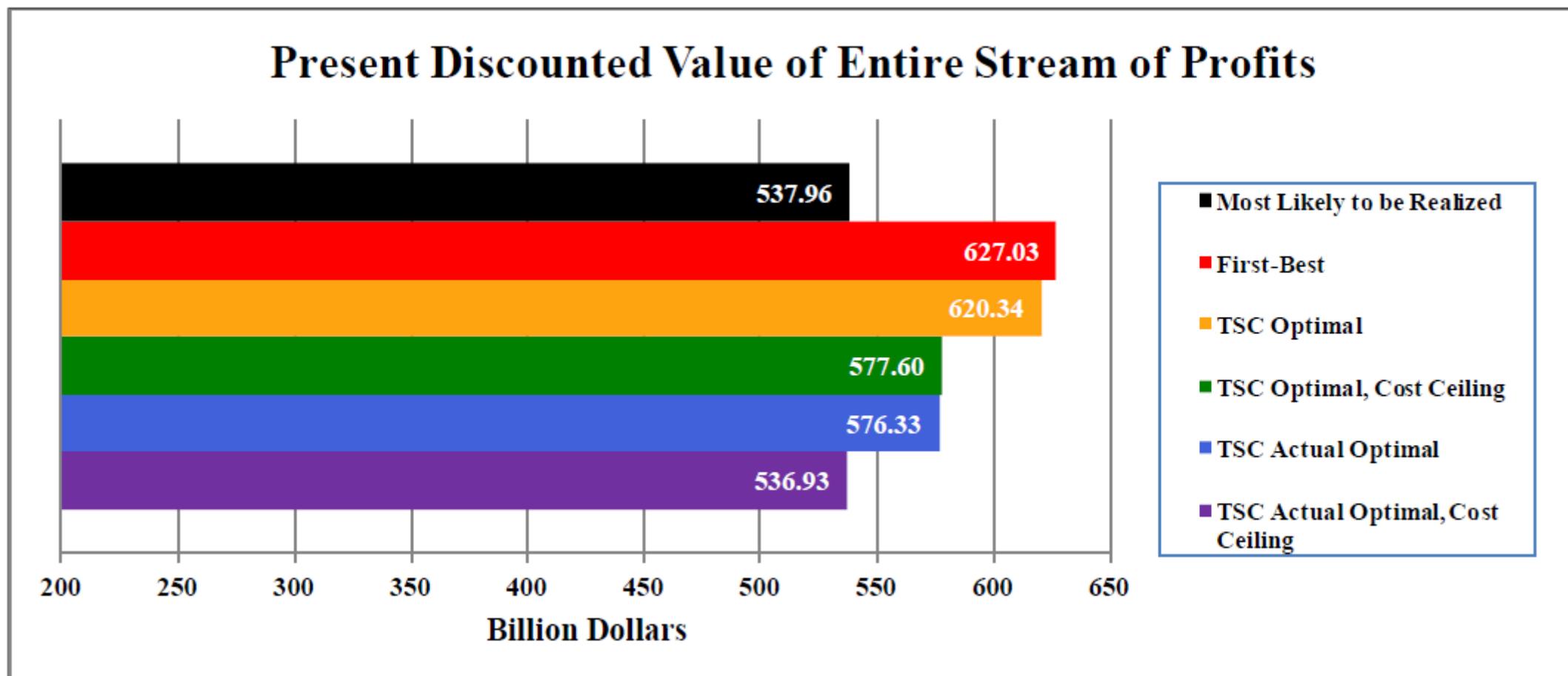
- The results for oil production, well drilling, revenue, and costs for the first-best scenario, “Most Likely to be Realized” scenario, and technical service contract (TSC) scenarios are presented

Lecture B: Iraq TSC-Results



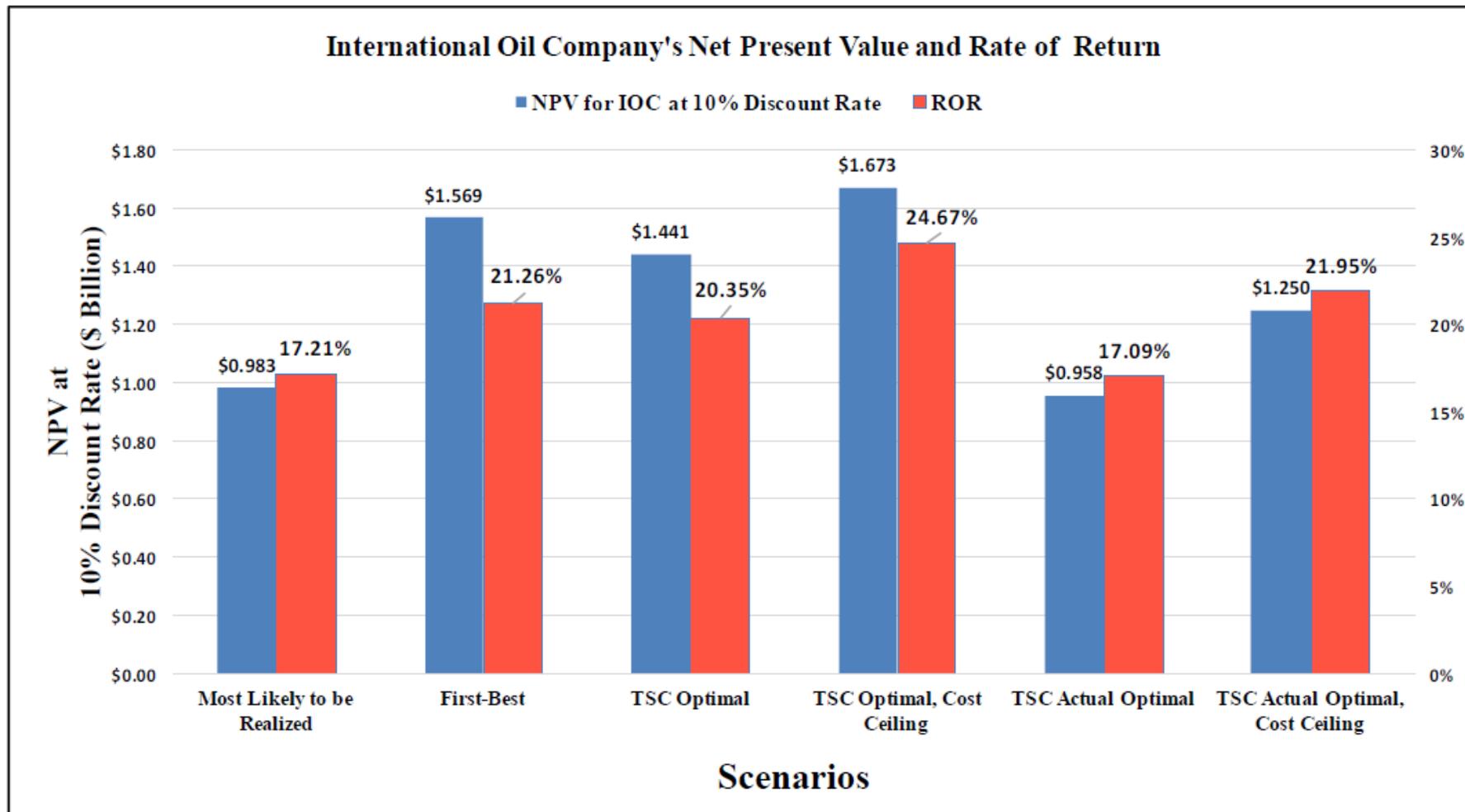
- The first-best production increases each year until the year 2020, declines from 2020 to 2028, and increases in the final 2 years.
- When comparing the TSC scenarios with the first-best, we see that, owing to the production cap, maximum production in all the TSC scenarios is not as high as in the first-best.

Lecture B: Iraq TSC-Results



- Most Likely PDV is \$89 billion lower than the first-best, representing a deadweight loss of 14.2% relative to the first-best

Lecture B: Iraq TSC-Results



- model the Rumaila technical service contract cash flow from the IOC's perspective in order to calculate the IOC's net present value and rate of return under the contract.

Lecture B: Iraq TSC-Findings Summary

- According to the results of our application to the Rumaila oil field in Iraq, production sharing contracts tend to be the most efficient, followed by technical service contracts
- Buy-back contracts tend to be the least efficient of the three
- The Rumaila technical service contract is predicted to result in a deadweight loss of 14.2% relative to the first-best, which is higher than the deadweight loss due to the terms of the contract alone.

Questions?