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An Analysis of Risk and Rate of Return to International Oil Companies from Iran's Buy-Back Service Contracts[1]

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Abstract

We model Shell Exploration's contractual and actual cash flow in its Soroosh and Nowrooz buy-back service contract in Iran. Based on our models of cash flow, we also analyze the buy-back specific contributing risk factors that lead to a reduction in the rate of return (ROR) for the international oil company (IOC). Our models of actual and contractual cash flows reveal that Shell Exploration's actual rate of return was much lower than the contractual level. Furthermore, we find that all the risk factors are capable of reducing the IOC's rate of return. However, among them, we find that capital costs have the largest effect on ROR. Moreover, our model of risk-sharing cash flow suggests that there is a potential for modifying the contracts to better share the risk. By sharing the risk, the IOC could face an actual ROR closer to the contractual ROR even if the contract faces cost overrun or delay, and yet still keep the actual ROR from exceeding the maximum contractual ROR that the National Iranian Oil Company is willing to give.

Keywords: rate of return, risk analysis, Iran's buy-back service contract

1 Introduction

This paper assesses the risks and rate of return to international oil companies (IOC) from Iran's oil and natural gas buy-back service contracts. A buy-back service contract is the primary framework that the National Iranian Oil Company (NIOC) uses to engage IOCs in the development of Iran's oil and natural gas fields in order to benefit from the IOCs' expertise and investment. In these contracts, once the fields reach contractual full production level, the operation of the developed fields is transferred to the NIOC, and the IOC recovers its cost plus additional remuneration fees through an allocation of the developed fields' produced crude based on an agreed-upon targeted rate of return (ROR).

Studies that discuss Iran's buy-back service contracts can be categorized in three groups. The first group, which includes Bindemann (1999) and Marcel (2006), provide basic definitions and some general characteristics of buy-back service contract. Both studies consider this contract as having characteristics that lie in between a service contract and a production sharing contract. The studies that fall under second type, which cover more aspects of a buy-back contract, include Shiravi and Ebrahimi (2006) and Van Groenendaal and Mazraati (2006). Shiravi and Ebrahimi (2006) discuss the terms and a history with a brief overview of some possible risk factors for the IOCs in these contracts. Van Groenendaal and Mazraati (2006) further the discussion over risk factors by analyzing two of the risk factors’ effects on the IOC's rate of return. Based on their model of cash flow of a natural gas buy-back service contract, they show the potential of oil price fluctuations and delays in reducing the IOC's rate of return. However, they limit the scope of the study on just these two risk factors with a limited range of possibilities. Ghandi and Lin’s (forthcoming) approach to studying Soroosh and Nowrooz buy-back service contract falls in a third distinct group of buy-back related studies. Based on dynamically optimal oil production models, they show that the NIOC has not reached contractual goals, nor has it achieved optimality in either profit maximization or cumulative production maximization.

The unique nature of a buy-back service contract, and the fact that the IOC does not share in the profit raise the question of how much the inherent risk due to the nature of buy-back service contract could affect the IOC's actual ROR.[2] To conduct such an analysis, we model Shell Exploration's contractual and actual cash flow in its Soroosh and Nowrooz buy-back service contract as a case study. Based on our models of cash flow, we also analyze the buy-back specific contributing risk factors that lead to reduction in the IOC's rate of return. These risk factors include capital cost, percentages of capital cost spending, operating and maintenance cost, oil price fluctuations, delay in construction, deviations from the contractual production level, London Interbank Offered Rate (LIBOR) rate reduction, and finally the remuneration not being realized.[3] As a further step, we also propose modifications to buy-back service contracts based on our risk-sharing cash flow models in order for the IOC to face a lower degree of risk.

Our contractual cash flow model of the Soroosh and Nowrooz buy-back service contract suggests that Shell signed the contract with a 14.44% rate of return. However, our actual cash flow model reveals that Shell has ended up with an actual rate of return of 0.53%, which is significantly lower than the contractual rate of return. This finding clearly suggests that the IOC may face very high degrees of risk in a buy-back service contract.

In order to analyze the risk factors in buy-back service contracts, and in order to capture every possibility in these contracts, we define various scenarios that include a wide range of possible values for the parameters. In general, we find that all the risk factors are capable of reducing the IOC's rate of return, and therefore, we indeed recognize them as risk factors with different potential effects on the rate of return. In addition to reducing effects, we also study the parameters' effects in increasing the ROR even though in the buy-back service contract, the IOC does not benefit from increasing the ROR. We do that in order to show the potential of parameters' effects in increasing the ROR and to support our risk-sharing cash flow modification proposal.

Shell's low actual ROR implies a potential threat to the IOC's presence in Iran's oil and natural gas industry through the buy-back service contract framework. However, our model of risk-sharing cash flow suggests that there is a potential for modifying the contracts to better share the risk, while still remaining in the framework of buy-back service contract. In particular, we show that when a buy-back service contract faces cost overrun or delay, the NIOC could reduce the risk for the IOC by letting the remuneration increase proportionally with the capital increase and by bearing the interest of the delay period and covering the additional cost. By modifying the contracts to share the risk, the IOC could face an actual ROR closer to the contractual ROR even if the contract faces cost overrun or delay, and yet still keep the actual ROR from exceeding the maximum contractual ROR the NIOC is willing to give. If the NIOC wants to continue using the buy-back framework, such modification is vital in order to avoid deterrence of the IOCs from large investments in Iran's oil and natural gas industry.

The remainder of this paper is structured as follows. In section 2, main parameters of the Soroosh and Nowrooz buy-back service contract are introduced in order to discuss our methodology in modeling the cash flow of such contracts. For each parameter, we discuss the data that are used in the model. Section 3 describes our methodology in analyzing the risk and rate of return in three sub-sections. Sub-section 3.1 discusses modeling of Soroosh and Nowrooz contractual and actual cash flow followed by these models' contractual and actual ROR results.

In sub-section 3.2, buy-back service contract risk factors are discussed. In this sub-section, each risk factor's ROR effects are also provided. Then in sub-section 3.3, our proposed risk-sharing cash flow modeling and the potential ROR effects of such modification in a buy-back service contract are shown. Finally, section 4 includes the conclusion and discussion.

2 Parameters and Data

In this study, there are 15 parts of the contract that we considered in developing our model. These parameters include development and extended periods, capital cost expenditures (contractual and actual), capital cost percentages, non-capital cost expenditures, operating and maintenance cost, bank charges, LIBOR (contractual and actual), production (contractual and actual), oil price (contractual and actual) and remuneration. In what follows, each of these parameters is discussed.

The contractual development period in Soroosh and Nowrooz buy-back service contract was from 1999 until 2002. However, the fields were handed over in 2005 (Middle East Economic Survey, 2005). Therefore, we consider the years 2003 and 2004 as the extended development period.

The capital cost is the IOC's investment in the development period to fund the expenditures of developing the fields of the contract (Shiravi & Ebrahimi, 2006). The capital cost is one of the most important, and sometimes controversial, parts of a buy-back service contract cash flow. It might be controversial because in the negotiations over the cash flow of the contract, the NIOC has to agree on the capital cost ceiling before the start of the project. On the other hand, since the IOC might not have a perfect assessment of the fields before start of the project, this requirement probably makes the capital cost the number one risk factor in these contracts. We therefore give particular attention to all aspects of the capital cost including the contractual and actual capital cost levels, percentages of capital spending in the years of the contractual and extended development periods, and whether or not the cost overrun was recoverable by Shell.

For the capital cost, we need the contractual and actual levels of capital cost as well as the capital cost percentage of spending in each year of development and extended periods. As summarized in Table 1 below, the contractual capital cost level varies from $799M[4] to $806M based on the literature and commercial sources. Due to reliability of the source, we choose the $806M as the contractual capital cost in our cash flow.[5]

Table 1: Soroosh and Nowrooz Contractual and Actual Capital Cost

Description	Value1 (million dollars)	Value2 (million dollars)	Value3 (million dollars)	Final Chosen Value(million dollars) (2005 dollars)	Final Chosen Value(million dollars) (1999 dollars)
Capital Cost (Contractual)	800[1]	799[1] [2]	806 [3]	806	806
Capital Cost (Actual)		906 [4]	1400 [5]	1400	1194
Sources					
[1]	Soroosh and Nowrooz Buy-Back Service Contract (Personal communications with NIOC staff)				
[2]	Van Groenendaal, W. J., & Mazraati, M. (2006). A critical review of Iran's buyback contracts. Energy Policy, Volume 34, Issue 18, 3709-3718.				
[3]	Oil Industries’ Engineering and Construction (OIEC). (2002). *Soroosh and Nowrooz*. Retrieved March 2011, from: http://www.oiecgroup.com/pr/projects/sor_nor.aspx				
[4]	Wolfensberger, M., & Critchlow, A. (2005). Shell loses $100M at Iran field. Gulf times. Retrieved March 15, 2011 from http://www.gulf-times.com/site/topics/printArticle.asp?cu_no=2&item_no=44192&version=1&template_id=48&parent_id=28				
[5]	Platts Oilgram News. (July 26, 2010). *Iran*. As reported from Shana News Agency. Retrieved March 16, 2011 from LexisNexis Academic.				

Table 1 also includes a range of reported values for the actual capital cost between $906M to $1400M. In this paper, we choose to take the $1400M (higher end) as the actual capital cost level since this value was taken from more reliable sources including our personal communication with NIOC staff. The $1400M total actual cost is based on announcements in 2010. However, since the fields were handed over in 2005, it is reasonable to assume that the $1400M is based on 2005 dollars. Therefore, in order to be able to compare the actual and contractual cash flows, we convert that to 1999 real dollars which means that $1400M in 2005 dollars is equivalent to $1194M in 1999 dollars.

Besides the total capital cost ceiling, in a buy-back service contract, the NIOC and IOC have to agree on the IOC's capital expenditure level in each year of the development period.[6] These percentages for Soroosh and Nowrooz buy-back service contract were not available. Therefore, in order to model the capital expenditure profile, we have to assume a specific capital expenditure percentage for each year of the contractual and extended development periods. We also assume that the IOC is not strategically delaying its capital cost expenditure in order to receive a higher rate of return.

In buy-back service contracts, the non-capital cost includes taxes, social security fixed charges, custom import duties and all other levies required by the Iranian laws (Shiravi & Ebrahimi, 2006). Non-capital costs in these contracts are between 5 to 15% of the capital cost.[7] In our study, we consider 10%, which is the mid-value of the range. Since non-capital costs include taxes, we do not have a separate section for tax. This assumption is in accordance with what Van Groenendaal and Mazraati (2006) argue about tax considerations in a buy-back service contract cash flow. They provide the Net Present Value formulas from the perspective of the IOC and the NIOC separately, and neither formula includes tax parameters. For the IOC, they emphasize the fact that the remuneration is not taxable. Moreover, for the NIOC, they assert that the taxes that the NIOC should pay as a government entity is in fact reallocating revenue to other government entities and therefore, that should not affect the NIOC Net Present Value in this contract. However, any tax consideration might decrease the IOC's upper bound repayment, which is 60% of the fields' profit. That is because in reality, the NIOC might be taxed on its profit from the fields, which subsequently decrease the upper bound for the repayment to the IOC. In case the NIOC is being taxed and in order to make sure that the taxes are not affecting the IOC's rate of return, we assume that the amount of tax is reduced from the NIOC's 40% of the net profit that it keeps for itself. In other words, this assumption implies that taxes do not affect the upper bound revenue of the IOC repayments.

Another important parameter of the contract is the operating and maintenance cost, which refers to the cost of crude oil production from Soroosh and Nowrooz starting 2002. As mentioned in the above, the period from 2002 until 2004 is actually part of the development and extended periods. In order to calculate net profit in this period, we follow Shiravi and Ebrahimi's (2006) definition of the operating and maintenance cost as one of the four categories of cost during the development period. Having the operating and maintenance cost to calculate the net profit implicitly suggests that there is no bank charges on this cost, since it is assumed that the operating and maintenance cost is cleared by the fields' next period revenue. Since we did not have access to the contractual and actual operating and maintenance cost for the Soroosh and Nowrooz buy-back service contract, we define scenarios in order to capture a wide range of possibilities. These scenarios are discussed in the appendix (to be posted online). Among the defined scenarios, we follow Van Groenendaal and Mazraati's (2006) suggestion of annual operating and maintenance cost as 3% of total capital cost (our Scenario 2). We also use Scenario 7: Based on Ghandi and Lin (forthcoming) actual cost results**Error! Reference source not found.** as the actual operating and maintenance cost.[8]

In the cash flow of a buy-back service contract, bank charges are among the parameters that are directly negotiated over. In general, bank charges are the interests on the capital cost, which include both the interest on the principal investment as well as compounded interests. In order to set-up the cash flow models in this study, we have to calculate the interest on the IOC's principal investment and the compounded interests. As reported by Shiravi and Ebrahimi (2006)[9] and Van Groenendaal and Mazraati (2006),[10] the interest rate in these contracts is calculated based on the London Interbank Offered Rate (LIBOR) and an additional premium. The LIBOR is an interest rate index for the global money markets. It is announced daily for 10 currencies and 15 different maturities. However, for this study, we use the historic USD LIBOR for one-month period maturity from 1999 to 2010 provided by BBA LIBOR Company.

Due to fluctuations in the LIBOR over time, we also consider LIBOR as another risk factor in this study, and we study its effects on the rate of return.[11] In particular, for our contractual cash flow, we use a LIBOR rate of 6%, which includes a 5.25% annual average for1999 and a 0.75% premium. We keep this fixed for the whole periods of development and amortization. For our actual cash flow, we use the actual annual average of the LIBOR for the years 1999 to 2010 plus the premium.

In our contractual cash flow model, we use the contractual production profile and oil price. However, in reality, the actual production profile and oil price may deviate from the contractual levels. Therefore, in this paper, we also consider the production level and oil price as two risk factors for the rate of return.

We consider the contractual oil price in our models of cash flow at $15/barrel fixed (Van Groenendaal & Mazraati, 2006). We also need actual oil prices for 2002 (2005 for Nowrooz) until 2010. Since we do not have access to actual oil prices, we follow Ghandi and Lin’s (forthcoming) price estimates. For the years 2005 to 2010, we use Ghandi and Lin’s (forthcoming) 2009 perspective's price estimates, which are based on the EIA 2008 Reference case estimates in 2006 dollars.[12] We assume that the EIA's adjusted 2008 Reference case price levels for the years before 2008 are in fact actual prices. Since Soroosh reached the production in 2002, we also need price estimates for the years 2002 to 2004. For the year 2004, we use Ghandi and Lin’s (forthcoming) 2009 perspective price estimate of 2004 which is based on 2004 adjusted OPEC basket price.[13] For 2002 and 2003, we use Ghandi and Lin’s (forthcoming) 2004 perspective price estimates, which are based on the EIA 2003 Reference case estimates in 2001 dollars. As mentioned, based on the EIA's 2003 Reference case price projection, the price levels for 2002 and 2003 are indeed actual prices.[14] All conversions are based on the US CPI of the associated years. Table 2 includes the price estimates that will be used in the cash flow.

Table 2: Soroosh and Nowrooz Prices

	Soroosh	Nowrooz	Soroosh	Nowrooz
	2001/2006 dollars per barrel	2006 dollars per barrel	1999 dollars per barrel	1999 dollars per barrel
2002	12.59		11.66	
2003	15.09		13.66	
2004	25.31		22.32	
2005	42.54	43.24	36.29	36.89
2006	50.28	50.98	41.55	42.13
2007	51.31	52.01	41.23	41.79
2008	67.85	68.55	52.51	53.05
2009	61.22	61.92	47.54	48.09
2010	58.29	58.99	44.54	45.07

For the contractual cash flow, we use the Soroosh and Nowrooz contractual production profile based on the fields' production forecast curves. For the actual cash flow, we use the actual production profiles of the two fields until 2009.

The contractual production profiles, which we use in this paper, are complete versions of Ghandi and Lin's (forthcoming) contractual production profiles since here in this paper, the contractual production profiles also include production levels for the years before 2004. For the cash flow analysis, it is important to consider the production before 2004.[15] This is because in the Soroosh and Nowrooz buy-back service contract, once production reaches and stays at a certain threshold, the amortization period starts. Based on the contractual production profiles, the amortization period should have been started in 2002 along with the start of production from Soroosh field. Actual production profile also suggests that the amortization did start in 2002.

Remuneration is another parameter of attention in this study. The remuneration consists of additional payments to the IOC as the reward for carrying out the project. In general, IOC and the NIOC agree on the remuneration level in association with the targeted rate of return for the IOC. Its realization in a buy-back service contract is contingent upon successful conclusion of the development and the handing over of the fields to the NIOC. Therefore, as argued by Shiravi & Ebrahimi (2006), the remuneration parameter could also be a source of risk in the buy-back service contract. There are five important considerations in our study regarding the remuneration. First, the contractual value for the remuneration is about $450M. Second, the remuneration fee recovery period is considered 60 months, or 5 years, and we assume the remuneration fee recovery starts after the fields reach full production. We also assume equal percentages of remuneration payments in the five years in order to avoid any arbitrary choice of percentages. Fourth, in our actual cash flow, we need to make sure that Shell has indeed received the remuneration, and since the contract reached the objective, we assume that Shell has received the remunerations in full.[16] Since in the contract, the two fields' cumulative contractual production should have reached the 190,000 barrels/day by 2004, we assume that remuneration payments should have started in 2005.

3 Model and Results

3.1 Contractual and Actual ROR Comparison

In analyzing an IOC's performance in a buy-back service contract and as a case study, we model Shell Exploration's contractual and actual cash flow in its Soroosh and Nowrooz buy-back service contract. Based on these models, we compare Shell's contractual and actual rate of return in this contract. The rate of return is mathematically the rate that gives zero net present value (NPV) of the cash flow. For two reasons, we just rely on the rate of return for our analysis.[17] First, in the buy-back service contract, the NIOC and the IOC agree on a ceiling for the rate of return for the IOC.[18] Second, the discount rate in the net present value formula requires additional assumptions about the IOC's returns expectation on the competing projects or the IOC's perception of the inflation rate in 1999 as well as the IOC's cost of capital. We use these models mainly to show the difference of what Shell signed for and what the company ended up with in terms of rate of return.

In general, a buy-back service contract cash flow in its basic contractual form[19] has three main sections: expenditure (IOC cash out), revenue (payable to IOC calculation) and repayment (IOC cash in). The expenditure part of the cash flow has three main sections including capital cost, non-capital cost and bank charges. The revenue section of the cash flow consists of four elements: a contractual oil price; the contractual production level; operating and maintenance cost; and 60% of contractual profit, which is the maximum possible payable amount to the IOC in each period. The repayment (IOC cash in) section includes total capital cost, compounded interest, total owed to the IOC, remuneration, IOC cash balance and the IOC's contractual rate of return.

In a buy-back service contract, the IOC has also a second rate of return: the actual rate of return that is realized based on the actual cash flow. The actual cash flow[20] accounts for the additional non-recoverable capital cost, delay in construction, some other configurations about bank charges, actual oil prices, production, and the LIBOR. As a result, the IOC's actual rate of return could be substantially different from the contractual ROR.

As shown on Table 3, our contractual cash flow model suggests that Shell signed the contract with a 14.44% rate of return. However, our actual cash flow model reveals that Shell has ended up with a 0.53% actual rate of return, which is significantly lower than the contractual rate of return.

Table 3: Contractual and Actual ROR

Cash Flow	Shell's Rate of Return
Contractual	14.44%
Actual	0.53%

3.2 Risk Analysis

Based on our models of cash flow, we also analyze the buy-back specific contributing risk factors that lead to reduction in the IOC's rate of return (ROR). These risk factors include capital cost, percentages of capital cost spending, operating and maintenance cost, oil price fluctuations, delay in construction, reduction in the oil price, the contractual production level, the LIBOR, and finally the remuneration not being realized.[21]

Once we demonstrate the factors' significant potential of effect, we could argue that not only was the Soroosh and Nowrooz buy-back service contract inefficient, as Ghandi and Lin (forthcoming) found, but the IOC may also face high risk in the buy-back service contracts.

3.2.1 Capital Cost

In order to show the effects of capital cost level changes on the IOC's rate of return, we define five scenarios with 20% and 50% higher or lower capital cost level compared to the contractual level as well as a scenario in which the capital cost is at the actual level. We assume that the changes in the capital cost level happen in the contractual development period with no extended period. Moreover, for the three scenarios with additional capital cost, we assume that the additional capital cost and the associated bank charges are non-recoverable by the IOC. For all the five scenarios, the remuneration remains constant.[22]

Figure 1 represents the effects of capital cost on the rate of return. Compared to the contractual level of 14.44%, increases of 20% and 50% in the capital cost will decrease the ROR to 5.40% and 0.24%, respectively. By itself, the realized actual level of capital cost can decrease the ROR to 0.52%. Therefore, the capital cost is an important risk factor in a buy-back service contract.

Interestingly, even though in the contract Shell could not benefit from a reduction in the capital cost, however, our model shows that 20% and 50% decreases in the capital cost level could increase the rate of return to 16.39% and 21.47%, respectively.[23] This suggests that capital cost reduction had the potential to increase the ROR. It is significant, since as a reward, the NIOC could consider this option to let the IOC benefit from this. Also, the same percentage reduction in the level of capital cost, compared to same percentage increase, has smaller absolute effects on the rate of return.

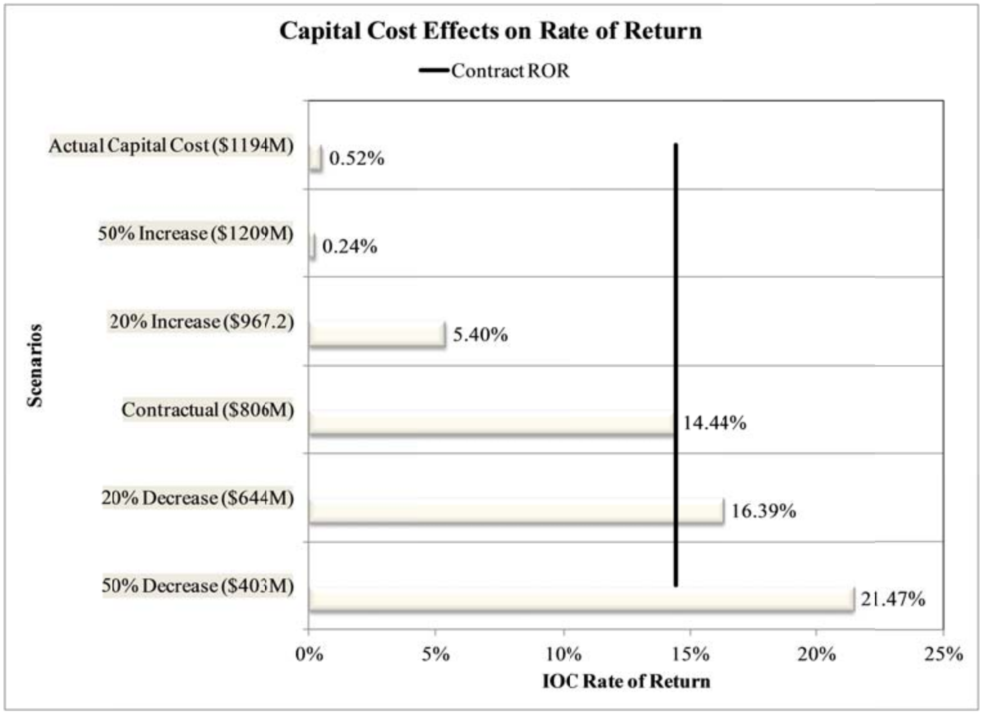

Figure 1: Capital Cost Effects on the IOC's Rate of Return

3.2.2 Capital Cost Percentages

To show the effects of capital cost percentages on the rate of return, as summarized in Table 7, in the appendix (to be posted online), we define eight different investment profiles, and we report their resulting rate of returns holding all else constant.[24]

Figure 2 includes the option plans and their associated rate of return, which suggest that changes in the capital cost percentages could affect the IOC's rate of return. Therefore, capital cost percentage is a risk factor.

Moreover, as shown on the left-hand side of Figure 2, in scenarios one and two, the capital cost levels of the development and the extended period are the same. However, in scenario one, the spending happens in the first year of each period while in scenario two, the spending spreads equally in the years of each period. And in between the two, IOC will benefit of higher ROR by spreading the capital cost.

This and also a comparison of scenarios four and seven which represent two extreme and unlikely possibilities, suggest that the IOC benefits most by postponing the spending towards the later years of development.

However, it may not be feasible to spend all the capital cost in one year at the beginning or at the end of the development and extended periods. As a result, a likely scenario that we actually assume for our models of cash flows relies on equal percentages of capital cost (option plan two).[25]

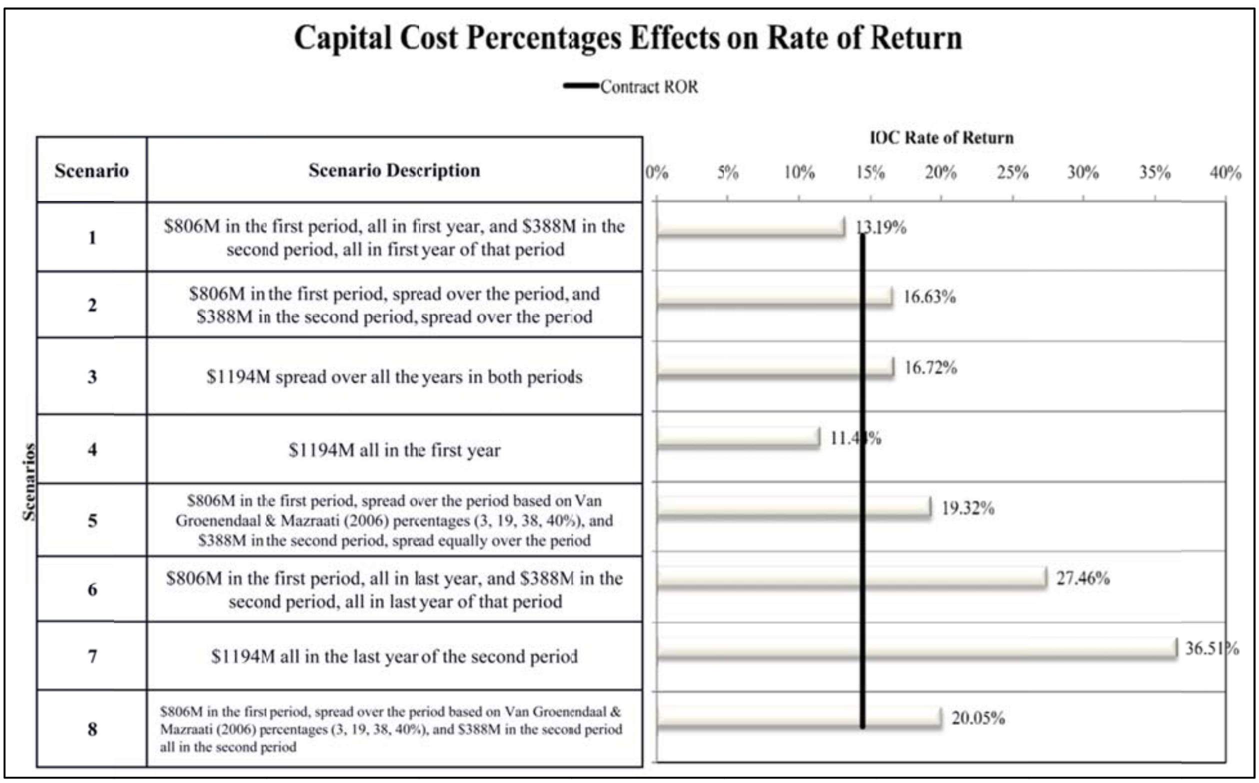

Figure 2: Capital Cost Percentages Effects on the IOC's Rate of Return

3.2.3 Operating and Maintenance Cost

Overall, in 9 different scenarios we investigate the effects of operating and maintenance cost on the ROR in two groups of scenarios: fixed and fluctuating cost.[26] These scenarios are designed to show three possible types of risk related to the operating and maintenance cost. First, it is more likely that in a real cash flow, the NIOC and IOC consider a fixed operating and maintenance cost. However, a wrong fixed cost estimate could affect the IOC's ROR. Therefore, in our fixed group of scenarios, we try a range of operating and maintenance cost from 0.35 to 3.73 dollars/barrel. We find that higher operating and maintenance cost will decrease the IOC's rate of return. But the degree of effect on the rate of return is not large. Second, in reality the cost may fluctuate, which could affect the ROR. In this study, we assume the 0.35 dollars/barrel as the operating and maintenance cost in our contractual cash flow. However, the rate of returns of the 0.35 dollars/barrel and the actual and the optimal operating and maintenance cost scenarios are close to each other. And this suggests that fluctuating cost trends could not change the IOC's ROR in this contract.

Third, the NIOC and the IOC could also consider a potentially fluctuating trend. Therefore, our fluctuating group of scenarios is designed to investigate all possible fluctuating cost trends and their effects on the ROR. The rate of return of our four fluctuating scenarios are all close to each other, and that reinforces that in this contract fluctuating operating and maintenance cost is not a source of risk for the IOC.

Figure 3 includes the scenarios and their associated rate of returns.[27]

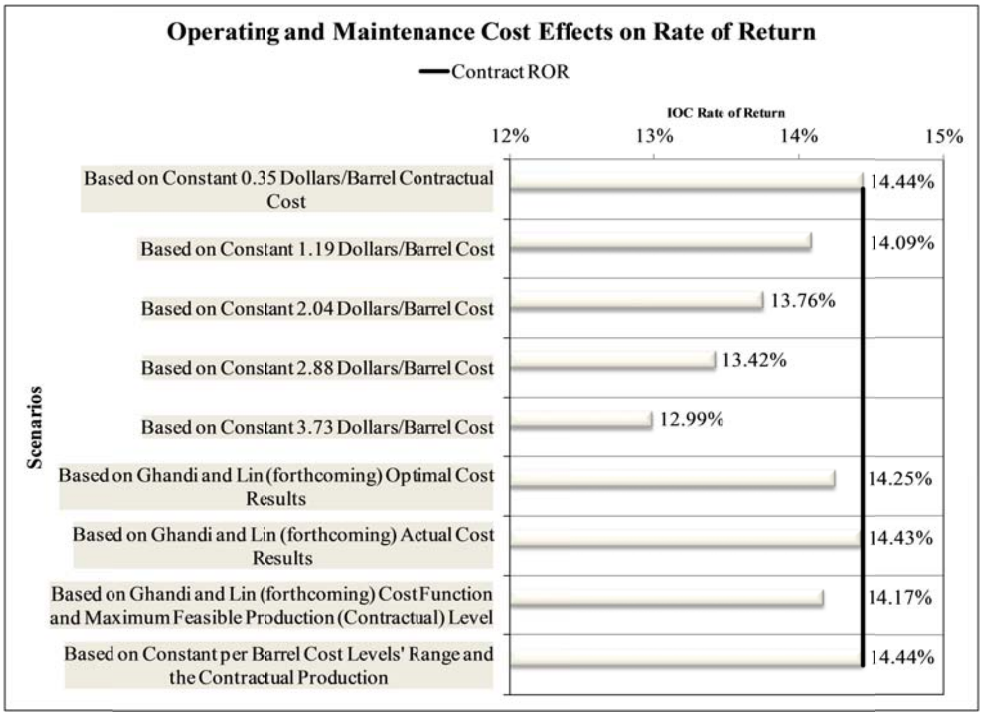

Figure 3: Operating and Maintenance Cost Effects on the IOC's Rate of Return

3.2.4 Delay in Construction

While delay in a complicated oil development project is sometimes unavoidable, the IOC may face great deal of risk if it turns out that the IOC is responsible for the delay. Delay can pose risk through reducing the IOC's rate of return in two ways. First, delay in construction means delay in reaching the contractual production, which affects the revenue of the fields. Lower than expected revenue will also affect the maximum payable amount to the IOC that reduces the IOC's overall rate of return. In other words, the repayments are contingent upon a certain production level starting in a certain year. Not reaching that production level for any reason, including delay in construction, will disrupt the repayments to the IOC. Second, as suggested by Van Groenendaal and Mazraati (2006), if it turns out that the IOC's shortages in some areas have caused the delay, the IOC should bear the bank charges for the period of delay. And that subsequently reduces the rate of return as well.

In order to study the delay parameter as a risk factor, we compare the contractual rate of return with five scenarios' rate of return in which, the contract is delayed/expedited for one to three years. Table 4 and Figure 4 represent these six scenarios and their associated rate of returns. In the delay scenarios, delay means extension of the development period,[28] and we assume that is due to the IOC's fault.[29] As a result, in the delay period, the bank charges should be covered by the IOC.

As shown in Table 4 and Figure 4, one, two and three years' delay in the construction could decrease the rate of return to 12.86%, 12.33% and 10.57%, respectively, compared to a 14.44% contractual rate of return.

On the other hand, even though the IOC in a buy-back service contract cannot benefit from finishing the project earlier than schedule, our two such scenarios suggest that by expediting the development period for one to two years, the IOC could benefit from a 17.35% to 20.49% rate of return compared to the contractual level of 14.44%.

Table 4: Delay in Construction Effects on the IOC's Rate of Return

Scenario		**Two Years Early Termination**	**One Year Early Termination**	**Contractual**	**One Year Delay**	**Two Years Delay (Actual)**	**Three Years Delay**
Main Differences of the Scenarios	Production Starts	2000	2001	2002	2002	2002	2002
	Development Period Ends	2000	2001	2002	2003	2004	2005
	Remuneration Starts	2002	2004	2005	2005	2006	2007
Delay Effects on Rate of Return		**20.49%**	**17.35%**	**14.44%**	**12.86%**	**12.33%**	**10.57%**

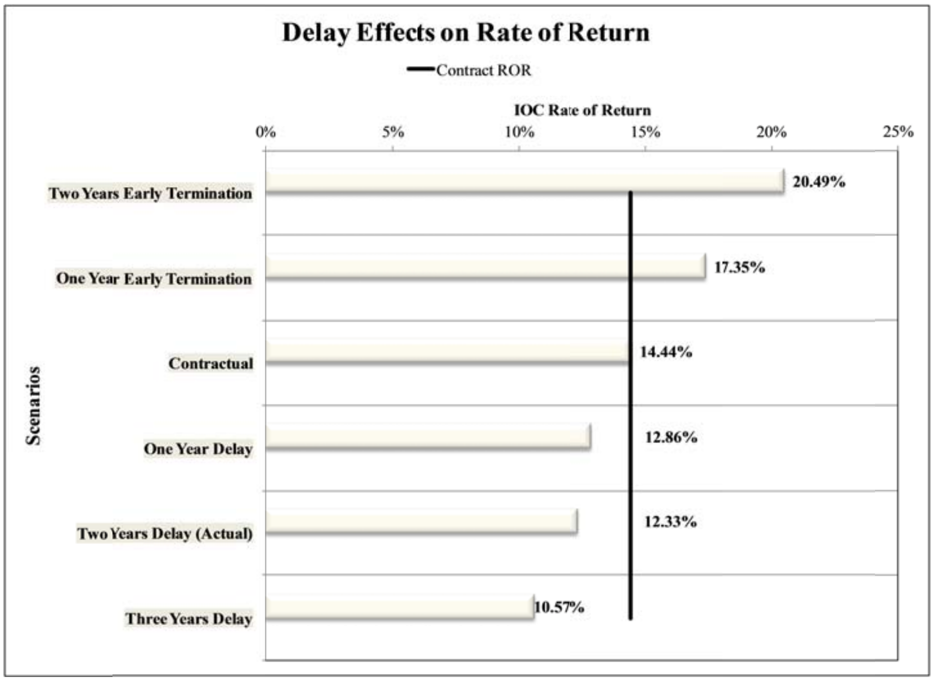

Figure 4: Delay in Construction Effects on the IOC's Rate of Return

3.2.5 Oil Price

Among the risk factors, oil price, production profile and the LIBOR rate all share some common features, and we use similar methodology for them. In general, the changes in the rate of return through these three parameters occur in two different ways including the change in the level of the variables as well as the timing of those changes.

Figure 5 shows the oil price scenarios and their associated rate of returns. The scenarios can be divided into three main groups plus an actual oil price scenario. In the first group, we use different oil price trends in all the years of amortization. We find that an oil price 20% lower than contractual in all the years has larger absolute effects in terms of reducing the IOC ROR compared to a scenario with an oil price 20% higher than contractual in all the years. In this group, we also have two paired increasing/decreasing trend scenarios with mixed results. While a simple increasing trend has slightly higher absolute effects in increasing the IOC ROR compared to a simple decreasing scenario, a scenario with an increasing trend from the beginning followed by a decreasing trend from the middle year has smaller absolute effects compared to a scenario when the decreasing trend starts from the beginning followed by an increasing trend from the middle year.

In the second group of scenarios, we have an oil price one year 20% lower or higher than the contractual level. Among these scenarios, the timing of the changes is important. In particular, we find that an oil price 20% lower or higher than contractual in the first and last year of the amortization period has no effects on the IOC ROR. However, similar changes in the middle year of the amortization could change the ROR to 14.26% (14.57% for higher scenario). The same way, an oil price 20% lower or higher than contractual in the year of start of repayment could reduce/increase the IOC ROR to 14.23% or14.66%, respectively, compared to a 14.44% contractual level.

In the third group, we have an oil price 20% lower or higher than contractual in the two consecutive years with the start of the repayment. Among these scenarios, we find that a scenario with an oil price 20% higher than contractual has larger absolute effects than a scenario with an oil price 20% lower than contractual. Also, a scenario with an oil price 20% lower in the first year and 20% higher in the second year could reduce the IOC ROR to 14.37%[30] while a vice versa situation could increase the IOC ROR to 14.52%.

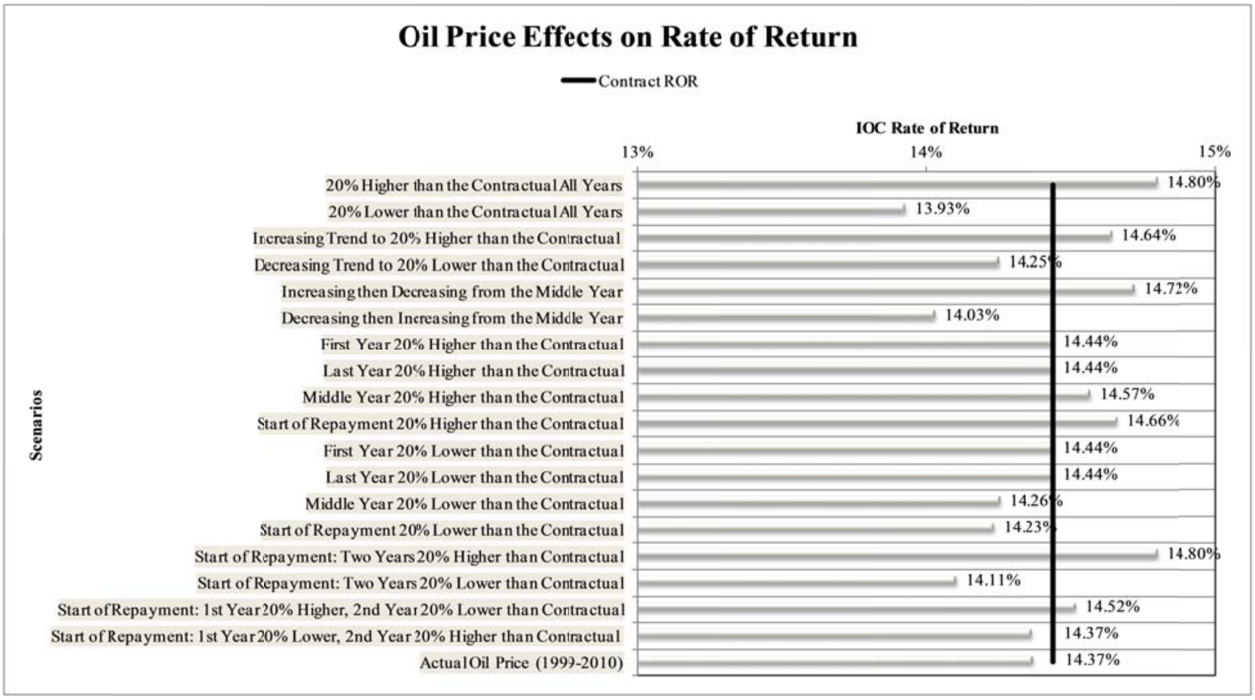

Figure 5: Oil Price Effects on the IOC's Rate of Return

3.2.6 Production Profile

Similar to the oil price scenarios, the production scenarios represent cases with small changes in the production level as well as the timing effects of those changes. Overall, the production scenarios results are very similar to their counterparts in the oil price section.[31] Here, we still have all three groups of scenarios in addition to an actual production profile scenario. In the first group, we have investigated the effects of having the production level 20% lower or higher in all the years of amortization. Similar to the oil price scenarios, we find that production level 20% lower than contractual in all the years have larger absolute effects in terms of reducing the IOC ROR compared to a scenario with production level 20% higher than contractual in all the years. In the second group, we have shown the effects of changing the production level for one year in different points of time. We find that changes in the last year of amortization have no effects on the rate of return. However, 20% production level lower or higher than the contractual level, in the start year of repayment, could reduce or increase the IOC ROR to 14.23% or14.66%, respectively. These effects are slightly higher than the effects of similar such changes in the middle year of amortization. Therefore, regarding the timing of changes, we find the start of the repayment year as the most important year of the amortization period. In the third group, we have two similar scenarios in which the production level for two consecutive years from the start of repayment is higher in the first year and lower in the second year (or vice versa). For this scenario, we find similar results as described for the oil price. Finally, our actual production profile scenario shows that production profile by itself can reduce the IOC ROR to 12.73%.

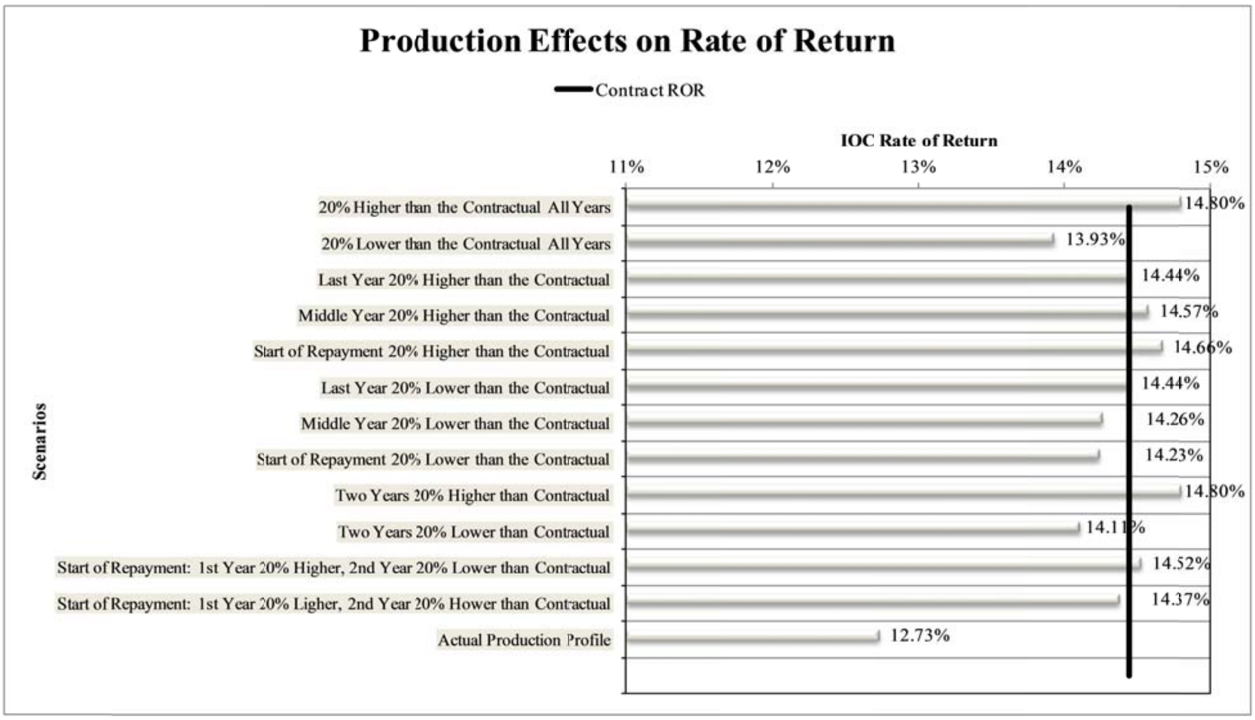

Figure 6: Production Effects on the IOC's Rate of Return

3.2.7 LIBOR

Figure 7 includes the LIBOR related scenarios and their associated rate of returns. Similar to the oil price and production parameters, in several groups of scenarios, we investigate the effects of changes in the LIBOR on the rate of return and the effects of the timing of those changes.

In the first group of scenarios, the LIBOR trend is different from the contractual level in all the years of amortization. We find that LIBOR 20% lower than contractual in all the years have smaller absolute effects in terms of reducing the IOC ROR compared to a scenario with LIBOR 20% higher than contractual in all the years. In this group, we also have two paired increasing/decreasing trend scenarios. The scenario with simple increasing trend has slightly higher absolute effects in increasing the IOC ROR compared to a simple decreasing scenario. Also, a scenario with an increasing trend from the beginning followed by a decreasing trend from the middle year has larger absolute effects compared to a scenario when the decreasing trend starts from the beginning followed by an increasing trend from the middle year.

In the second group of scenarios, we have LIBOR one year 20% lower or higher than the contractual level. Similar to oil price and production parameters, the timing of changes in the LIBOR is important since, for example, LIBOR 20% lower or higher than contractual in the first and last year of the amortization period has no effects on the IOC ROR. In contrast, similar changes in the middle year of the amortization period could change the ROR to 14.29% or14.59%, respectively. In the start of repayment LIBOR 20% lower or higher than contractual could change the ROR to 14.26% or 14.63%, respectively, compared to a 14.44% contractual level.

In the third group and in two scenarios, we have the LIBOR 20% lower or higher than the contractual level in the two consecutive years with the start of the repayment. However, these changes have almost no effects on the rate of return. Interestingly, our actual LIBOR scenario reveals that reduction in the LIBOR could reduce the IOC ROR to 12.72%.

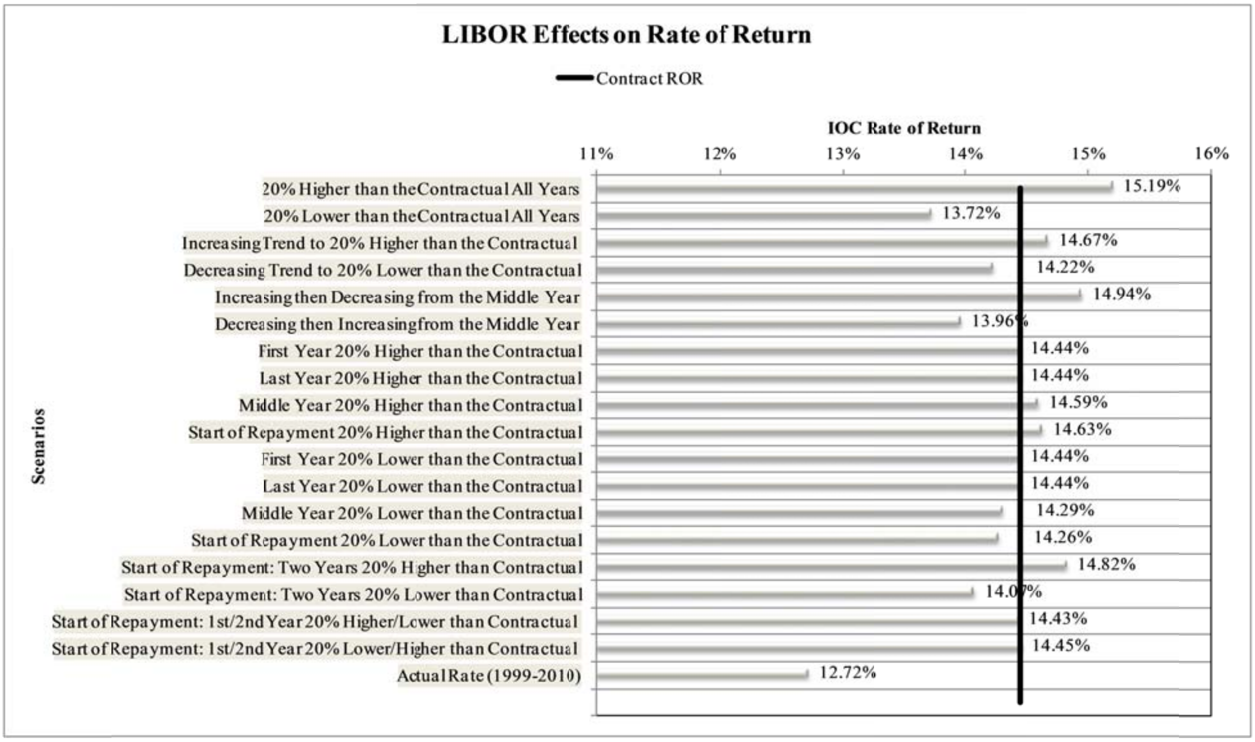

Figure 7: LIBOR Effects on the IOC's Rate of Return

3.2.8 Remuneration Not Being Realized

The realization of the remuneration in the buy-back service contract is contingent upon successful conclusion of the development and handing over the fields to the NIOC. This implies that if for any reason the IOC could not achieve the contractual objectives, there is the possibility that the remuneration may not be paid. In order to investigate such a scenario, we take out the remuneration in our contractual cash flow, and we compare the associated rate of return with the contractual. In comparison with a 14.44% contractual rate of return, without remuneration, the rate of return will reach 6%.

3.2.9 Contribution of Actual Level of Each of the Risk Factor to Total Potential Decrease in the ROR

In order to see the contribution of the actual level of each risk factor to the total potential reduction of the actual ROR, as shown on Table 5 and Figure 8, in separate scenarios, we measure the effects of the actual levels of each of the risk factors holding everything else constant. Overall we find that capital cost has the largest potential effect with a 71.2% contribution to the total potential ROR reduction.[32]

Table 5: Actual Level of Risk Factor Effect on Rate of Return

Actual Risk Factor	Percentage Points Change with Respect to Contractual ROR	Contribution of Actual Level of Risk Factor to Total Potential Change in ROR
Capital Cost	-13.92%	71.20%
Delay	-2.12%	10.81%
Operating and Maintenance Cost	-0.01%	0.06%
Oil Price	-0.07%	0.36%
Production	-1.71%	8.75%
LIBOR	-1.73%	8.82%

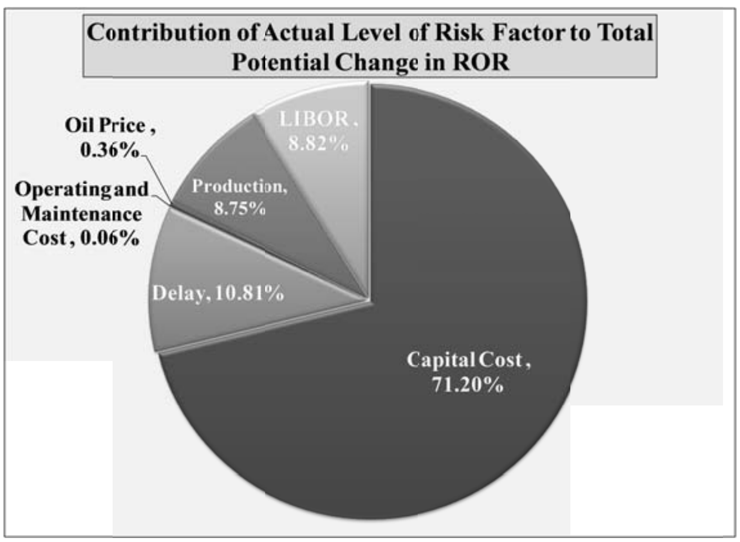

Figure 8: Contribution of Actual Level of Risk Factor to Total Potential Change in ROR

3.3 Risk-Sharing Cash Flow

Based on our analysis of Shell's Soroosh and Nowrooz buy-back service contract as well our personal interactions with the NIOC staff, Shell's actual rate of return is significantly lower than its contractual ROR. This suggests that there are potentially high risks involved in buy-back service contracts. The difference between the Shell's actual and contractual rate of return also represents uncertainty, which may prevent many IOCs from cooperating with the NIOC through the buy-back framework. However, in this paper, we look at the contractual design issues, and we argue that even in the buy-back framework there are ways to alleviate the degrees of risk for the IOCs. For that, we propose a risk-sharing cash flow modeling in which the NIOC shares more risks with the IOC. Figure 9 represents our risk-sharing scenarios and their rate of returns. For a risk-sharing scenario, we have two distinct periods of development. In addition to that, we consider two distinct possibilities for each of three variables.

The first variable is capital cost overrun. As was discussed, in the Soroosh and Nowrooz buy-back service contract, the capital cost overrun was not covered by the NIOC. A possible modification in order to reduce the IOC's risk is for the NIOC to cover the additional cost. Therefore, in the risk-sharing cash flow, we could consider the two possibilities of the cost overrun being covered by the NIOC or not.

The second variable regards bank charges in the case of delay in construction. Based on our personal communication with the NIOC staff, in this contract, it was the case that Shell covered the bank charges in the extended development period since Shell was responsible for the delay. That subsequently decreased Shell's rate of return on this contract. As a result, in a risk-sharing framework, we consider two possibilities of whether the NIOC covers the bank charges in the extended period or not.

The third variable is the remuneration in the case of cost overrun. In general, even though the remuneration in the Soroosh and Nowrooz buy-back service contract is $450M fixed, as argued by Van Groenendaal and Mazraati (2006), remuneration is about 60% of the contractual capital cost. However, in the case of capital cost overrun, the current buy-back framework does not allow any changes in the remuneration. As a modification, we could consider a situation that the remuneration increases proportionally with the increase in the capital cost.

These three variables with their possibilities allow us to define 8 types of risk-sharing cash flow in which the NIOC and the IOC share, to some extent, the risk due to the cost overrun or delay by increasing the IOC's ROR.

The rates of return for the different risk-sharing scenarios are presented in Figure 9. The scenario in which the cost overrun is non-recoverable, the IOC pays the interest during the delayed period and a fixed remuneration depicts the actual cash flow of Soroosh and Nowrooz. The rest of the scenarios could be used by the NIOC to incentivize the IOC to participate in buy-back service contracts by reducing the risk and allowing changes in the rate of return in some special cases. In particular, regarding the capital cost, among the three parameters listed, if the NIOC just covers the additional cost, Shell could have reached a more acceptable rate of return at 7.47% compared to the low level of 0.53%. A risk-sharing framework in which the NIOC was covering the additional cost, bearing the interest in the delay period and paying a fixed remuneration would have let the IOC to reach a 10.43% rate of return. If the NIOC let the remuneration increase proportionally with the capital cost increase, bore the interest of the delay period and covered the additional cost, the IOC could have reached a 13.28% rate of return. This level is very close to the contractual level. Therefore, it is indeed possible to follow a more flexible framework in which the IOC avoids risks by getting its contractual rate of return while the contract reaches its objective as well.

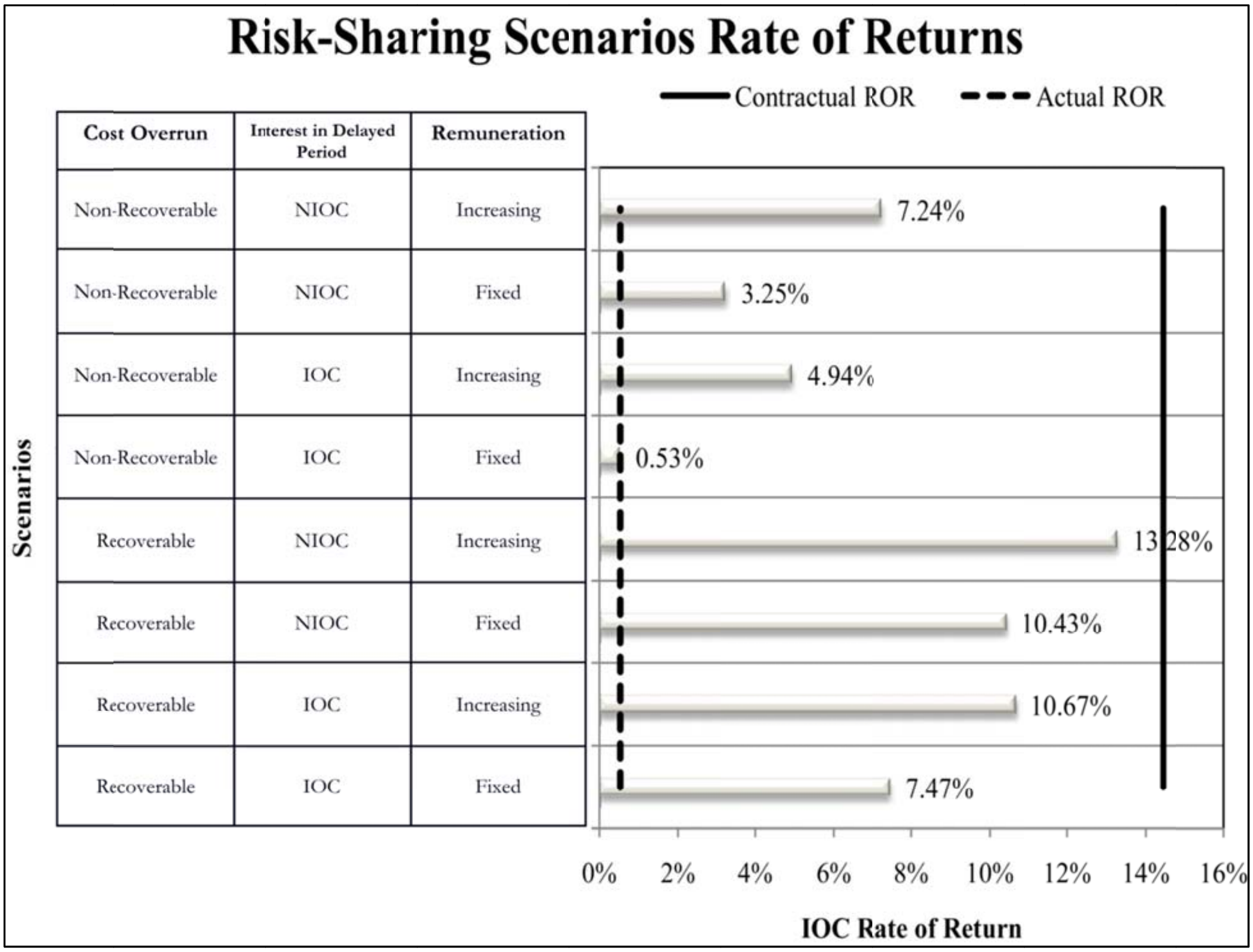

Figure 9: Risk-Sharing Scenarios Rate of Returns

4 Conclusion and Discussion

As summarized in Table 3, our models of actual and contractual cash flows of Soroosh and Nowrooz buy-back service contract reveal that Shell Exploration has suffered a very low actual rate of return compared to the contractual level. This finding clearly suggests that the IOC in a buy-back service contract may face very high degrees of risk. By analyzing the risk factors as shown on Figure 1 to Figure 7, we conclude that all the risk factors are capable of reducing the IOC's rate of return, and therefore we recognize them as risk factors.

In order for the NIOC to share more risk with the IOC, as shown on Figure 9, we conclude that there is a potential for modifying the contracts to better share the risk, while still remaining in the framework of buy-back service contract. In particular, we show that when a buy-back service contract faces cost overrun or delay, the NIOC could reduce the risk for the IOC by letting the remuneration to increase proportionally with the capital increase, bearing the interest of the delay period and covering the additional cost.

Our estimate of Shell's contractual rate of return, at 14.44%, is indeed in the approximate range of expected rate of return in other service type contracts in Iran and Iraq, as listed on Table 6. However, our estimate of Shell's actual rate of return in this contract, 0.53%, as discussed above, is not only very low compared to the contractual ROR, it might also be even lower than the minimum expected rate of return that IOCs generally would be willing to accept.[33]

Table 6: International Oil Companies' Expected Rate of Return in Iran and Iraq

Country	Type of Contract	International Oil Companies' Expected Rate of Return	Source
Iran	Buy-Back Service Contract	12%-15%	Van Groenendaal and Mazraati, (2006)
Iran	Buy-Back Service Contract	16%	Shiravi abd Ebrahimi, (2006)
Iraq	Technical Service Contract	12%-22%	Sankey, Clark, & Micheloto, (2010)

The low actual rate of return Shell received may lead one to ask why Shell decided to invest in this project and agree to such terms in a buy-back service contract in the first place.

To answer, while we could never know for sure on what criteria this decision was based, the circumstances surrounding the contract might help to explore some explanations for Shell's decision. These circumstances include the lack of exploration risk, the size of the investment, outcomes that were unforeseen by Shell, and the involvement of other entities in the contract to share the risks and low rate of return. In what follows, we explore each of these circumstances.

First, this contract was a developing contract without any exploration phase. The lack of an exploration phase, which meant the lack of exploration and geological risks, might have been one important factor in favor of accepting the terms of buy-back service contract by Shell. As shown in this paper, the buy-back framework has some inherent contractual risk in addition to geopolitical risk of doing business in Iran. However, it seems that Shell might have been trying to offset its higher contractual and geopolitical risk with the absence of geological risk in its buy-back service contract by a 14.44% contractual rate of return. In other words, the 14.44% contractual ROR might have allowed Shell to tolerate higher geopolitical degrees of risk. This is also a reasonable objective for IOCs to try to spread their risks especially since they face geological risks in other areas like the Gulf of Mexico or the North Sea. Going forward, this particular buy-back framework might not be attractive enough for the IOCs to do both exploration and development.[34] The existence of geological risks in the exploration phase may make it necessary for the NIOC to find ways to better share the risk with the IOCs based on some variations of this study's risk-sharing framework.

Second, for a major IOC like Shell, $806 million might not be considered a large investment. And as long as the actual ROR was not negative, Shell could afford to not gain much on this relatively small investment. This even makes more sense considering Shell looked at this investment as an initial step of long-term presence in Iran with potentially high future gains. However, the complications of the relation with Iran and new rounds of sanctions by the international community have forced Shell to leave the country without achieving its long-term objectives.

As a third explanation and since the Soroosh and Nowrooz particular buy-back framework was new, and it had never been tested before, there is a possibility that Shell did not foresee the outcomes of the contract. As discussed in this paper, the capital cost overrun was a reason for the low actual rate of return. And probably capital cost overrun is the most important risk factor in the buy-back service contract. Interestingly, the NIOC has started a new policy regarding the capital cost in its recent contract with Sinopec International Petroleum E&P Corporation to develop Iran's Yadavarn field. In this new policy, the IOC is allowed to determine the capital cost ceiling up to two years after the start of the project.[35] This policy will minimize the chances of a capital cost overrun, and it will keep the ROR from decreasing. In other words, this policy eventually should reduce the degree of risks in new buy-back service contracts. Such change in the contract might reinforce the possibility that the outcomes of the contract were unforeseeable for Shell in the beginning.

As for the fourth explanation, it is the case that in the Soroosh and Nowrooz buy-back service contract, other parties including a group of Japanese companies (Japan Petroleum Exploration Co., Ltd. (JAPEX), 2006) as well as an Iranian company (Oil Industries' Engineering and Construction (OIEC), 2002) bought up to 30% of the interest from Shell. This suggests that Shell might have been able to share the low actual rate of return with other entities. Regarding the involvement of other entities, what happened in the Soroosh and Nowrooz buy-back service contract could be used in order to establish a guideline or an amendment in buy-back service contracts for a situation in which the IOC faces a higher than usual loss in the rate of return. The involvement of other entities could happen in different levels and scales for different reasons. For example, regarding the risk associated with the LIBOR, banks could get more involved. For risks associated with the production rate or operating and maintenance cost, since they are related to the NIOC, involvement of government entities or other companies, like the Iranian company in the case of Soroosh and Nowrooz, could be considered.

Our risk-sharing cash flow methodology also opens the door for other types of modifications in buy-back service contracts. In what follows three such modifications are discussed.

As the first modification, the NIOC could consider a limited open ROR policy in the buy-back service contracts. The NIOC could think of this as rewards for the IOCs who could fulfill certain objectives in favor the project. For example, since we have argued that delay in construction is a risk factor for the IOC, in cases that the IOC finishes the job sooner than it was expected, as shown on Figure 4, the IOC ROR could be increased. Therefore, in such situation, the NIOC should allow the IOC to benefit from the higher ROR as a reward. This way, we may even go further and argue a new name for such contracts such as a risk and rewards contract, or a risk and rewards buy-back service contract.

Another modification could be to put a lower bound on the IOC's ROR in these contracts. In order to keep the ROR above certain minimum level, 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. Such design of the contract might require assessing the optimal degree of risk-sharing between the NIOC and the IOC and in accordance with determining the maximum and minimum contractual ROR. It is also important to remember that the risk-sharing framework in development versus exploration and development contracts might not necessarily be the same.

As a third modification, since there is a wide range of possible modifications to buy-back service contracts, NIOC could offer different types of risk-sharing contracts to different IOCs. That is important because it is the case that not all the IOCs are the same regarding their ability of carrying out complicated oil and natural gas exploration and development projects. In addition, since the NIOC uses the buy-back framework for exploration projects, it can offer a risk-sharing contract as a reward for the IOCs that carry the exploration successfully.

5 References

Bindemann, K. (1999). *Production Sharing Agreements: An Economic Analysis.* Oxford Institute for Energy Studies. Oxford Institute for Energy Studies.

Energy Information Administration [EIA], (1996). Oil production capacity expansion costs for the Persian Gulf. Retrieved January 29, 2011 from http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/oil_production_expansion_cost_persian_gulf/pdf/tr0606.pdf

Gao, W., Hartley, P. R., & Sickles, R. C. (2009). Optimal dynamic production from a large oil field in Saudi Arabia. *Empirical Economics , 37* (1), 153-184.

Ghandi, A., & Lin, C.-Y.C. (forthcoming). Do Iran's Buy-Back Service Contracts Lead to Optimal Production? The Case of Soroosh and Nowrooz. *Energy Policy*.

Japan Petroleum Exploration Co., Ltd. (JAPEX). (2006). *JAPEX Annual Report 2006*. Retrieved March 2011, from: http://www.japex.co.jp/pdf/ir/library/anual_report/2006e.pdf

Marcel, V. (2006). *Oil Titans National Oil Companies in the Middle East.* Brookings Institution Press.

Middle East Economic Survey. (2005, August 1). Zanganeh Inaugurates Soroush/Nowruz Fields. *A Weekly Review of Energy, Finanance and Politics*.

Oil Industries' Engineering and Construction (OIEC). (2002). *Soroosh and Nowrooz*. Retrieved March 2011, from: http://www.oiecgroup.com/pr/projects/sor_nor.aspx

Platts Oilgram News. (July 26, 2010). *Iran*. As reported from Shana News Agency. Retrieved March 16, 2011 from LexisNexis Academic.

Sankey, P., Clark, D. T., & Micheloto, S. (2010). *The Mother of All Oil Stories.* Deutsche Bank.

Shiravi, A., & Ebrahimi, S. N. (2006). Exploration and development of Iran's oilfields through buyback. *Natural Resources Forum , 30* (3), 199-206.

Van Groenendaal, W. J., & Mazraati, M. (2006). A critical review of Iran's buyback contracts. *Energy Policy , Volume 34, Issue 18*, 3709-3718.

Wolfensberger, M., & Critchlow, A. (2005). Shell loses $100M at Iran field. Gulf times. Retrieved March 15, 2011 from http://www.gulf-times.com/site/topics/printArticle.asp?cu_no=2&item_no=44192&version=1&template_id=48&parent_id=28

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[2] In this paper, we use the IOC's rate of return (ROR) in order to analyze an IOC's performance in a buy-back service contract. We also use the ROR to study the contract's risk factors and their effects on the IOC's rate of return and to propose some modifications in the buy-back framework.

[3] We do not consider other risks including geology, geopolitical, sanctions, domestic economical and political instability and inflation/recession related effects.

[4] 799 million dollars

[5] Even though the differences of the reported values are not high, we could justify taking the highest end of the range by assuming that $806M was the total recoverable capital cost.

[6] These are the capital cost percentages.

[7] Personal communication with NIOC staff, September 2009.

[8] These estimates have been converted to 1999 real dollars.

[9] Shiravi & Ebrahimi (2006) suggest a 0.75% premium.

[10] Van Groenendaal & Mazraati (2006) consider a 6.5% LIBOR and a 1% premium in their model of cash flow.

[11] Overall, in our cash flow models, we need a LIBOR rate in two separate places. First, in the expenditure part of the cash flow, at the end of each year, we calculate the total owed to the IOC, which includes the total capital invested by the end of that year plus the interest over the last year's total owed. Then, in the repayment section of the cash flow, total owed to the IOC is calculated annually, with the consideration that there is still the interest incurred

on the remaining total owed to the IOC, which includes the remaining of the principal investment and compounded interest.

[12] The estimates have been converted to 1999 dollars.

[13] This estimate has also been converted from 2004 to 1999 dollars.

[14] 2002 and 2003 estimates based on 2001 dollars have also been converted to 1999 dollars.

[15] We consider 58,000 and 62,000 barrels/day cumulative contractual production for the years 2002 and 2003 respectively.

[16] This does not contradict the fact that Shell had to fund the non-recoverable additional capital cost beyond the contractual level.

[17] In showing the effects of the delay as a risk factor, Van Groenendaal and Mazraati (2006) also report the IOC's net present value for a 10% discount rate as well as return on invested capital as the division of sum of the remuneration and bank charges by the capital cost.

[18] That means that the rate of return cannot exceed the contractual or targeted value. However, it can be lower.

[19] The basic idea for the contractual cash flow is to mimic the real Soroosh and Nowrooz buy-back service contract cash flow. However, since we do not have access to the real one, we decide on the components of the contractual cash flow in such a way to be as close as possible to the terms of the contract.

[20] In this paper, since the payback to the IOC has ended in 2009/2010, by setting-up the cash flow based on 2009 realized values, we are able to capture Shell's actual rate of return.

[21] These are all risk factors since they have the potential of reducing the IOC's rate of return in a buy-back service contract.

[22] However, in the Risk-Sharing Cash Flow section, we show the effect of the possibility of a proportionate increase in the remuneration in accordance with increase of the capital cost.

[23] This is mostly due to the lower IOC's cash-out (capital cost level) as well as the assumption that in case of capital cost reduction, remuneration will still be fixed at the contractual level.

[24] We have discussed these investment profiles in the appendix (to be posted online).

[25] We use option plan two in order to avoid any arbitrary choice for the cash flow of Soroosh and Nowrooz buy-back service contract, and since it yields intermediate rate of return compared to other options. This means that in our contractual cash flow, we spread the contractual capital cost equally to the contractual years of the contract. For the

actual cash flow, we will have two separate periods with two different percentages. In the first period (contractual), we spread the contractual capital cost equally while for the second period, we do the same with the additional capital cost in the extended development period.

[26] In the appendix (to be posted online), we first discuss our methodology for calculating fixed operating and maintenance cost in four options. We then use these options' cost values to define five scenarios to examine different constant cost levels' effects on the rate of return. To do that, in our four options and based on the literature, we find a range for the operating and maintenance cost. Then by knowing the lower and higher bound, we select the other three operating and maintenance costs from within this range in an evenly spaced manner. In the next step, we define four scenarios, which yield fluctuating cost trends.

[27] Another consideration in the operating and maintenance cost scenarios regards constant versus current dollars. In the operating and maintenance cost tables and scenarios, whenever it was necessary, we convert the current dollars to 1999 dollars in order to be consistent with the contractual cash flow. For the Group one scenarios, we do not have any conversion since in this group of scenarios, the goal was to find the upper and lower bounds for the operating and maintenance cost levels. And even for the EIA based level, which is based on 1996 dollars, we just use the same values as reported by the EIA. In Group two, for scenarios 6, 7 and 8, we convert the cost results to 1999 dollars. Scenario 9 has no conversion neither since it is based on constant cost level scenarios.

[28] Even though one of the fields reached early production in 2002, the contract faced delay mostly due to the extension of the development period. Therefore, in the delay scenarios, we keep production the same as in the contract, and we only change the end of the development period and the start of remuneration payments. For the capital cost, we assume that it does not change, but the percentage is changing in accordance with the total years of development in each scenario. This way, in each scenario and in each year of development, the capital cost spending is equal to the other years' of that scenario.

[29] That means that the IOC should bear the extra bank charges of this period. In the case of promptness of the IOC for one or two years in finishing the development period, we just reschedule the repayments accordingly. While the disruption in the IOC's repayments due to the delay is an unavoidable risk for the IOC, the NIOC could cover the bank charges of the delay period. We discuss the possibility of such a modification in the contract in the Risk-Sharing Cash Flow section.

[30] This scenario has resulted in the same ROR as in the actual oil price scenario. That is due to the fact that the actual oil price in the year of the start of the repayment is lower than contractual, and it is higher in the second year of the start of the repayment.

[31] Except for the actual production profile scenario

[32] It is important to remember that in the actual ROR calculation, more than one risk factor is in effect, and sometimes these risk factors are capable of increasing the ROR.

[33] Personal communications with Chevron Corporate Strategic Planning staff, March 2011.

[34] Personal communications with NIOC staff, September 2009.

[35] Personal communications with NIOC staff, September 2009.