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Original Paper

Modelling the Iranian Petroleum Contract fiscal regime using bargaining game theory to guide contract negotiators

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ABSTRACT

Based on Iran's sixth development plan, the country's oil and gas industry requires an investment of about $200bn in the next five years to increase production. The Iranian government, to attract and motivate international oil company investment in their oil and gas fields, has presented a new type of risk service contract: the Iranian Petroleum Contract (IPC). This paper summarizes the features of the IPC and presents mathematical models of its fiscal regime for the benefit and guidance of both the National Iranian Oil Company (NIOC) and the contractors. Next, adopting bargaining game theory provides a mathematical model for reaching a win-win situation between the NIOC and the contractor. Finally, a numerical example is given and a sensitivity analysis performed to illustrate the implementation of the proposed models. The contractor and the NIOC may use these models when preparing their proposal and in the course of actual negotiations to calculate their internal rate of return, remuneration fee, and net present value for developing the fields at different conditions of their bargaining power, and derive a logical bargain to protect their best possible interests.

1. Introduction

Iran ranks number one in the world with respect to combined oil and natural gas reserves (BP, 2019). However, it ranks only ninth among oil-producing countries with respect to oil production, accounting for only 3% of the world's total oil production. Realizing this gap, and in order to increase oil production and improve world ranking in keeping with Iran's sixth development plan, a $200bn[1] investment in the NIOC's oil and gas industries is needed within five years to develop new fields and increase the recovery factor of mature fields by employing new techniques such as enhanced oil recovery and improved oil recovery systems. In this connection, the NIOC is determined to attract international oil companies (IOCs) to invest in its oil and gas fields by using buyback or IPC contracts.

A buyback contract is a type of service contract which has served as the main framework in developing Iran's oil and gas fields for more than a decade. At least twenty-five contracts based on this method have been signed between the NIOC and IOCs for the development of Iranian oil and gas upstream projects, and some significant research has been completed.

Marcel (2006) reviewed the terms of buyback contracts and compares their differences with production sharing agreements. Shiravi and Ebrahimi (2006) provided a comprehensive analysis of Iranian buyback contracts, including the history of service contracts in Iran from 1974, their main features, and the risks taken by IOCs. Van Groenendaal and Mazraati (2006) formulated a buyback service contract cash flow. Ghandi and Lin (2012) presented a dynamically optimal oil production model for buyback contracts of the Soroosh and Nowrooz fields. Ghandi and Lawell (2017) analyzed the rate of return (ROR) and risk factors for the Shell company in developing the Soroosh and Nowruz fields under buyback service contract and discover Shell's ROR was lower than the contractual value, suggesting that the impact of capital cost overruns is predominant. Li et al. (2017) presented an updated review of operational risks of Iran's buyback contract. Perhaps most significantly, Wood Mackenzie (2015) reports that, of contracts signed on a buyback basis, only one in eight reached the expected ROR. Clearly, this would be an important concern for IOCs.

As buyback contracts, despite three rounds of revision, continued to face seemingly inherent obstacles in absorbing foreign

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[1] US dollars are used throughout this analysis.

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investment, the NIOC designed a new type of contract: the Iranian Petroleum Contract. The general conditions, structure and fiscal regime of the IPC were approved by the Iranian government in 2016. The NIOC signed its first contract based on this model for the development and production of the South Pars phase 11 gas field on July 3rd, 2017, with a consortium consisting of the French firm Total, China's CNPC and Petropars of Iran. Thereafter, the NIOC signed five contracts using the IPC framework, with Pasargad (for developing the Sepehr and Jofeir oil fields) and with Persia oil and gas industry (for developing the Yaran oil field), among others.

Studies devoted to reviewing the IPC, as a new type of contract introduced in 2016, are still limited. Ghorbani (2020) studied the legislative background of IPC contracts. Ebrahimi and Shahmoradi (2017) examined the decisions of various oil-producing countries' legal systems in response to a number of legal proceedings encountered by oil and gas industries, and make a comparative analysis among them with an emphasis on the IPC.

Soleimani and Tavakolian (2017) compared the fiscal regime of buyback with the IPC using a number of financial metrics such as internal rate of return (IRR), net present value (NPV) and discounted payback period. In this research they show that the IPC is more attractive to contractors than a buyback contract. Sahebhonar et al. (2016) use the technical information of the Sardare Jangal field as a case study to simulate the fiscal regime of IPC, reveals that the contractor's take is small, about 8% calculated in discounted manner, with a maximum IRR of 14.6%; they argue this shows the service nature of the contract. This also indicates that the fiscal regime is regressive at oil prices of lower than $50, and is progressive at higher prices.

Sahebhonar et al. (2017) analyzed the fiscal features of the IPC of Darquin oil field, showing that the contractor's take is very low at around three percent. In addition, the contractor's IRR cannot be more than 14.6% irrespective of increasing in oil price. Farimani et al. (2020) analyze the financial provisions of the IPC with technical information from a real oil field located in the south of Iran and conclude the IPC is more like a service contract than a production sharing contract: the contractor's take is low in general and less than five percent. The analysis also indicates that the IPC is a progressive contract, in the sense that as the outcome of the project improves, the government's share of its economic rent increases.

None of the aforementioned studies, in reviewing the IPC, presents a mathematical model of its fiscal regime. These studies use a VBA spreadsheet to run a simulation and to analyze cash flow. Also, they assume the remuneration fee is to be determined and adjusted by R-factor, whereas in the finalized version of the IPC the R-factor is eliminated from the contract. Moreover, in all these studies it is assumed that the contractor and the NIOC have already reached a mutual agreement on the expected IRR, while in practice they must first negotiate to reach an agreement on the contractor's expected IRR and other aspects of the contract. This process will sometimes lead to heavy, lengthy negotiations. In such cases, the bargaining game theory approach is a powerful tool for seeking a win-win solution.

Kıbrıs (2010) reviewed different types of bargaining problems and the characterizations of the Nash rule (Nash Jr, 1950), the Kalai-Smorodinsky rule (Kalai and Smorodinsky, 1975) and the Egalitarian rule (Kalai, 1977) bargaining problems. This paper adopts the Kalai-Smorodinsky approach for modelling the negotiation between the contractor and the NIOC since, by contrast with the Nash rule, the Kalai-Smorodinsky bargaining solution takes into account not only the worst trade outcome (i.e. the disagreement point), but also the best trade outcome (i.e. the maximum profit) of each negotiation party. Also, Li (2020) showed that the Kalai-Smorodinsky bargaining solution appropriately captures most influencing elements—including the negotiation power shift induced by the decision makers, the negotiation sequence, the vertical relationship, the competition intensity, the contract contingency and the contract type—in the contract negotiations. This approach is also used in different studies such as Bao et al. (2015), Rezaee et al. (2016) and Wang and Li (2014).

This paper, in addition to summarizing the features of the IPC and comparing it with buyback contracts, also introduces two models which may be considered as its contributions to literature in this field.

The first model derives a mathematical model of the IPC fiscal regime for the NIOC and the contractor by considering the limitations and constraints for repayment of costs as provided in the contract. In accordance with the formula presented in this paper, the contractor's remuneration fee per barrel of production is calculated based on the contractor's expected IRR, in order to maximize NPV.

This model relies upon the assumption that the contractor and the NIOC have reached mutual agreement on an expected IRR. However, reaching such an agreement during the course of actual negotiations can in reality be a very lengthy and tedious task. Therefore, a second model can be derived, applying bargaining game theory to the application of the first model. This provides both the contractor and the NIOC with a readily available mathematical tool for calculating and attending to their logical best interests, with consideration of their respective bargaining powers, during the negotiation process.

A case study of an Iranian oil field is also conducted to illustrate the implementation of the proposed models. The result of sensitivity analysis shows that among different risk factors, the direct capital cost and production profile have the most important impacts on reducing the contractor's expected IRR. This paper also concludes with recommendations for making the IPC more attractive to the contractors.

For this purpose, a brief overview and outline of the IPC for the development of upstream projects is illustrated and then the difference between the IPC and the buyback contract is described. Next, by focusing on the fiscal regime of the IPC, mathematical models for the fiscal regime and cash flow of the NIOC and the contractor are presented. Third, a mathematical bargaining model for reaching a win-win solution between the NIOC and the contractor is developed through the bargaining game theory approach. Finally, a numerical example and a sensitivity analysis are performed to illustrate the implementation of proposed model.

2. The salient features of IPC in comparison with the buyback contract

The IPC is based upon the general conditions, structure, and model of upstream oil and gas contracts approved by the Iranian government in 2016 in the form of a bylaw. This bylaw defines the contractual details, fiscal regime, and terms and conditions for the IPC. As with the buyback contract, the IPC is a type of risk service contract securing Iran's control over its oil and gas resources. In this model, the contractor performs all activities for and on behalf of the NIOC, not as an owner or partner of the project.

Under the IPC mechanism, the contractor undertakes to provide all funds and capital for carrying out the exploration, development, and production phases. One of the most important features of the IPC is that the contractor produces oil directly from the field during the production phase. This feature distinguishes the IPC from other service contracts concluded in Iran, such as buyback contracts, in which the coverage of the contract was limited to only exploration and development phases, with the NIOC taking over the project on production commencement and carrying out operations. Contractors in these cases argued this was not the business they looked for, as they preferred to conduct production by themselves. Therefore, the NIOC decided to award contracts based on the IPC instead of the buyback model.

The bylaw limits the duration of the IPC contract to a maximum of 20 years for development and production operation activities, significantly more than in the traditional buyback contract with a four- to seven-year duration to the completion of the development phase. In the IPC, the contractor is entitled to recover its investments, operations costs, and remuneration fee after achieving the first targeted production figure (FTP) declared in the contract. The contactor's remuneration fee is based on the production of each barrel for crude oil, or each 1000 cubic feet for gas. By contrast, in buyback contracts, the remuneration fee was a fixed amount calculated via the fixed rate of return of the project, and the contractor did not gain or lose by any increase or decrease in the production of oil or gas.

In the IPC, the contractor can either be a fully Iranian company/companies or a consortium of an IOC with at least one Iranian company. That is to say, the IOC is obliged to form a consortium with at least one Iranian exploration and production company—a provision intended to transfer technology to Iranian companies. The IOC must promote and improve the capabilities and abilities of the Iranian party in reservoir engineering and management, managing oil and gas megaprojects, and managing oil and gas assets (including project economics and project bankability), and must empower the Iranian party to operate the production facilities independently. Table 1 summarizes the main differences between the IPC and the buyback contract.

3. Model

In the IPC, the contractor and the NIOC negotiate on the expected IRR of the project in order to calculate the contractor's remuneration fee to maximize the NPV. This model leads to calculation of the fee per barrel of production and consequently the NPV of the project through IRR.

Notably, the expected IRR will not be mentioned in the contract and only the fee per barrel is fixed and included therein. In other words, the expected IRR is the basis for calculating a fixed remuneration fee per barrel of production and maximum NPV. This is why the IPC is a risk service contract, in which the contractor's future IRR may be lower or higher than what it was at the time of negotiation, depending on another variable: the amount of production.

The direct capital cost (DCC), the indirect cost (IDC), the operation expenditure (OPEX), the remuneration fee, and the cost of money (COM), are the main fiscal elements of the IPC as described below:

The direct capital cost (DCC) refers to all capital costs and expenditures required for the development, improved oil/gas recovery and enhanced oil/gas recovery of the reservoir, including all managerial, engineering, drilling and construction of all surface and subsurface facilities.

The indirect cost (IDC) refers to all the costs to be paid to the government, ministries and public organizations such as taxes, levies, custom duties, social security charges, etc.

The operation expenditure (OPEX), also known as operation cost, is all the contractor's costs, based on the terms of the contract and accounting standards, in performing the production operations.

The remuneration fee is an agreed amount per barrel of incremental production of crude oil produced from the fields as a result of the contractor's endeavors.

The cost of money (COM) is applied to any late payments to which the contractor is entitled according to the terms and conditions of the contract. It is calculated based on the London Interbank Offered Rate (LIBOR), plus a percentage up to a maximum of "x" percent in total (COM = LIBOR + x%).

3.1. Contractor's cash outflow

The contractor's cash outflow in IPC includes direct capital costs, indirect costs and operation costs. Let's denote DDC_i, IDC_i and $OPEX_i$ to designate the direct capital costs, indirect costs and operation costs of the ith year, i=1,2, …,20, respectively. CO_i denotes the contractor's cash outflow to develop the field, for year i, and is calculated as follows:

$$CO_i = DCC_i + IDC_i + OPEX_i \tag{1}$$

3.2. Contractor's cash inflow

The contractor's cash inflow in the IPC includes reimbursement of costs (direct capital costs, indirect costs and operation costs) plus the payment of remuneration fees, and any applicable costs of money. The recovery of these items starts only after the contractor produces a specified number of barrels of crude oil per day from the field. In other words, recovery starts in the year when the contractor achieves the FTP amount from the field; this is designated the "year of FTP". Therefore, the total payment to the contractor is as follows:

$$Tr_i = rdcc_i + ridc_i + ropex_i + fee_i + rcom_i \quad i = FTP, \ldots, 20 \tag{2}$$

where Tr_i, $rdcc_i$, $ridc_i$, $ropex_i$, fee_i and $rcom_i$ denote the total amount of recoverable money by the contractor, the recovery of direct costs, the recovery of indirect costs, the recovery of operation costs, the payment of remuneration fees and the recovery of cost of money of ith year, respectively.

3.2.1. Recovery of direct capital costs

The direct capital cost is amortized in equal instalments over a certain number of cost-recovery years, as specified in the IPC. All instalments of direct capital costs before FTP will be paid in the FTP year, and the instalments of direct capital costs after that will be covered on a current basis. Designating N as the cost-recovery year:

Table 1
Main differences between the IPC and the buyback contract.

	IPC	buyback contract
Phases	exploration, development and production	exploration and development only
Duration	up to 20 years	4–7 years
Remuneration	based on fee per barrel of production	based on IRR
Contractor's partnership	IOCs with at least one Iranian E&P company. Or fully Iranian E&P companies	no condition

$$rdcc_{\mathrm{FTP}} = \sum_{i=1}^{\mathrm{FTP}} \sum_{\mathrm{r}=1}^{N} \frac{DCC_{i-\mathrm{r}}}{N} \tag{3}$$

$$rdcc_i = \sum_{\mathrm{r}=1}^{N} \frac{DCC_{i-\mathrm{r}}}{N} \quad i = FTP+1, FTP+2, \ldots, 20 \tag{4}$$

where $rdcc_{\mathrm{FTP}}$ is the recovery of summation of all instalments of direct capital costs before year of FTP, and $rdcc_i$ is the recovery of instalments of direct capital costs of year i.

3.2.2. Recovery of indirect costs

All indirect costs paid by the contractor before FTP will be recovered in the first targeted production year, and the indirect costs paid by the contractor after achieving FTP will be recovered on a current basis as follows:

$$ridc_{\mathrm{FTP}} = \sum_{i=1}^{\mathrm{FTP}} IDC_i \tag{5}$$

$$ridc_i = IDC_i \quad i = FTP+1, FTP+2, \ldots, 20 \tag{6}$$

where $ridc_{\mathrm{FTP}}$ and $ridc_i$ denote the recovery of all indirect costs before first targeted production, and the recovery of indirect costs after first targeted production of ith year.

3.2.3. Recovery of operation costs

The procedure for recovering operation costs is the same as the procedure for recovering indirect costs. Therefore, all operation costs paid by the contractor before FTP will be recovered in the year of FTP, and the operation costs paid by the contractor after achieving the first targeted production will be recovered on a current basis as follows:

$$ropex_{\mathrm{FTP}} = \sum_{i=1}^{\mathrm{FTP}} OPEX_i \tag{7}$$

$$ropex_i = OPEX_i \quad i = FTP+1, FTP+2, \ldots, 20 \tag{8}$$

where $ropex_{\mathrm{FTP}}$ is the recovery of all operation costs before FTP and $ropex_i$ is the recovery of operation costs after FTP in year i.

3.2.4. Remuneration fee

The contractor's remuneration fee in IPC is based on the annual production volume in barrels, multiplied by the contracted fee per barrel. Therefore, the remuneration fee is calculated as follows:

$$fee_i = fpb \times Q_i \quad i = 1, 2, \ldots, 20 \tag{9}$$

where fee_i denotes the contractor's remuneration in year i, Q_i is the production at year i, and fpb denotes the remuneration fee per barrel.

3.2.5. Cost of money

The cost of money is calculated from the date on which the direct capital costs and indirect costs are incurred, until they are recovered. The cost of money will not apply to operation costs and fees, because they are to be recovered by the contractor on a current basis. The cost of money will apply to operation costs and fees only in situations where they are not recovered on current basis. The contractor's cost of money is calculated as follows:

$$com_i = Libor\left[\sum_{i=1}^{i}[(DCC_{i-1} + \mathrm{IDC}_{i-1} + OPEX_{i-1} + fee_{i-1} + com_{i-1} - TR_{i-1}) + 0.5Libor[(DCC_i + \mathrm{IDC}_i + OPEX_i + fee_i + com_i - TR_i)] \quad i = 1, 2, \ldots, 20 \right. \tag{10}$$

where com_{i} is the cost of money of year i, and $Libor$ is the London Inter-bank Offered Rate plus x percent. The recovery of cost of money starts after first production; therefore,

$$rcom_{\mathrm{FTP}} = \sum_{i=1}^{\mathrm{FTP}} com_i \tag{11}$$

$$rcom_i = com_i \quad i = FTP+1, FTP+2, \ldots, 20 \tag{12}$$

3.2.6. Total payment to the contractor

By substituting models (3), (5), (7), (9) and (11) in model (2), the total payment to the contractor in first production year becomes:

$$Tr_{\mathrm{FTP}} = \sum_{i=1}^{\mathrm{FTP}} \sum_{\mathrm{r}=0}^{N-1} \frac{DCC_{i-\mathrm{r}}}{N} + \sum_{i=1}^{\mathrm{FTP}} IDC_i + \sum_{i=1}^{\mathrm{FTP}} OPEX_i + fpb \times Q_{\mathrm{FTP}} + \sum_{i=1}^{\mathrm{FTP}} com_i \tag{13}$$

By substituting models (4), (6), (8), (9) and (12) in model (2), the total payment to the contractor after first production year becomes:

$$Tr_i = \sum_{\mathrm{r}=0}^{N-1} \frac{DCC_{i-\mathrm{r}}}{N} + IDC_i + OPEX_i + fpb \times Q_i + com_i \quad i = FTP+1, FTP+2, \ldots, 20 \tag{14}$$

3.2.7. Recovery constraint

Without considering any limitation in reimbursement, the total payment to the contractor is the summation of reimbursements of direct capital cost, indirect costs, operation costs, remuneration fees and the cost of money as shown in models (13) and (14). However, there are two elements which limit the amount of the payment allocated to the contractor.

The first limitation is that the costs, the remuneration fees, and the cost of money are to be recovered through an allocation of 50% of project revenue in each year; therefore, the total recovery for the contractor in each year is limited to a maximum 50% of project revenue, as follows:

$$CI_i = \left(\sum_{i=\mathrm{FTP}}^{i} Tr_i - \sum_{i=\mathrm{FTP}}^{i} CI_{(i-1)}\right) y_i + (0.5P_iQ_i)(1-y_i) \quad i = FTP, FTP+1, \ldots, 20 \tag{15}$$

$$CI_i \le \sum_{i=\mathrm{FTP}}^{i} Tr_i - \sum_{i=\mathrm{FTP}}^{i} CI_{(i-1)} \quad i = FTP, FTP+1, \ldots, 20 \tag{16}$$

$$CI_i \le 0.5P_iQ_i \quad i = FTP, FTP+1, \ldots, 20 \tag{17}$$

where CI_i is the maximum possible amount payable to the contractor based on the IPC defined ceiling of 50% of project revenue for each year. P_{i} denotes the oil price, Q_i denotes the production from field and y_i is a binary variable, $y_i \in \{0,1\}$.

Model (15) ensures that the amount of money to be paid to the contractor is the summation of all unrecovered payments, or 50% of the project revenue in year *i*. Model (16) ensures that the amount of money to be paid to the contractor is equal to or less than the sum of unrecovered payments to the contractor. Model (17) ensures that the amount of money to be paid to the contractor is equal or less than 50% of the project revenue in each year, referred to as "cost stop constraint" in the IPC.

The second limitation is that the contractor's expected IRR shall not exceed a fixed percentage. Therefore, the NPV of a contractor based on an agreed IRR should be zero:

$$-\sum_{i=1}^{20}\frac{(CO_i)}{(1+irr)^i}+\sum_{i=1}^{20}\frac{CI_i}{(1+iir)^i}=0 \tag{18}$$

where *irr* is an IRR agreed upon during negotiations between the NIOC and the contractor.

3.3. The contractor's objective function

The contractor's objective value is the NPV of the difference between its cash outflow and cash inflow. Therefore, the NPV for the project from the contractor's point of view is as follows:

$$NPV_{\mathrm{CTR}} = -\sum_{i=1}^{20}\frac{(\mathrm{CO}_i)}{(1+r)^i} + \sum_{i=1}^{20}\frac{CI_i}{(1+r)^i} \tag{19}$$

where *r* is the discount rate.

3.4. The NIOC's objective function

The NIOC's objective value is the NPV of the difference between its revenue and the total payment to the contractor. Therefore, the NPV for the project from the NIOC's point of view is as follows:

$$NPV_{\mathrm{NIOC}} = \sum_{i=1}^{20}\frac{P_iQ_i-CI_i}{(1+r)^i} \tag{20}$$

3.5. The contractor's net present value

The contractor's main objective in the IPC fiscal regime is to attain a fee per barrel such as to maximize its NPV. According to the present model, both the contractor's cash inflow and outflow are expressed as the functions of fee per barrel. Model (21) presents the IPC fiscal regime for the project from the contractor's point of view, determining the contractor's maximum NPV and the amount of fee per barrel under the IPC contract:

$$\max NPV_{\mathrm{CTR}} = -\sum_{\mathrm{i=1}}^{20}\frac{(\mathrm{CO_i})}{(1+r)^{\mathrm{i}}}+\sum_{\mathrm{i=1}}^{20}\frac{CI_{\mathrm{i}}}{(1+r)^{\mathrm{i}}} st: Tr_{\mathrm{FTP}} = \sum_{\mathrm{i=1}}^{\mathrm{FTP}}\sum_{\mathrm{r=0}}^{N-1}\frac{DCC_{\mathrm{i-r}}}{N} + \sum_{\mathrm{i=1}}^{\mathrm{FTP}} IDC_{\mathrm{i}} + \sum_{\mathrm{i=1}}^{\mathrm{FTP}} OPEX_{\mathrm{i}} + fpb\times Q_{\mathrm{FTP}} + \sum_{\mathrm{i=1}}^{\mathrm{FTP}} com_{\mathrm{i}} Tr_{\mathrm{i}} = \sum_{\mathrm{r=0}}^{N-1}\frac{DCC_{\mathrm{i-r}}}{N} + IDC_{\mathrm{i}} + OPEX_{\mathrm{i}} + fpb\times Q_{\mathrm{i}} + com_{\mathrm{i}}$$

$$i = FTP+1, FTP+2, \ldots, 20 Tr_{\mathrm{i}} = 0 \quad i < FTP com_{\mathrm{i}} = Libor\left[\sum_{\mathrm{i=1}}^{\mathrm{i}}[(DCC_{\mathrm{i-1}} + \mathrm{IDC_{i-1}} + OPEX_{\mathrm{i-1}} + fee_{\mathrm{i-1}} + com_{\mathrm{i-1}} - TR_{\mathrm{i-1}}) + 0.5Libor[(DCC_{\mathrm{i}} + \mathrm{IDC_i} + OPEX_{\mathrm{i}} + fee_{\mathrm{i}} + com_{\mathrm{i}} - TR_{\mathrm{i}}) \times\right] \quad i = 1,2,\ldots,20 CI_{\mathrm{i}} = \left(\sum_{\mathrm{i=FTP}}^{\mathrm{i}} Tr_{\mathrm{i}} - \sum_{\mathrm{i=FTP}}^{\mathrm{i}} CI_{(\mathrm{i-1})}\right)y_{\mathrm{i}} + (0.5P_{\mathrm{i}}Q_{\mathrm{i}})(1-y_{\mathrm{i}})$$

$$i = FTP, FTP+1, \ldots, 20 CI_{\mathrm{i}} \le \sum_{\mathrm{i=FTP}}^{\mathrm{i}} Tr_{\mathrm{i}} - \sum_{\mathrm{i=FTP}}^{\mathrm{i}} CI_{(i-1)} \quad i = FTP, FTP+1, \ldots, 20 CI_{\mathrm{i}} \le 0.5P_{\mathrm{i}}Q_{\mathrm{i}}$$

$$i = FTP, FTP+1, \ldots, 20 \quad -\sum_{\mathrm{i=1}}^{20}\frac{(CO_{\mathrm{i}})}{(1+irr)^{\mathrm{i}}}+\sum_{\mathrm{i=1}}^{20}\frac{CI_{\mathrm{i}}}{(1+iir)^{\mathrm{i}}} = 0 Tr_{\mathrm{i}}, fpb, com_{\mathrm{i}}, CI_{\mathrm{i}} \ge 0$$

$$i = FTP, FTP+1, \ldots, 20 \; y_{\mathrm{i}} \in \{0,1\} \quad i = FTP, FTP+1, \ldots, 20 \tag{21}$$

3.6. The NIOC's net present value

The NPV of the project from the NIOC's point of view is as follows:

$$\max NPV_{\mathrm{NIOC}} = \sum_{\mathrm{i=1}}^{20}\frac{P_{\mathrm{i}}Q_{\mathrm{i}}-CI_{\mathrm{i}}}{(1+r)^{\mathrm{i}}} st: Tr_{\mathrm{FTP}} = \sum_{\mathrm{i=1}}^{\mathrm{FTP}}\sum_{\mathrm{r=0}}^{N-1}\frac{DCC_{\mathrm{i-r}}}{N} + \sum_{\mathrm{i=1}}^{\mathrm{FTP}} IDC_{\mathrm{i}} + \sum_{\mathrm{i=1}}^{\mathrm{FTP}} OPEX_{\mathrm{i}} + fpb\times Q_{\mathrm{FTP}} + \sum_{\mathrm{i=1}}^{\mathrm{FTP}} com_{\mathrm{i}} Tr_{\mathrm{i}} = \sum_{\mathrm{r=0}}^{N-1}\frac{DCC_{\mathrm{i-r}}}{N} + IDC_{\mathrm{i}} + OPEX_{\mathrm{i}} + fpb\times Q_{\mathrm{i}} + com_{\mathrm{i}} \quad i = FTP+1, FTP+2, \ldots, 20 Tr_{\mathrm{i}} = 0 \quad i < FTP com_{\mathrm{i}}$$

$$= Libor\left[\sum_{\mathrm{i=1}}^{\mathrm{i}}[(DCC_{\mathrm{i-1}} + \mathrm{IDC_{i-1}} + OPEX_{\mathrm{i-1}} + fee_{\mathrm{i-1}} + com_{\mathrm{i-1}} - TR_{\mathrm{i-1}}) + 0.5Libor[(DCC_{\mathrm{i}} + \mathrm{IDC_i} + OPEX_{\mathrm{i}} + fee_{\mathrm{i}} + com_{\mathrm{i}} - TR_{\mathrm{i}}) \times\right] \quad i = 1,2,\ldots,20 CI_{\mathrm{i}} = \left(\sum_{\mathrm{i=FTP}}^{\mathrm{i}} Tr_{\mathrm{i}} - \sum_{\mathrm{i=FTP}}^{\mathrm{i}} CI_{(\mathrm{i-1})}\right)y_{\mathrm{i}} + (0.5P_{\mathrm{i}}Q_{\mathrm{i}})(1-y_{\mathrm{i}})$$

$$i = FTP, FTP+1, \ldots, 20 CI_{\mathrm{i}} \le \sum_{\mathrm{i=FTP}}^{\mathrm{i}} Tr_{\mathrm{i}} - \sum_{\mathrm{i=FTP}}^{\mathrm{i}} CI_{(\mathrm{i-1})} \quad i = FTP, FTP+1, \ldots, 20 CI_{\mathrm{i}} \le 0.5P_{\mathrm{i}}Q_{\mathrm{i}} \quad i = FTP, FTP+1, \ldots, 20$$

$$-\sum_{\mathrm{i=1}}^{20}\frac{(CO_{\mathrm{i}})}{(1+irr)^{\mathrm{i}}}+\sum_{\mathrm{i=1}}^{20}\frac{CI_{\mathrm{i}}}{(1+iir)^{\mathrm{i}}} = 0 Tr_{\mathrm{i}}, fpb, com_{\mathrm{i}}, CI_{\mathrm{i}} \ge 0 \quad i = FTP, FTP+1, \ldots, 20 y_{\mathrm{i}} \in \{0,1\} \quad i = FTP, FTP+1, \ldots, 20 \tag{22}$$

3.7. Bargaining game theory

The previous section assumes the NIOC and the contractor have mutually agreed upon on the IRR. However, in a real-world situation, and especially in the course of contractual negotiations, it is not so easy and simple to reach such an agreement. In such circumstances, bargaining game theory is a powerful approach to seek a compromise and a win-win solution between the NIOC and the

Table 2
Data for development of a field.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DCC ($MM)	79	331	655	594	531	441	333	196	44	61	61	67	74	0	0	0	0	0	0	0
Opex ($MM)	0	4	12	56	96	90	92	93	95	95	117	93	94	93	90	89	88	88	86	85
IDC ($MM)	8	33	66	59	53	44	33	20	4	6	6.1	7	7	0	0	0	0	0	0	0
Production (Mbbl/d)	0	3	9	39	66	99	134	150	150	150	150	150	150	150	150	81	69	59	50	44

contractor. In the bargaining model, the players negotiate upon the NPV (as objective function) and based on that, the fee per barrel and the IRR will be calculated.

Assume IRR^N is the NIOC's desired IRR, and IRR^C is the contractor's desired IRR. Both parties bargain to achieve their optimal IRR until they agree on a compromise value.

For a two-party game (following the axiomatic model of Kavlak et al. (2009), which is based in turn on the Kalai-Smorodinsky rule) the bargaining objective function of the NIOC and the contractor is defined as follows:

$$\text{argmaxmin}\left\{\left(\frac{NPV_{\text{NIOC}}-NPV^{L}_{\text{NIOC}}}{NPV^{U}_{\text{NIOC}}-NPV^{L}_{\text{NIOC}}}\right)^{w_1},\left(\frac{NPV_{\text{CTR}}-NPV^{L}_{\text{CTR}}}{NPV^{U}_{\text{CTR}}-NPV^{L}_{\text{CTR}}}\right)^{w_2}\right\} \tag{23}$$

Where $NPV_{\text{CTR}}, NPV^{L}_{\text{NIOC}}, NPV^{U}_{\text{CTR}}, NPV_{\text{NIOC}}, NPV^{L}_{\text{CTR}}, NPV^{U}_{\text{NIOC}}$ denote the contractor's NPV, the NIOC's undesired NPV, the contractor's desired NPV, the NIOC's NPV, the contractor's undesired NPV and the NIOC's desired NPV, respectively. In addition, w_1 and w_2 are in turn the bargaining power weights for the NIOC and the contractor. The terms in parentheses in model (23) are the bargaining values for the NIOC and the contractor, respectively. Naturally a higher weighted bargaining value is more desirable for both the NIOC and the contractor. The elementary value proposed in model (23) is the normalized distance of the involved party from their respective undesired solution (Kavlak et al., 2009). The bargaining objective function, then, aims to maximize the minimum normalized distances of the objective function values of NPV_{NIOC} and NPV_{CTR} from NPV^{L}_{NIOC} and NPV^{L}_{CTR}, respectively. The overall bargaining model of the IPC is as follows:

$$\begin{aligned}
&\text{maxmin}\left\{\left(\frac{NPV_{\text{NIOC}}-NPV^{L}_{\text{NIOC}}}{NPV^{U}_{\text{NIOC}}-NPV^{L}_{\text{NIOC}}}\right)^{w_1},\left(\frac{NPV_{\text{CTR}}-NPV^{L}_{\text{CTR}}}{NPV^{U}_{\text{CTR}}-NPV^{L}_{\text{CTR}}}\right)^{w_2}\right\}\\
&st:\\
&NPV_{\text{CTR}}=-\sum_{i=1}^{20}\frac{(\text{CO}_i)}{(1+r)^i}+\sum_{i=1}^{20}\frac{CI_i}{(1+r)^i}NPV_{\text{NIOC}}=\sum_{i=1}^{20}\frac{P_iQ_i-CI_i}{(1+r)^i}w_1\\
&\quad+w_2=10Tr_{\text{FTP}}\\
&\quad=\sum_{i=1}^{\text{FTP}}\sum_{\text{r}=0}^{N-1}\frac{DCC_{i-\text{r}}}{N}+\sum_{i=1}^{\text{FTP}}IDC_i+\sum_{i=1}^{\text{FTP}}OPEX_i+fpb\times Q_{\text{FTP}}\\
&+\sum_{i=1}^{\text{FTP}}com_iTr_i=\sum_{\text{r}=0}^{N-1}\frac{DCC_{i-\text{r}}}{N}+IDC_i+OPEX_i+fpb\times Q_i+com_i\\
&\quad i=FTP+1,FTP+2,\ldots,20Tr_i=0\quad i<FTPcom_i\\
&\quad=Libor\left[\sum_{i=1}^{i}[(DCC_{i-1}+\text{IDC}_{i-1}+OPEX_{i-1}+fee_{i-1}+com_{i-1}\right.\\
&\quad-TR_{i-1})+0.5Libor[(DCC_i+\text{IDC}_i+OPEX_i+fee_i+com_i\\
&\quad-TR_i)]\quad i\\
&\quad=1,2,\ldots,20CI_i\\
&\quad=\left(\sum_{i=\text{FTP}}^{i}Tr_i-\sum_{i=\text{FTP}}^{i}CI_{(i-1)}\right)y_i+(0.5P_iQ_i)(1-y_i)\\
&\quad i=FTP,FTP+1,\ldots,20CI_i\\
&\quad\le\sum_{i=\text{FTP}}^{i}Tr_i-\sum_{i=\text{FTP}}^{i}CI_{(i-1)}\qquad i=FTP,FTP+1,\ldots,20CI_i\\
&\le 0.5P_iQ_i\quad i=FTP,FTP+1,\ldots,20-\sum_{i=1}^{20}\frac{(CO_i)}{(1+irr)^i}+\sum_{i=1}^{20}\frac{CI_i}{(1+iir)^i}\\
&=0fpb\le fpb^*_{\text{CTR}}fpb\ge fpb^*_{\text{NIOC}}Tr_i,fpb,com_i,CI_i\ge 0\quad i\\
&\quad=FTP,FTP+1,\ldots,20y_i\in\{0,1\}\quad i=FTP,FTP+1,\ldots,20
\end{aligned} \tag{24}$$

The objective function of model (24) is nonlinear due to the max-min problem. It can be transformed to a linear problem as follows:

$$\begin{aligned}
&\max B\\
&st:\\
&B\le\left(\frac{NPV_{\text{NIOC}}-NPV^{L}_{\text{NIOC}}}{NPV^{U}_{\text{NIOC}}-NPV^{L}_{\text{NIOC}}}\right)w_1\\
&B\le\left(\frac{NPV_{\text{CTR}}-NPV^{L}_{\text{CTR}}}{NPV^{U}_{\text{CTR}}-NPV^{L}_{\text{CTR}}}\right)w_2\\
&NPV_{\text{CTR}}=-\sum_{i=1}^{20}\frac{(\text{CO}_i)}{(1+r)^i}+\sum_{i=1}^{20}\frac{CI_i}{(1+r)^i}NPV_{\text{NIOC}}\\
&\quad=\sum_{i=1}^{20}\frac{P_iQ_i-CI_i}{(1+r)^i}w_1+w_2=10Tr_{\text{FTP}}=\sum_{i=1}^{\text{FTP}}\sum_{\text{r}=0}^{N-1}\frac{DCC_{i-\text{r}}}{N}\\
&\quad+\sum_{i=1}^{\text{FTP}}IDC_i+\sum_{i=1}^{\text{FTP}}OPEX_i+fpb\times Q_{\text{FTP}}+\sum_{i=1}^{\text{FTP}}com_iTr_i\\
&\quad=\sum_{\text{r}=0}^{N-1}\frac{DCC_{i-\text{r}}}{N}+IDC_i+OPEX_i+fpb\times Q_i+com_i\quad i=FTP\\
&+1,FTP+2,\ldots,20Tr_i=0\quad i<FTPcom_i\\
&\quad=Libor\left[\sum_{i=1}^{i}[(DCC_{i-1}+\text{IDC}_{i-1}+OPEX_{i-1}\right.\\
&+fee_{i-1}+com_{i-1}-TR_{i-1})+0.5Libor[(DCC_i+\text{IDC}_i+OPEX_i\\
&\quad+fee_i+com_i-TR_i)]\quad i\\
&\quad=1,2,\ldots,20CI_i\\
&\quad=\left(\sum_{i=\text{FTP}}^{i}Tr_i-\sum_{i=\text{FTP}}^{i}CI_{(i-1)}\right)y_i+(0.5P_iQ_i)(1-y_i)\quad i
\end{aligned}$$

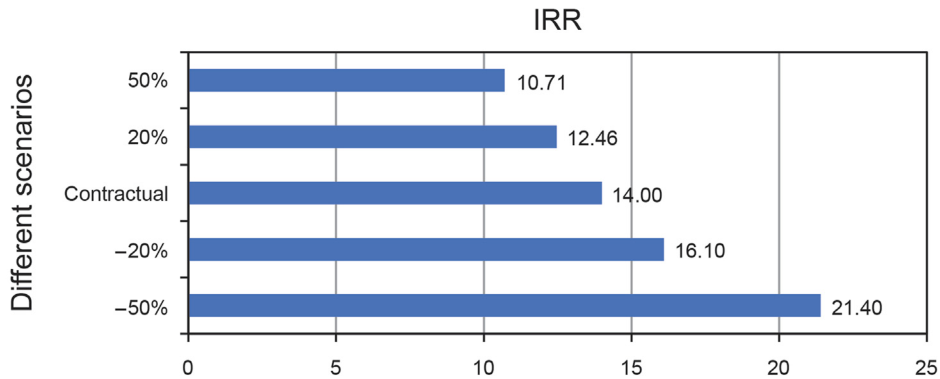

Fig. 1. The effects of direct capital cost on the contractor's IRR.

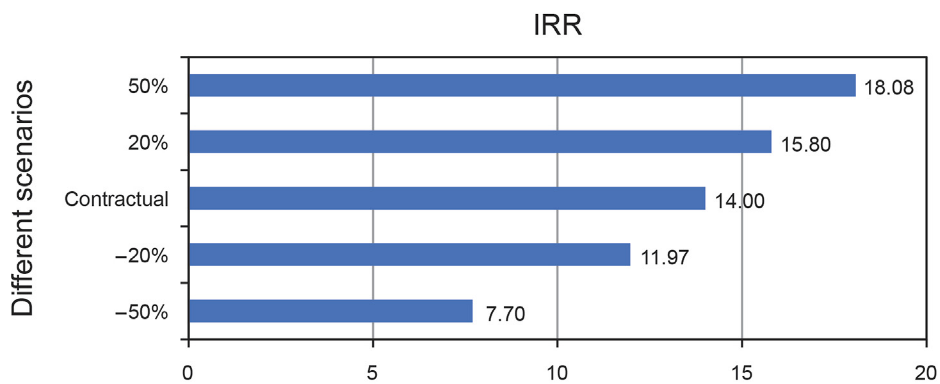

Fig 2. The effects of production profile on the contractor's IRR.

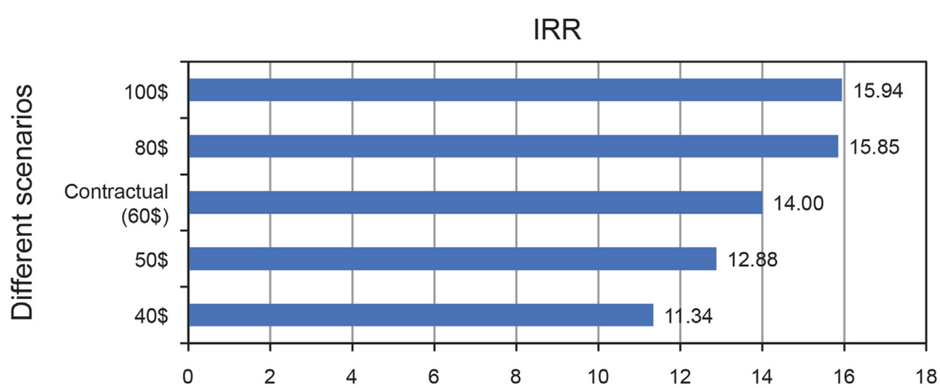

Fig. 3. The effects of oil price on the contractor's IRR.

$$= FTP, FTP+1, \ldots, 20 \qquad CI_i \le \sum_{i=\mathrm{FTP}}^{i} Tr_i - \sum_{i=\mathrm{FTP}}^{i} CI_{(i-1)}$$

$$i = FTP, FTP+1, \ldots, 20 CI_i \le 0.5 P_i Q_i \quad i$$

$$= FTP, FTP+1, \ldots, 20$$

$$-\sum_{i=1}^{20} \frac{(CO_i)}{(1+irr)^i} + \sum_{i=1}^{20} \frac{CI_i}{(1+iir)^i} = 0 fpb \le fpb^*_{\mathrm{CTR}} fpb$$

$$\ge fpb^*_{\mathrm{NIOC}} Tr_i, fpb, com_i, CI_i \ge 0 \quad i$$

$$= FTP, FTP+1, \ldots, 20 y_i \in \{0,1\} \quad i$$

$$= FTP, FTP+1, \ldots, 20 \tag{25}$$

In order to solve model (25), first the amount of $NPV^U{}_{\mathrm{CTR}}$, $NPV^L{}_{\mathrm{NIOC}}$, $NPV^U{}_{\mathrm{NIOC}}$ *and* $NPV^L{}_{\mathrm{CTR}}$ must be calculated, then the bargaining model will be solved. The procedure leading to the calculation of model (25) is as follows:

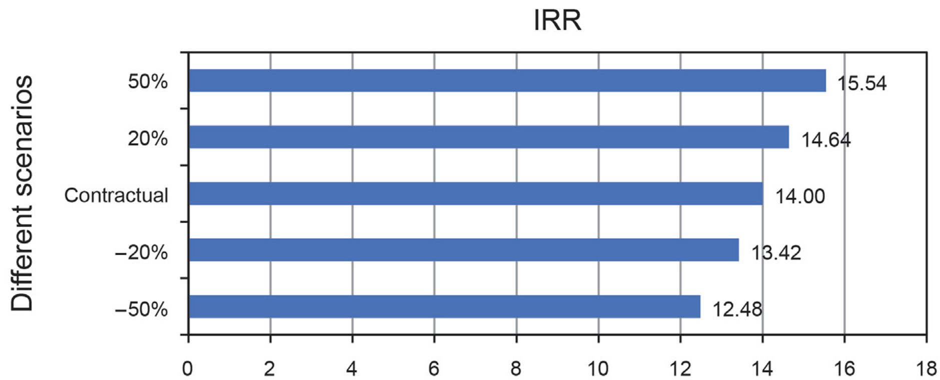

Fig. 4. The effects of cost of money on the contractor's IRR.

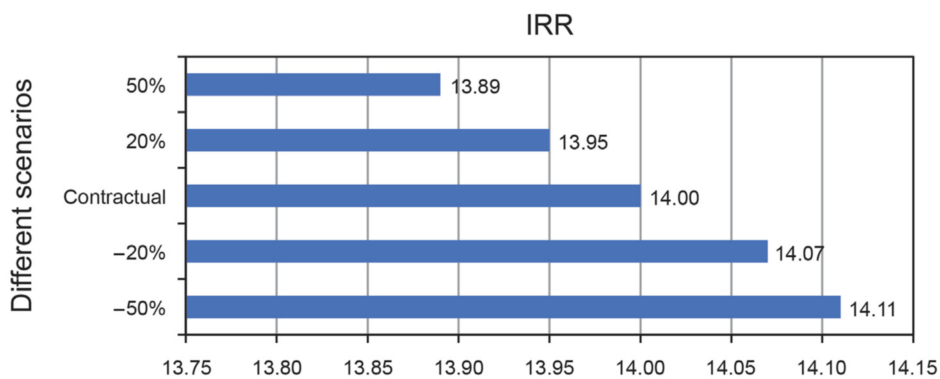

Fig. 5. The effects of operation cost on the contractor's IRR.

Table 3
The win- win solution between the NIOC and contractors in different conditions of the contractor's bargaining power.

Variable	Contractor's Power									
										10
fpb ($)	1.33	1.93	2.26	2.53	2.78	3.02	3.26	3.5	3.78	4.16	4.7
expected IRR	10	12.18	13.28	14.14	14.89	15.59	16.27	16.93	17.68	18.66	20
NIOC's NPV (MM$)	11683	11537	11457	11329	11302	11274	11217	11159	11092	11000	10870
Contractor's NPV (MM$)	1.6	147	227	293	353	410	468	528	593	684	814

Step 1: Calculate the contractor's desired NPV (NPV^{U}_{CTR}) and the NIOC's undesired NPV (NPV^{L}_{NIOC}) as follows:

Step 1-1: Adjust $IRR= IRR^{C}$ (the contractor's desired IRR) in model (21).

Step 1-2: Solve model (21) and designate NPV^{U}_{CTR} the contractor's optimal NPV, fpb^{*}_{CTR} the contractor's optimal fee per barrel and CI^{*}_{CTR} the optimal maximum possible amount payable to the contractor in a desired situation.

Step 1-3: Adjust $CI= CI^{*}_{CTR}$ in model (20) and designate NPV^{L}_{NIOC} the NIOC's undesired NPV.

Step 2: Calculate the NIOC's desired NPV (NPV^{U}_{NIOC}) and the contractor's undesired NPV (NPV^{L}_{CTR}) as follows:

Step 2-1: Adjust IRR= IRR^{N} (the NIOC's desired IRR) in model (22).

Step 2-2: Solve model (22) and designate NPV^{U}_{NIOC} the NIOC's optimal NPV, fpb^{*}_{NIOC} the NIOC's optimal fee per barrel, and CI^{*}_{NIOC} the optimal maximum possible amount payable to the NIOC in a desired situation.

Step 2-3: Adjust $CI= CI^{*}_{NIOC}$ in model (19) and designate NPV^{L}_{CTR} the contractor's undesired NPV.

Step 3: Substitute NPV^{U}_{CTR}, fpb^{*}_{CTR} and NPV^{L}_{NIOC} obtained from step 1, and NPV^{U}_{NIOC}, fpb^{*}_{NIOC} and NPV^{L}_{CTR} obtained from step 2, in model (25).

Step 4: Adjust $w_1 = 0$ and $w_2 = 10 - w_1$.

Step 5: Solve model (25) and designate fpb^{*}, IRR^{*}, $NPV^{B}_{w1,NIOC}$ and $NPV^{B}_{w2,CTR}$ the optimal bargaining solution for fee per barrel, IRR, the NIOC's NPV and contractor's NPV, respectively.

Step 6: If $w_1 <= 10$ then $w_1 = w_1 + 1$ and $w_2 = 10 - w_1$

Step 7: Go to step 5.

The above steps will calculate optimal values for all different scenarios, with respect to the bargaining powers of the NIOC and the contractor. Although model (25) is a nonlinear model, the extent of nonlinearity is not substantial and solving the model is not difficult. The authors' experience of using the NLP Solver (GAMS) shows that the optimal solutions are usually obtained in seconds.

Table 4
The effects of direct capital cost on the contractor's expected IRR in different conditions of the contractor's bargaining power.

Change in direct capital cost	Contractor's Power										
											10
−50%	14.93	18.51	20.31	21.71	22.94	24.12	25.25	26.36	27.59	29.92	31.45
−20%	11.41	13.98	15.28	16.29	17.19	18.02	18.84	19.62	20.52	21.69	23.29
Contractual direct capital cost	10	12.18	13.28	14.14	14.89	15.59	16.27	16.93	17.68	18.66	20
+20%	8.98	10.82	11.76	12.49	13.15	13.76	14.34	14.9	15.54	16.37	17.5
+50%	7.79	9.27	10.02	10.6	11.11	11.6	12.06	12.52	13.03	13.71	14.62

4. Data

In this section, the data for the case study were collected by personal communications from an oil field[2] located in the west of Iran. As the field has not been developed yet, there are currently no production wells in the field.

After long negotiations, the NIOC and the contractor reached an agreement on the rate of direct capital cost (DCC), the operation cost (OPEX), the indirect cost (IDC) and the production profile for the selected field, as shown in Table 2. Also, by agreement, the cost of money (COM) is 4%, the first target production (FTP) year is in the second year, oil price is $60, and the amortization period is 6 years.

5. Results and discussion

This contract is analyzed in two different scenarios. Scenario one represents the NIOC and the contractor having reached a mutual agreement on the expected IRR, and in scenario two the NIOC and the contractor have not reached such an agreement.

5.1. Scenario one: mutual agreement on expected IRR

This scenario assumes that the NIOC and the contractor have mutually agreed upon on the expected IRR of 14%. By applying models (19) and (20), and using GAMS software, the fee per barrel, the contractor's NPV and the NIOC's NPV were $2.5, $282m and $11,400m, respectively. The results show that as the contractor will earn $2.5 per production of every oil barrel, multiplying the total production figure in 20 years from the field (676 million barrels) to the remuneration fee per barrel ($2.5), results in the contractor's total remuneration fee of $1,600m.

When the IPC contract is signed, the fee per barrel is fixed for the duration of the contract. Therefore, the contractor bears the risks of changes to direct capital costs, operating costs, oil price, production level or cost of money. Changing any of these factors may have a significant impact on the contractor's IRR.

5.1.1. Changes in the amount of direct capital cost

This analysis varies the direct capital costs from −50% to +50% in order to show the effect on the contractor's expected IRR. As shown in Fig. 1, an increase of 20% or 50% in direct capital cost would decrease the contractor's expected IRR from 14% to 12.46% or 10.71%. A reduction of 20% or 50% of direct capital cost would increase the contractor's expected IRR from 14% to 16.1% or 21.4%. Therefore, contractors should pay close attention to their direct capital costs for developing the field, and calculate these in a reasonable manner to avoid facing a reduction in their final IRR. Usually contractors should pre-calculate their IRR for three levels (i.e. low, middle and high) of direct capital costs, and observe this value carefully in the course of their negotiations for expected IRR. In practice their expertise, knowledge of the field and accuracy of projected development costs will be decisive in the actual IRR of the project.

In other words, contractors, while presenting their details of direct capital cost to the NIOC, must be diligent with their estimates to cover any contingencies or unforeseen costs in practice, so as to avoid falling below their targeted IRR. This reemphasizes that the direct capital cost has a high impact on the IRR and is an important risk factor for contractors negotiating an IPC contract.

5.1.2. Changes in the amount of production profile

This analysis varies the production profile from −50% to +50% in order to show the effects on the contractor's expected IRR. As shown in Fig. 2, an increase of 20% or 50% of production profile would increase the contractor's expected IRR from 14% to 15.8% or 18.08%. A reduction of 20% or 50% of production profile would decrease the contractor's expected IRR from 14% to 11.97% or 7.7%.

This is one of the major differences between the IPC and the buyback contract. In a buyback contract, the contractor will not gain any profit by increasing production. However, in the IPC the contractor's remuneration fee is based on the fee per barrel of production and therefore the contractor has an incentive to increase production: maximizing their efforts, and employing their best technologies for this outcome, will increase their remuneration fee and IRR. Of course, by increasing the amount of production, the NIOC's revenue from the field will also increase. Therefore, both parties will gain from increased production.

5.1.3. Changes in oil price

This analysis varies the oil price from $40 to $100 in order to show the effects on the contractor's expected IRR. As shown in Fig. 3, an increase of oil price from $60 to $80 or $100 would increase the contractor's expected IRR from 14% to 15.85% or 15.94%. A reduction of oil price from $60 to $50 or $40 would decrease the contractor's expected IRR from 14% to 12.88% or 11.34%.

Notably, changes of oil price below the contractual value have a greater effect on IRR than do changes to prices higher than contractual value. In other words, rising oil price has less effect on increasing IRR than decreasing oil price has on lowering it. This is because according to the contract, in each year a maximum 50% of the field revenue is allocated to the contractors for the reimbursement of their costs. Therefore, a contractor will not be able to cover its complete cost and remuneration fee immediately in the running year during low oil prices, and the remaining amount will be postponed to subsequent years. It is suggested that contractors in the course of their negotiations try to increase the field revenue allocation of 50% to higher values, in order to reduce their risks of late payment during periods of lower oil price.

5.1.4. Changes in the cost of money

This analysis varies the cost of money from −50% to +50% in order to show the effects on the contractor's expected IRR. As shown in Fig. 4, an increase of 20% or 50% in the cost of money would increase the contractor's expected IRR from 14% to 14.64% or

[2] The name of the field is removed due to confidentiality limitations.

Table 5
The effects of production profile on the expected contractor's IRR for different conditions of the contractor's bargaining power.

Change in production profile	Contractor's Power										
											10
−50%	5.88	6.84	7.33	7.71	8.05	8.38	8.68	8.99	9.33	9.76	10.33
−20%	8.73	10.47	11.35	12.04	12.66	13.25	13.79	14.34	14.95	15.75	16.84
Contractual production profile	10	12.18	13.28	14.14	14.89	15.61	16.27	16.93	17.68	18.66	20
+20%	11.16	13.65	14.91	15.89	16.77	17.60	18.37	19.14	20.01	21.15	22.71
+50%	12.64	15.57	17.05	18.21	19.24	20.22	21.13	22.04	23.07	24.42	26.26

15.54%. A reduction of 20% or 50% in the cost of money would decrease the contractor's expected IRR from 14% to 13.42% or 12.48%.

5.1.5. Changes in operation cost

This analysis varies the operation cost from −50% to +50% in order to show the effects on the contractor's expected IRR. As shown in Fig. 5, an increase of 20% or 50% of operation cost would decrease the contractor's expected IRR from 14% to 13.95% or 13.89%. A reduction of 20% or 50% of operation cost would increase the contractor's expected IRR from 14% to 14.07% or 14.11%. Both, proving minor effects on contractor's IRR (around 0.1%). However, it must also be noted that although the operation costs does not have appreciable effect on contractor's IRR, and will be covered by the NIOC, but contractor's must still be careful in projecting their operation costs, in comparison to their real and actually finished costs, in order to maintain the consistency and reliability of their initial offer to maintain positive records of performance for technical evaluations for the NIOC's potential future bidding.

5.2. Scenario two: The NIOC and the contractor have not reached a mutual agreement on the rate of IRR

This scenario assumes that the NIOC and the contractor could not reach an agreement on the rate of IRR; therefore, a point of compromise must be found on the IRR along with the other aspects of the contract. A compromise solution between the NIOC and the contractor is calculated by applying model (25) and using GAMS software. Table 3 shows the win-win solution for the NIOC and the contractor for different conditions of bargaining power. A considerable variation can be noted, as the contractor's remuneration fee changes from \$1.33 to \$4.7 per barrel as the IRR changes from 10% to 20%.

With knowledge of the above, contactors will always try to bargain that they have considerable hidden technical, operational and financial costs in developing the fields. This is to push for a higher IRR and consequently a higher fee per barrel.

This table assists both the contractor and the NIOC, at the time of preparing their proposal and in the course of actual negotiations, to calculate their IRR and remuneration fee for developing the fields at different conditions of their bargaining power, and to conduct a logical bargain protecting their best possible interests. For example, in the case where the contractor's bargaining power is 2 ($w_2 = 2$) and the NIOC's bargaining power is 8 ($w_1 = 8$), the fpb, IRR, the NIOC's NPV ($NPV^B_{8,\mathrm{NIOC}}$) and the contractor's NPV ($NPV^B_{2,\mathrm{CTR}}$) will be \$2.26, 13.28, \$11,457 m and \$227 m, respectively.

As shown in scenario one, the direct capital cost and production profile have the largest effects on the contractor's expected IRR. Therefore, in order to show these effects on the contractor's expected IRR in different conditions of bargaining power, an analysis sensitive to these two parameters is further presented.

5.2.1. Changes in the amount of direct capital cost

This analysis varies the direct capital costs from −50% to +50% in order to show the effect on the contractor's expected IRR in different conditions of bargaining power. This is shown in Table 4.

This table provides particularly interesting results. First, an increase of 50% in direct capital cost will increase the contractor's IRR from 7.79% to 14.62% (depending on the contractor's bargaining power). For example, if a contractor has maximum bargaining power ($w_2 = 10$), an increase of 50% direct capital cost will decrease the contractor's IRR from its contracted value of 20% to 14.62%; that is, even if the contractor has maximum bargaining power, this increase of 50% in direct capital cost will still cause the contractor's IRR to equal the IRR at the contractual direct capital cost value, where the contractor's bargaining power was only between 3 and 4.

Second, the reduction of 50% in direct capital cost will increase the contractor's IRR from 14.93% to 31.45% as the contractor's bargaining power changes from 0 to 10. For example, in a situation when the contractor has the minimum bargaining power, a decrease of 50% in direct capital cost will increase the contractor's IRR from 10% to 14.93%. This means even if the contractor's bargaining power is at a minimum, this decrease in direct capital cost will provide a gain in IRR nearly equal to the expected IRR at the contractual direct capital cost value when the contractor's bargaining power is 4.

Third, it is also noteworthy that the contractor's IRR, when bargaining power is 0 and the direct capital cost is decreased about 50%, is nearly equal to the IRR when the bargaining power is 10 and the direct capital cost has increased about 50%.

Finally, the contractor's IRR varies from 7.79% (with contractor's bargaining power of 0 and an increase of 50% in direct capital cost) to 31.45% (contractor's bargaining power of 10 and a reduction of 50% in direct capital cost) while the expected IR R varies from 10% to 20%. This suggests that in a worst-case scenario, the contractor's IRR will decrease from 10% to 7.79% while in the best situation the contractor's IRR will increase from 20% to 31.45%. Therefore, the slope of changes in direct capital cost is not linear and the scale of the slope is to the favor of the contractor.

The above analysis emphasizes that direct capital cost has an enormous effect on the contractor's expected IRR. Thus, the contractor must take great care with direct capital cost estimates for developing the field, in order to avoid the loss of its expected IRR. Conversely, the NIOC also must carefully evaluate the direct capital cost in order to avoid the contractor's IRR jumping to unreasonable ranges.

5.2.2. Changes in the amount of production profile

This analysis varies the production profile from −50% to +50% in order to show the effects on the contractor's expected IRR for different conditions of bargaining power. This is shown in Table 5.

This table shows some interesting results. First, a decrease of 50% in production profile will cause the contractor's IRR to vary from 5.88% to 10.33% (depending on contractor's bargaining powers) while the expected contractual values at the same range of bargaining power was from 10% to 20%. In other words, if the contractor has the maximum bargaining power ($w_2 = 10$), a decline of 50% in production profile will decrease the contractor's IRR from 20% to 10.33% which is near to its expected IRR of 10% even at zero bargaining power.

Second, an increase of 50% in production profile will change the contractor’s IRR from 12.64% to 26.26% as the contractor’s bargaining power changes from 0 to 10, while the expected contractual values at the same range of bargaining power was from 10% to 20%. That is, when the contractor has the minimum bargaining power, an increase of 50% of production profile will increase the contractor’s IRR from 10% only to 12.64%. In a situation where the contractor has the maximum bargaining power, an increase of 50% in production profile will increase the contractor’s IRR from 20% to 26.26%.

Third, it is notable that when the contractor’s bargaining power is 0 and production profile is increased by about 50% (IRR = 12.64%), the contractor’s IRR exceeds that when the contractor’s bargaining power is 10 and the production profile is decreased by about 50% (IRR = 10.33%).

Finally, the contractor’s IRR varies from 5.88% (when the contractor’s bargaining power is 0 and production profile decreases by 50%) to 26.26% (when the contractor’s bargaining power is 10, and production profile increases by 50%). However, the expected IRR varies from 10% to 20%. This shows that in the worst-case scenario the contractor’s IRR will decrease from 10% to 5.88%, while in the best case the contractor's IRR will increase from 20% to 26.26%. Therefore, once again the slope of changing of production profile is not monotonic and the scale of the slope is in favor of the contractor.

The above analysis indicates how significantly variations in production profile will affect the contractor’s expected IRR in different conditions of bargaining power. This may be used to advantage when studying and preparing master development plans, as well as during the course of negotiations to avoid unaccounted losses and to maximize NPV.

6. Conclusion

Iran's oil and gas industry requires an investment of about $200bn in five years to increase oil and gas production, and so aims to attract IOC investment in its oil and gas industry. For more than a decade, the buyback method has been the main framework for developing Iranian oil and gas fields. However, in spite of three revisions, the weaknesses of buyback contracts for absorbing foreign investment has caused the NIOC to change its policy away from using this framework, and instead to introduce a new model known as the IPC. Therefore, it is necessary to study the IPC and its fiscal regime in order to clarify the features of this contract for exploration and production companies. This paper surveys the outline of the IPC for the development of upstream projects by focusing on its fiscal regime, and introduces a model to calculate the contractor’s remuneration fee for an agreed expected IRR value between the NIOC and the contractor.

Furthermore, since in the real world the contractor and the NIOC may have hard and lengthy negotiations to reach a mutual agreement on the expected IRR and other aspects of the contract, this paper applies bargaining game theory to the IPC in order to seek a win-win solution between the NIOC and the contractor. This model helps contract negotiators calculate the contractor’s remuneration fee per barrel of production in consideration of respective bargaining powers, and provides a guide to how changes in parameters and bargaining power may affect the contractor’s expected IRR.

In this paper, the proposed model was utilized to examine the data from real fields. The result shows that the contractor’s earning fee per barrel and NPV are $2.5 and $282m respectively, based on an expected IRR of 14%. Furthermore, the result reveals that any increase of direct capital cost or operation cost will decrease the contractor’s IRR, whereas an increase of production profile, oil price, or cost of money will increase the contractor's IRR.

The result for a second scenario shows that the contractor's remuneration fee per barrel of production changes from $1.33 to $4.7 as IRR changes from 10% to 20%. As is evident in Table 3, when the NIOC and the contractor have equal bargaining powers (each having a bargaining power of 5), fee per barrel, IRR, NPVs of the NIOC and of the contractor will be $3.02, 15.59, $11274m and $410m, respectively. Therefore, a contractor knowing the above facts and figures prior to negotiations can choose an appropriate target for discussion and compromise. If a contractor believes its bargaining power is greater than the NIOC’s, it may opt not to accept any IRR below 15.59 and press for higher values.

The detailed sensitivity analysis of the IPC performed on scenario one shows that among the different risk factors, the direct capital cost and production profile have the most important impacts on changing the contractor’s expected IRR. The sensitivity analysis performed on scenario two emphasizes that the effect of these two parameters are so strong that even if the contractor is in the possession of maximum bargaining power, it may not be able to reduce their impacts.

The NIOC has presented IPC as a new type of contract with a number of changes to its previous contracts, such as extending the duration to include exploration, development and production phases; prolonging the period of contract up to 20 years; and defining the remuneration based on fee per barrel of production. Nevertheless, contractors are still faced with substantial risk in this contract. If the NIOC wishes to continue using the IPC framework, some modifications are suggested in order to make this type of contract more attractive to contractors for investment. Same can be the demand of the contractors from NIOC.

As a first suggestion, to add an option in the contract for revising the contractual production profile after the behavior of the reservoir is fully understood (for example, two years after signing the contract). The fee per barrel of production can be calculated based on the new revised production profile and fixed in the contract. Second, to increase the allocation of field revenue to the contractor from 50% to a higher percentage, so as to reduce the risks of fluctuation in production profile and fall of oil prices.

Third, to recalculate direct capital cost when subcontracts are awarded via tendering, in order to reduce the risk of changes in direct capital cost. The fee per barrel of production can be calculated based on the new direct capital cost, and fixed in the contract.

Finally, to reduce the contractor's risks in determining the direct capital cost and production profile, the NIOC can use a mechanism for remuneration in which the maximum and minimum contractual values of IRR will be agreed upon in the course of negotiation and included in the contract. If the contractor’s IRR exceeds the maximum agreed amount, the NIOC and contractor will calculate the new fee per barrel of production, based on the maximum agreed IRR, which will certainly be lower than the fee per barrel of the contract if no top limit were defined. In this case, the contractor will return some of its profit back to the NIOC; whereas if their actual IRR is lower than contractual IRR, the reverse scenario will happen: the NIOC and contractor will calculate the new fee per barrel of production based on the minimum agreed IRR, which will be higher than the contractual fee per barrel if there were no bottom limit. By using this mechanism, the contractor's risk is covered, by the assurance that its IRR will not be less than an agreed minimum amount.

Ultimately, it must be noted that the parameters for developing upstream oil and gas fields are very uncertain by their nature. Therefore, for future research, the presented model could profitably be combined with uncertainty approaches. Furthermore, the proposed model in this research is sensitive to the level of bargaining powers of the NIOC and the contractor. Therefore, future researchers could collect all risk factors in the IPC and develop a method for determining the levels of bargaining power for both the NIOC and the contractor.

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