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On structuring offshore hydrocarbon production sharing contracts: Lebanon's case

Ali Yassine,* Bacel Maddah** and Najat Younes***

Interest in the Lebanese offshore hydrocarbon potentials has recently increased, especially after the discoveries in neighbouring countries that share the same geological offshore basin with Lebanon. In this article, we present a framework for structuring and analysing offshore hydrocarbon contracts. Our objective is to assist governments in formulating and managing the contracting process for hydrocarbon assets. The proposed framework is based on a benchmark study (ie database) of offshore production sharing contracts (PSCs). Contract profiling is then performed using three factors: political and economic risk, reserves status and water depth. Based on this database and on contract profiling, we propose plausible ranges for the parameters of potential PSCs; particularly, for Lebanon. We also utilise a simple 'take' model for PSCs to perform sensitivity analysis in order to identify critical contract parameters that have the highest effect on the government share. Additionally, our research statistically tests the significance of the three contract profiling factors on the PSC parameters.

1. Introduction

Recent seismic surveys offshore Lebanon, the discovery of offshore gas in Haifa (eg at Dalit, Tamar and Leviathan), and the Cypriot and the Syrian launchings of oil exploration bids in 2007, have significantly raised awareness and provided strong evidence for the availability of gas assets offshore Lebanon.[1,2,3,4,5] Accordingly, the Lebanese government has shown a big interest in this subject since 2000, and has employed international oil and survey companies to carry out 2-D and 3-D seismic surveys. The Petroleum

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** Dr. Maddah is an Associate Professor of Engineering Management at the American University of Beirut.

*** Ms. Younes is a graduate student of Engineering Management at the American University of Beirut.

1 D Gill, 'Israel Petroleum Discovery Curve' (1992) 1 Natural Resources Research Journal 231–38.

2 A Bar-Eli, 'Israel's Largest Ever Reserve of Natural Gas Discovered off Haifa coast' *Haaretz*, (18 January 2009).

3 European Weekly, 'Cyprus Launches Oil and Gas Exploration Tender' (2007) <http://www.neurope.eu/viewnews.php?id=70358> accessed 13 April 2009.

4 N Blanford, 'The Next Big Lebanon-Israel Flare-Up: Gas' *Time World* (6 April 2011) <http://www.time.com/time/world/article/0,8599,2061187,00.html>. accessed 10 June 2011.

5 CJ Schenk and others, Assessment of Undiscovered Oil and Gas Resources of the Levant Basin Province, (2010) Eastern Mediterranean. USGS Fact Sheet 2010–3014.

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Geo-Services (PGS) company affirmed that the data acquired is comprehensive and that there is sufficient evidence to allow the companies to drill.[6] Lebanon's offshore hydrocarbon potentials have led to a new petroleum policy and a law has recently been passed by the Lebanese government.[7] However, there exists a persistent lack of managerial and regulatory studies allowing the implementation of this law and policy. This translates as a strong need for further scientific research in support of policy- and law-makers entrusted with the management and exploitation of Lebanon's hydrocarbon resources.

The overarching goal of this article is to present a systematic approach to assist in structuring hydrocarbon contracts in Lebanon. It is concerned with the terms and conditions of production sharing contracts (PSCs) offered by governments, in particular the Lebanese government, to contractors (eg international oil companies—IOCs) for the extraction of their natural resources. This is achieved in the article through the following four tasks.

- Provide statistical analysis and discussion of the various PSCs (or hydrocarbon laws) collected (Section 3).
- Provide a simple model that maps PSC parameters to government take, which will be used to perform sensitivity analysis on the various PSC parameters and their impact on government take (Section 4).
- Assess the influence of three factors (political/economic risk level, status of hydrocarbon reserves and water depth) on the PSC parameters (Section 5 and 6).
- Suggest plausible ranges for Lebanon and other countries, to inform policy makers and provide them with a benchmark (Section 7).

We start by presenting the results of a rigorous benchmarking study of offshore PSCs in various countries with specific focus on neighbouring countries and countries with a similar profile to Lebanon. The PSCs used in our analysis are collected through searching for published PSCs in academic sources and in specialized professional databases. A profile for each of these contracts is built based on three factors: the political and economic risk level (assessed as high or low at the time of contract signing), the status of hydrocarbon reserves (assessed as proven or unproven at the time of contract signing) and water depth (assessed as deep and not deep). The profile is used to assess the influence of these three factors on the PSC parameters. Also, it is used for identifying the countries with the closest profile to Lebanon. Then a PSC structure for Lebanon's hydrocarbon assets is recommended; that is, we hypothesize ranges for the value of the parameters of the Lebanese PSC. These ranges could inform and guide policy makers and are not meant to provide the government with a final recommendation. As for the fourth task, we utilise a PSC model to relate the various contract parameters to the take[8] of the government and the take of the contractor; then, perform a sensitivity analysis to show how changes in one or more contract parameters or uncertainties (like royalty) influence both takes. This allows identifying the critical parameters of a potential Lebanese PSC,

[6] *Executive Magazine*, 'Energy Like Oil and Water' July 2009 issue, pp 64–70.

[7] LHL, 'Lebanese Official Journal' (2010) 41 <jo.pcm.gov.lb/j2010/j41/wfn/n132.htm#>. accessed 25 Dec. 2010.

[8] The take is the percentage of after tax net cash flow to total net cash flow. It is a widely used measure in the oil industry.

that is, the parameters that the Lebanese government should carefully negotiate with international oil companies.

The rest of the article is as follows. In Section 2, a literature review and background of hydrocarbons processing and production sharing contracting is provided. Section 3 describes and statistically analyses the data collected on 44 offshore PSCs from 31 countries. In Section 4, we present a simple 'take' model, which is used to carry sensitivity analysis on chosen PSC parameters. PSCs in our dataset are divided into groups based on profiling factors that are discussed in Section 5. The statistical analysis of the PSC dataset based on these factors is presented in Section 6. Section 7 studies the case of Lebanon with suggestions for quantitative values for PSC parameters. Section 8 summarizes the findings of this study and suggestions for future work.

2. Background

Many developing countries are unable to extract their hydrocarbon resources at a reasonable cost because they lack the technical know-how, management expertise and/or capital to do so.[9] As a result, they rely on IOCs to explore and develop these resources. With multiple parties involved, managing resources becomes more complicated, due to the conflicting interests between IOCs and the host governments. The IOC needs to recover its costs and would like to keep as much profit as possible. The host government, on the other hand, wants to maximize its revenue as much as possible while making sure that the IOC remains interested in investing in the host country.[10] This divergence in objectives yields the need of legislative arrangements that allocate the costs and benefits over a project's lifetime; which are included in the PSC. As such, a PSC uses the concept of contractual partnership to enhance oil and gas development.[11]

In a PSC, the foreign company provides the capital investment, first in exploration, then in drilling and in the construction of infrastructure. Once hydrocarbon is produced, the foreign company may have to pay royalty charged on gross production to the government. The IOC can recover some of its costs at a pre-specified percentage of production, the so-called 'cost recovery'. Once costs have been recovered, the remaining profit is divided between state and company in agreed proportions. The company is taxed on its profit share. Sometimes the state also participates as a commercial partner in the contract; in this case, the state provides its percentage share of capital investment, and directly receives the same percentage share of cost recovery and profit share. The IOC's share of the profit is then subdivided according to the production sharing terms.

[9] D Johnston, 'Changing Fiscal Landscape' (2008) 1 Journal of World Energy Law & Business 31–53.

[10] E Sunley, T Baunsgaard and D Simard, 'Revenue from the Oil and Gas Sector: Issues and Country Experience' in Jeffrey M Davis, Rolando Ossoski and Annalisa Fedelino (eds), *Fiscal Policy Formulation and Implementation in Oil-Producing Countries* (International Monetary Fund Publications, Services 2003).

[11] N Pongsiri, 'Partnerships in Oil and Gas Production-Sharing Contracts' (2004) 17(5) The International Journal of Public Sector Management 431–42.

The PSC is the most popular system for both host governments and the oil corporations.[12,13] It provides the host government with profit shares without the risk of direct investment. In theory, the host state has ultimate control over the hydrocarbon resources, while an international oil company or consortium of companies perform the exploration and production under a contract. In practice, however, the state's hands are tied by restrictions in the law, regulations and contract. As such, this agreement saves the host government political image and gives the company commercial satisfaction. The PSC provides a share of reward to the host government and a share to the IOC. The PSC can be considered an efficient contract; in the sense that neither party can improve its pay-out without making the other party worse off.[14] Table 1 shows all the parameters of a PSC along with their definitions and Figure 1 shows an example of PSC parameters using values from a PSC signed in Zambia in 2005.

Several other contract types were used in the oil and gas industry such as concessions, service contracts and joint ventures. Concession contracts, known as the royalty and tax system (R/T system), are not more than a simple combination of royalty and taxes. The government grants a foreign license to extract hydrocarbon, which becomes the company's property (to sell, transport or refine) once extracted. The company pays the government taxes and royalties for the hydrocarbon. The IOC bears all the risks and takes all the reward; the government's reward is a function of production and prices.[15] On the other hand, service contracts are contracts for nationalized industry model where the state makes all of the decisions, and takes all of the revenue.[16] The IOC is paid a cash fee for performing the service of producing mineral resources, which makes him the only bearer of the financial risk. The government bears all the risk.

In joint ventures, both the IOC and the government, participate actively in the operation of the oilfield and acquire ownership of a specified part of production.[17] The government and the company do not only share profit, they also share development and operating costs. With joint ventures, the government and the IOC share risk and reward.

A good PSC is the one having the best combination of parameters. Therefore, in order to determine a good combination of these PSC parameters, the effect and importance of each of these parameters in a PSC should be well recognized; particularly, their contribution to the national petroleum strategy. For example, when the concern of the government is to receive a guaranteed cash flow regardless of the profitability of the project, signature bonus and royalty should be high. On the other hand, governments seeking high potential profitability should require high profit share and tax.

12 Exploration and Production Agreement (EPA) is another commonly used term for PSCs.

13 G Muttitt, 'Production Sharing Agreements: Oil privatization by another name?' (2005) Paper presented to the General Union of Oil Employees' Conference on Privatization, Basrah, Iraq. <http://www.platformlondon.org/carbonweb/documents/PSAs_privatisation.pdf>. accessed 13 Apr. 2009.

14 C Blitzer, D Lessard and J Paddock, 'Risk Bearing and the Choice of Contract Forms for Oil Exploration and Development' (1984) 5(1) Energy Journal 1–29.

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

16 D Johnston, *International Exploration, Economics, Risk, and Contract Analysis* (PennWell Corporation 2003).

17 Bindemann (n 15).

Table 1. Typical parameters of a PSC and their definitions

Variables under a PSC	Definition
Royalty	Usage-based payments made by the IOC to the government for on-going use of an asset
Cost Recovery	A pre-specified portion of yearly production that it allocated to repay agreed costs to the IOC
Profit Share	The share of the IOC and the government from the remainder of production
Signature Bonus	A one-off payment on signing a contract made by the IOC
Production Bonus	Payments by the IOC due when production reaches a certain level
Discovery Bonus	A one-off fee required after commercial discovery is declared and after the government approves the OC's plan
Tax	An agreed percentage that the government gets from the IOC's net profit
Acreage	The size of the area in the PSC
Relinquishment	The surrender of unused parts of the contract area back to the government*
Export and Import duties	IOCs pay no export duties. Import duties may be charged on goods such as foodstuffs that are available in the host country
Work obligation	IOC's commitments with regard to seismic, drilling, information dissemination, financial obligations, etc
Local Content Obligations	Preference to local goods, services and personnel: employment of local workforce, procurement of local goods and services, training of NOC staff, etc†
Participation	The option for the government to participate in the venture of exploration and production
Arbitration	International arbitration maybe provided when conflict arises
Domestic Market Obligation (DMO)	A percentage of the IOC's production share at a heavily discounted price or at the international market price
Exploration period	The maximum duration of the exploration phase
Development period	The period prior to production where materials and services must be procured and everything has to be installed‡
Production period	The maximum duration of the production phase
Decommissioning Obligations	Licensees have to pay for offshore installations to be properly decommissioned; such as complete removal from the seabed of platforms and pipelines or re-use of platforms, etc[I]

* T Boykett and others, *Oil Contracts: How to Read and Understand a Petroleum Contract* (2012).

† A Msimang, 'Global Local Content: Legal Issues and Practical Reality' (2006) <http://www.menas.co.uk/App_Data/elib/Vinson%20%20and%20%20Elkins%20-%20LC%20info,%20examples,%20analysis.pdf>. accessed 13 Apr. 2009.

‡ A Bittencourt de Andrade Filho, 'Optimal Scheduling of Development in an Oil Field' (1994) <https://pangea.stanford.edu/ERE/pdf/pereports/MS/Bittencourt94.pdf>. accessed 13 Apr. 2009.

I Bureau Veritas, 'Decommissioning on the UK Continental Shelf- an overview of regulations' (2011) January 2011 issue, Version 02.

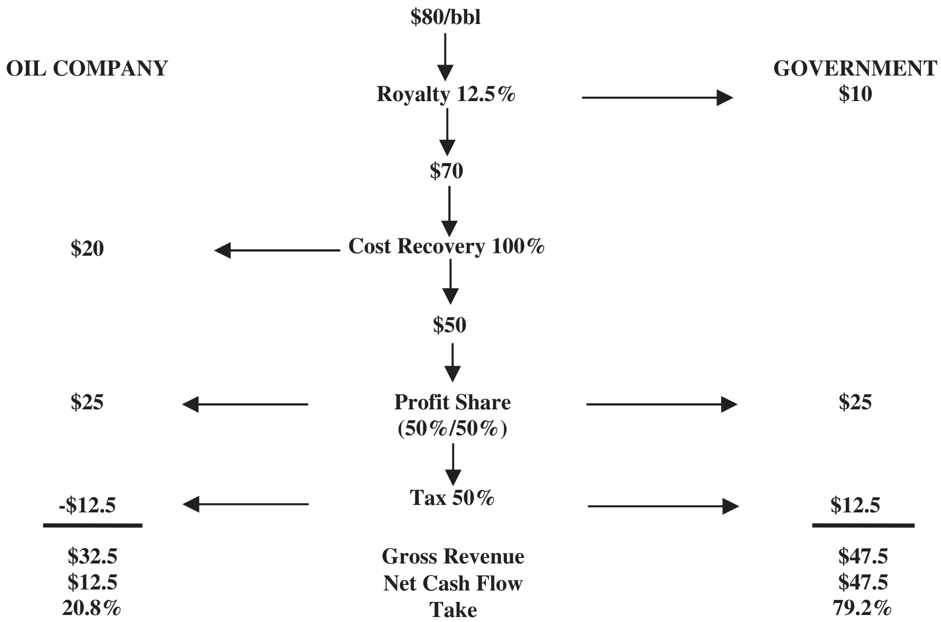

Figure 1. PSC structure (adapted from Bindemann).
(K Bindemann, (1999). *Production sharing Agreements: An Economic Analysis* (Oxford Institute for Energy Studies 1999)).

Each PSC parameter is correlated to an economic or a geological factor. For example, the profit share correlates directly with reserve values, field size and other measures of relative economics.[18] On the other hand, the work obligation (seismic surveys, drilling commitments, employment of local workforce, etc) and the signature bonus dominate the risk side of the contract since they are done before establishing the commerciality of the project; thus these two parameters should take into consideration the availability of information and the geological complexity of the area. In addition, low cost recovery can weaken the company's capability to resist a low hydrocarbon price;[19] hence, the cost oil parameter should take into consideration the uncertainty in hydrocarbon prices. In addition, countries that import oil and gas have a specific interest in minimizing the import cost,[20] thus they aim to satisfy the domestic demand for oil and gas by imposing a domestic market obligation (DMO) on the company.

When designing PSCs, a trade-off between stability and flexibility exists due to considerable geological and economic uncertainties.[21] Geological uncertainty derives from the uncertainty about the amount of the exploitable reserves. Economic uncertainty is due to the lack of knowledge about production costs and future hydrocarbon prices. PSCs

[18] Pongsiri (n 11) 431–42.
[19] Z Lin, L Mingming, and W Zhen, 'Impacts of PSC Elements on Contracts Economics Under Oil Price Uncertainty' (2010) Paper presented to the 2010 International Conference on E-business and E-Government, Beijing, China.
[20] G Muttitt, 'Production Sharing Agreements - Mortgaging Iraq's Wealth' (2006) 28(3) Arab Studies Quarterly 1–17.
[21] D Johnston, 'Changing Fiscal Landscape' (2008) 1(1) Journal of World Energy Law & Business 31–53.

must foresee a degree of flexibility so that both host governments and IOCs may adapt their main measures to unforeseen events that may affect their relations. Therefore, PSCs must be sufficiently credible to stabilize anticipations but they must be able to adapt to changing environmental conditions.

To create a flexible PSC, sliding scales are used. The usual approach is an incremental sliding scale based upon daily production. Moreover, there are many variations of calculating payments based on cumulative production, water depth, oil prices or R-factors (ie ratio of revenues to expenditures). The setting of rates and the design of the scale is based on the available information and the expected size of the discovery.

3. Data collection and statistical analysis

Our data was collected through a review of published PSCs and specialized databases.[22,23,24,25] We were able to collect 44 *offshore* hydrocarbon PSCs (model contracts and laws) signed by 30 different countries during the period 1962–2007.[26] We focused our PSC data collection on neighbouring countries and countries with a similar profile to Lebanon. The countries and their correspondent PSCs, model contracts and laws are detailed in Table 2. In this section, we present basic descriptive and graphical statistical analysis for the PSC parameters in our dataset. Firstly, in the subsection 'Sliding and fixed scale PSC parameters', we slice the data according to fixed and sliding scale. Then, in the subsection 'Analysis of PSC parameters', we present a detailed statistical analysis.

Sliding and fixed scale PSC parameters

Sliding scale parameters are the ones that provide the PSC its required flexibility, so it is important to classify the parameters for the 44 PSCs,[27] model contracts and laws in the dataset into sliding scale based parameters and fixed parameters. All sliding scale contracts in the database impose a progressively smaller percentage of profit share for the IOC as production rate increases. Table 3 presents the break-down of the sliding and fixed scale parameters found in the 44 PSCs of the dataset.[28] From Table 3, we see that in the majority of contracts (35 out of 41), the profit share parameter is sliding scale, since governments search to increase their take from their natural resources upon commerciality of production. Both royalty and profit share are received upon production; hence, with sliding scale profit share, governments use fixed royalties to build an attractive contract for companies. Profit share can be sliding scale based on hydrocarbon production or R-factor. Table 3 also shows that only 7 out of 34 contracts have sliding scale cost recovery. This is due to the fact that cost recovery, in general, is a function of costs paid

22 Bindemann, (n 15).

23 D Johnston, *International Exploration, Economics, Risk, and Contract Analysis* PennWell Corporation 2003).

24 Herold (2009) <http://www.herold.com/research/herold.home>.

25 Barrows Company (2009) <http://www.barrowscompany.com>.

26 Many of our PSC data are prior to 2000, but looking at their signature date and the exploration and production periods, all of these PSCs are still active, which maintains the usefulness of the dataset for benchmarking purposes.

27 Some PSCs specify the type of parameter (sliding/fixed), however, no specific value is provided.

28 Note that not all the PSC parameters in Table 1 are necessarily found in every PSC we collected in Table 2.

Table 2. Countries and the corresponding PSCs, model contracts and laws

Country	Oil contract/law available by year	Label	Political and economic risk	Condition of reserves	Water depth
Angola	1979–1991	Ang79	High	Unproven	Deep* and Not deep†
Angola	Mid 1990s	Ang90s	High	Proven	Deep and Not deep
Azerbaijan	AIOC PSC I, 20 Sep-94	Azer94	High	Proven	Deep
China	1990	Chi90	Moderate	Proven	Deep
Colombia	Association contract post, 1994	Col94	High	Proven	Deep
Congo	Hydrocarbon Law, 1994	Con94	High	Proven	Deep and Not deep
Cote d'Ivoire	Block CI-11 Pluspetrol, 27-Jun-95	Cot95	Low	Proven	Not deep
Cyprus	Mines regulation Law,1997	Cyp97	High	Unproven	Deep
Cyprus	Forest Oil Contract, 1962	Cyp62	High	Unproven	Deep
Ecuador	7th round, 1995	Ecua95	High	Proven	Not deep
Equatorial Guinea	United Meridian/Conoco, 92	Gui92	High	Unproven	Deep and Not deep
Guatemala	1997	Guat97	High	Proven	Deep
India	Late 1980s	Indi80	Moderate	Proven	Not deep
India	Marubeni, ONGC Ravva, 28-Oct-94	Indi94	Moderate	Proven	Not deep
India	Bidding Announcement, 94	Indi94	Moderate	Proven	Not deep
India	Model contract, 1995	Indi95	Moderate	Proven	Not deep
Indonesia	Offshore Northwest Java, 18-Aug-66	Indo66	High	Proven	Not deep
Indonesia	Southeast Sumatra, 6-Sep-68	Indo68	High	Proven	Not deep
Indonesia	Standard, Pre 1984	Indo84	Moderate	Proven	Deep
Indonesia	2nd generation, 1976	Indo76	Moderate	Proven	Deep
Indonesia	3rd generation, 1988	Indo88	Moderate	Proven	Deep
Iraq	Oil law in Iraq, 15-Feb-07	Ira07	High	Proven	Deep
Israel	Oil regulation, 2005	OccP05	High	Unproven	Deep

(continued)

Table 2. Continued

Country	Oil contract/law available by year	Label	Political and economic risk	Condition of reserves	Water depth
Libya	Model contract, 1990	Lib90	Moderate	Proven	Not deep
Malaysia	1994	Mal94	Moderate	Proven	Deep
Malaysia	Deepwater terms, 1994	Mal94	Moderate	Proven	Deep
Malaysia	Model contract, 1997	Mal97	High	Proven	Deep
Nigeria	Shell and Elf, 1994	Nig94	High	Proven	Deep
Oman	Conquest, 1989	Oma89	Moderate	Proven	Not deep
Pakistan	1994	Pak94	High	Proven	Deep and Not deep
Peru	License contracts, 1993 law/Dec 1994	Per94	High	Proven	Deep
Peru	1971	Per71	High	Unproven	Deep
Peru	After 1978	Per78	High	Proven	Deep
Trinidad & Tobago	BHP/ Elf, 29-Feb-96	Trin96	High	Proven	Not deep
Qatar	Contract model, 1994	Qat94	Moderate	Proven	Not deep
Russia	Sakhalin II-MMMMS Consortium, 23-Jun-94	Rus94	High	Proven	Not deep
Syria	SPC & 3companies, 30-Jan-97	Syr97Jan	High	Proven	Deep
Syria	Mol Palmyra East agreement, 19-Feb-97	Syr97Feb	High	Proven	Deep
Syria	Tel abyad agreement, 23-Jun-92	Syr92	High	Proven	Deep
Syria	Model contract, 23-Jun-92	Syr92	High	Proven	Deep
Timor Gap – Zoca	License round, 1991/1992	Tim92	High	Unproven	Deep
Turkmenistan	Monument, 7-Aug-96	Tur96	High	Proven	Deep
Yemen	2005	Yem05	High	Proven	Deep
Zambia	8-Jun-05	Zam05	High	Unproven	Deep

* Deep water is >500 meter.

† Some contracts may involve contracting deep and not deep water depth in the same contract.

Table 3. Sliding scale parameters

Contracts' parameter	Total number available	Number of PSCs with sliding scale parameter	Number of fixed scale parameters
Royalty	41	10	31
Profit share	41	35	6
Cost recovery	34	7	26
Signature bonus	24	0	24
Production bonus	28	16	12
Tax	37	2	35
DMO	19	0	19

not a function of the gross production. The signature bonus is always on a fixed-scale basis because it is received upon signing the contract. On the other hand, the production bonus, received upon production, is sliding scale in 16 out of 28 contracts to allow the government to capitalize further on commercial discoveries. Finally, sliding scale taxes were found in only in 2 out of 39 contracts.

Analysis of PSC parameters

Our analysis here involves examining one PSC parameter at a time. Profit share and production bonus are the PSC parameters that mostly use a sliding scale (Table 3). Even though information about the type of production bonus is available, we lack quantitative values for the volume ranges and their respective bonus. On the other hand, the production bonus and signature bonus have a $0 value in most contracts. Therefore, no analysis is done on these parameters.

For the sliding scale profit share, we unified its volume ranges in thousand barrels of oil per day (MBOPD) and collected statistics on each range. We also combined these with fixed scale, profit scale data. Figure 2 comprises nine box plots, one box plot for each range of hydrocarbon production volume (the fixed scale data shows up in every box per period). Descriptive statistics on each range are as follows. The mean profit oil starts at 60 per cent for low volume and increase to 72 per cent for high volume. The standard deviation is around 15 per cent for all ranges, the median shown in Figure 2 is equal or slightly larger than the mean indicating a symmetrical or slight left skew. Each number in the box plot refers to a contract and the legend found in the figure presents the details. For example, 1 is Ang90s; referring to Table 2 for labelling, Ang90s is the PSC signed in Angola during the 1990s.

The government profit share is higher in countries with proven reserves and low political and economic risk level such as Oman 1989. On the other hand, an instable and risky country status with unproven reserves pushes the government to lower its profit share such as Guatemala in 1997.

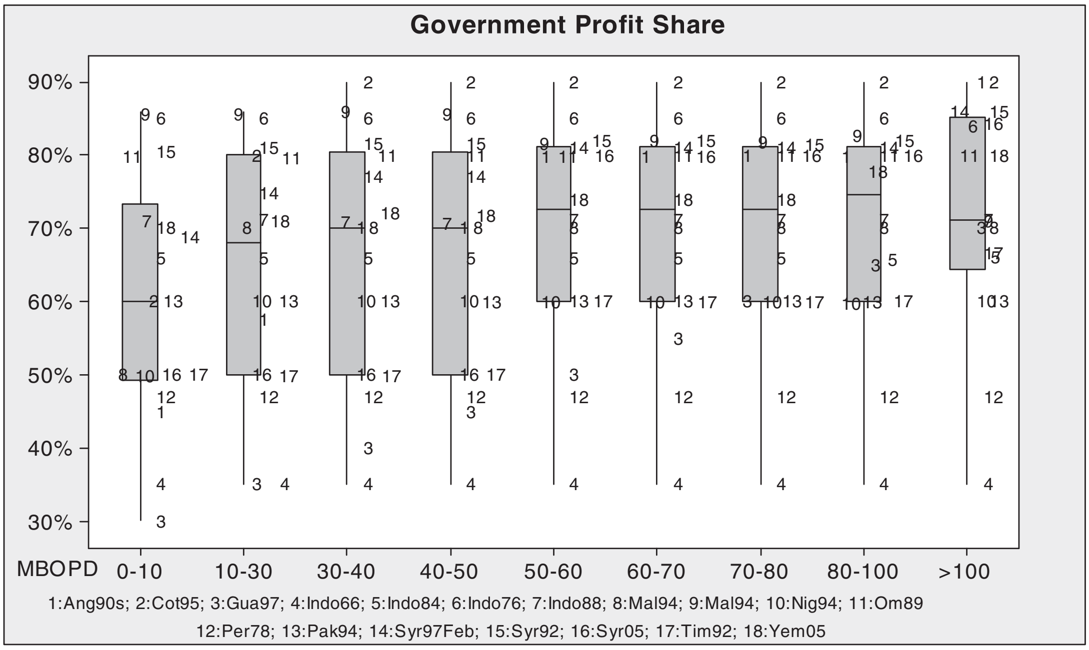

Figure 2. Fixed and sliding scale profit share.

Figure 3 shows a box plot for the royalty parameter in a PSC. Since most royalty data is fixed scale (Table 3), Figure 3 shows fixed scale data only. Descriptive statistics are shown in the top right of Figure 3 with a mean and standard deviation both around 7 per cent indicating high variability; the mode is 0 since most countries do not charge royalty. The figure also shows that several countries with unproven reserves at the time of PSC signature have 0 per cent royalty (eg Angola, Ecuador) to make their PSCs attractive; whereas countries like Colombia and Guatemala, which have proven reserves, have a high royalty, around 18 per cent.

As for the other parameters, we also developed their box plots and descriptive statistics as shown in Figures 4, 5, 6 and 7. For cost recovery (Figure 4) the lowest cost recovery is found in Peru (0%), ie no cost recovery, since the Peruvian reserves are proven and been attractive to oil companies for years. On the other hand, several countries have cost recovery during the production because of the need for incentives to attract oil companies, just like Cote d'Ivoire in 1995 where there is full cost recovery capped at 40 per cent of the yearly production.

The signature bonus has a value of $0 for most contracts except for Nigeria and Azerbaijan, which are outliers. Applying signature bonus in both Nigeria and Azerbaijan is due to their proven and commercial reserves. In addition to the fact that these countries are in need of cash and search for a quick cash flow from their hydrocarbon resources.

As for taxes (Figure 5), unattractive countries for investment (ie high-risk countries) are forced to lower their taxes. For example, when Indonesia was a high-risk country in 1966, it signed the Northwest Java contract with 0 per cent tax. Alternatively, when

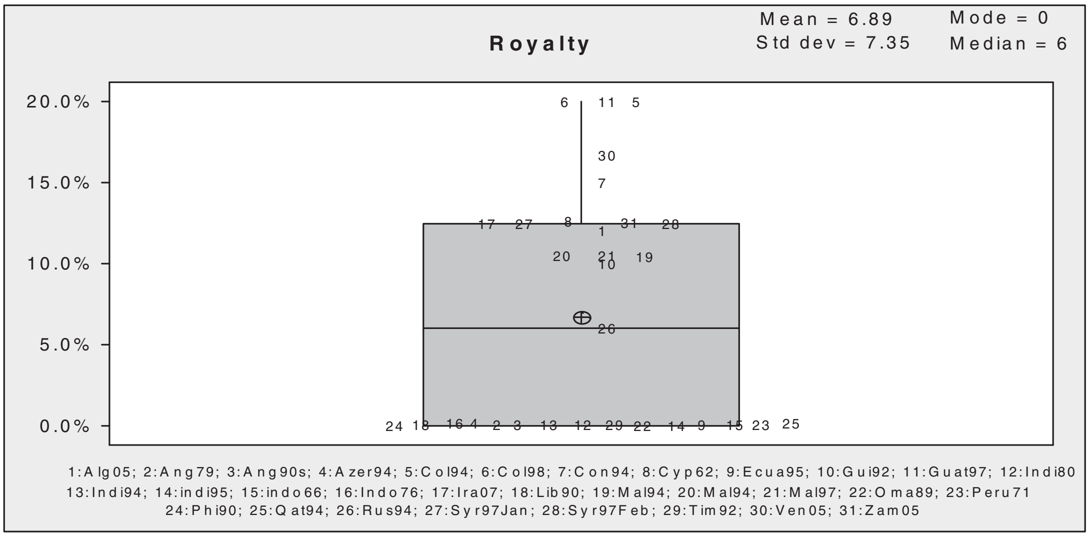

Figure 3. Distribution and descriptive statistics for royalty.

Indonesia became more stable in the 1980s, the tax rate went up to 56 per cent.

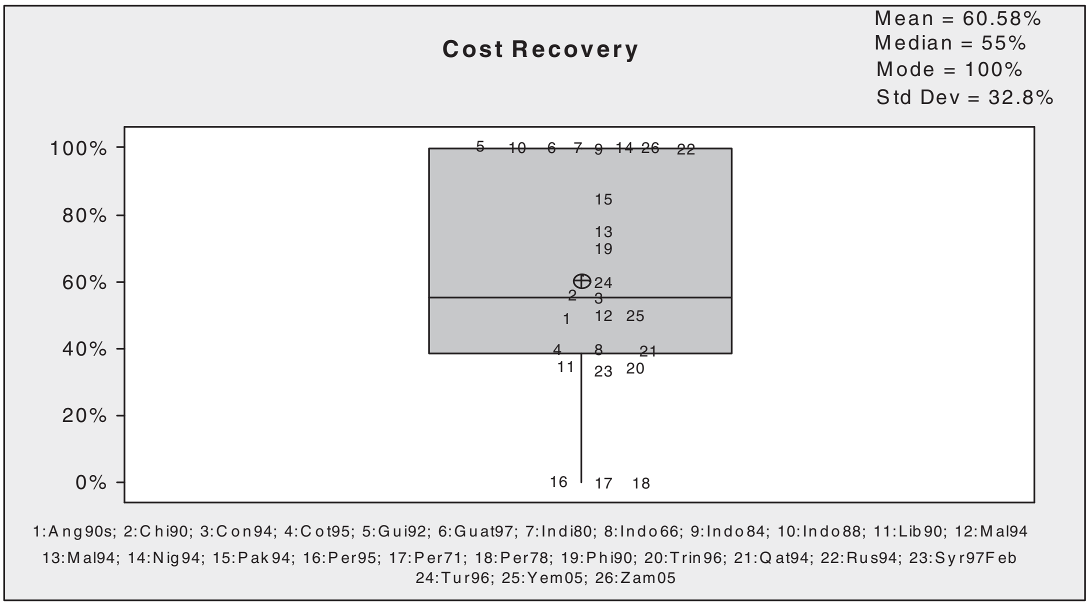

Figure 4. Distribution and descriptive statistics for cost recovery.

In terms of exploration period (Figure 6), countries working on proving their reserves (eg Congo, Philippines) have high exploration period of 10 years. On the other hand, the lowest exploration period is for 4 years found in Colombia where reserves had already proven.

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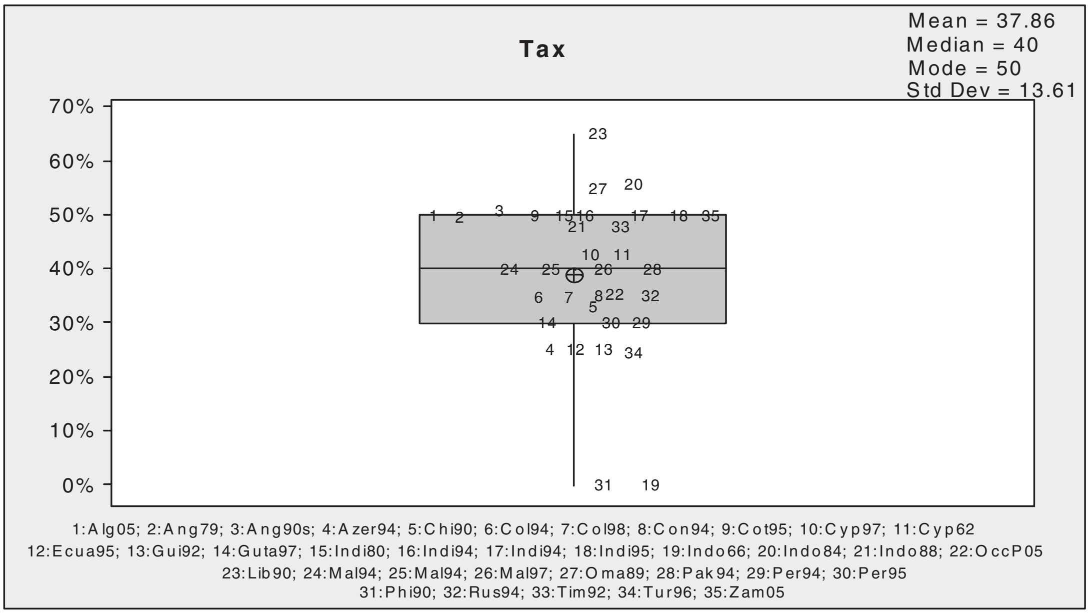

Figure 5. Distribution and descriptive statistics for tax.

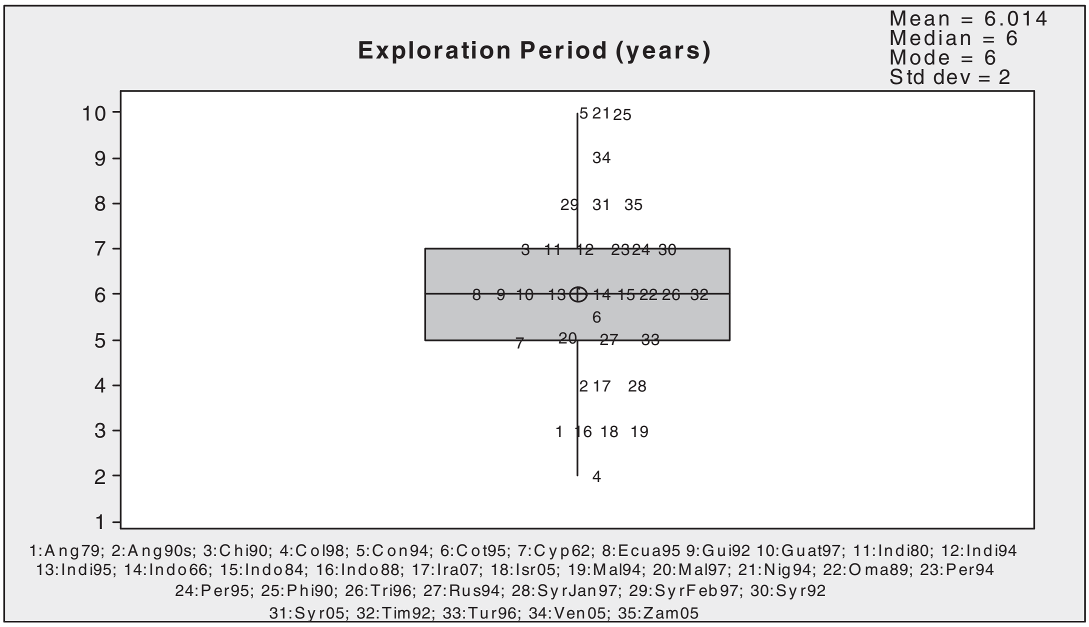

Figure 6. Distribution and descriptive statistics for exploration period.

In terms of production period (Figure 7), Peru in 1995 had the lowest production period of 10 years, because Peru in 1995 had proven high commercial hydrocarbon reserves, hence, it did not need to put incentives to attract companies using a long production period. On the other hand, several countries (eg Philippines) worked on attracting oil companies with high production periods of 30 years.

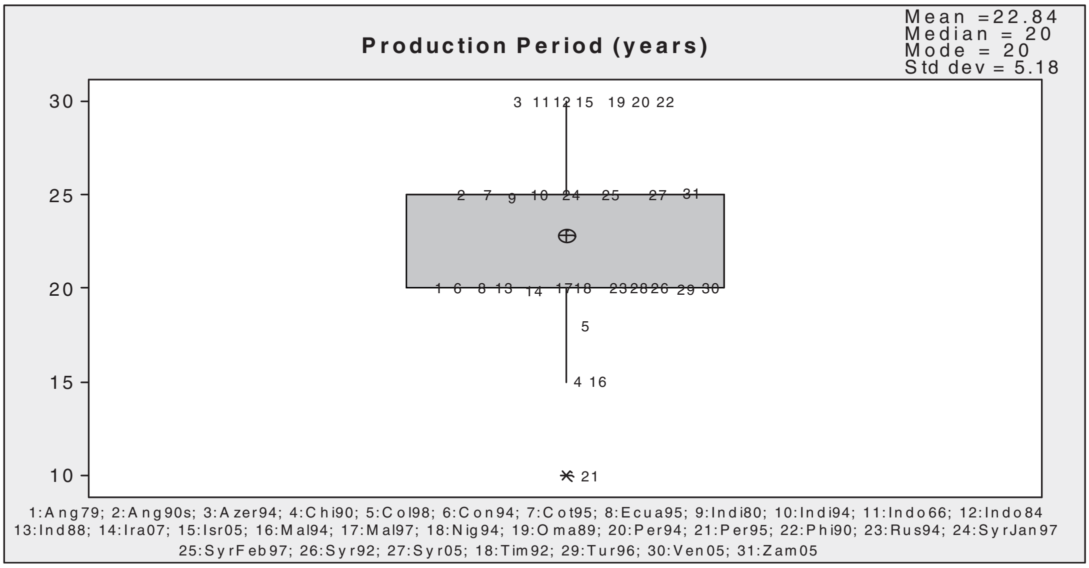

Figure 7. Distribution and descriptive statistics for production period.

4. Government and IOC take model

In order to understand the effect of the contract parameters on the takes of the government and the IOC, we introduce a simple model for a PSC that links the production of hydrocarbon to the take of the government and IOC, as shown in Figure 8.[29,30]

During the exploration period, there is no gas production. Therefore, the government take is null and the company cash flow is negative due to the capital and operating costs. For this reason, the financial model in Figure 8 is applicable throughout the production phase. Applying the model of Figure 8 allows both host governments and IOCs to calculate their take. Additionally, they can perform sensitivity analysis on the various PSC parameters to find out the impact of uncertainty in these parameters on their take. Thus, they can focus their attention and negotiation efforts on these parameters that have a larger impact on their take. In Section 7, we will utilize this model to do such a sensitivity analysis on the parameters for a potential Lebanese PSC.

5. Profiling

The political determinants of economy wide investment are used to form an index of ownership security. When introduced in empirical models of natural resource use, this index has a significant and quantitatively important effect on the use of petroleum.[31] In addition, Zanoyan mentions that the geological preferences based on proven reserves

[29] Bindemann (n 15).

[30] Johnston (n 16).

[31] H Bohn and R Deacon, 'Ownership Risk, Investment, and the Use of Natural Resources' (2000) 90(3) The American Economic Review 526–49.

Models Parameters

GT = Government Take	*GNCF* = Government Net Cash flow	*T* = Tax
IOCT = IOC Take	*OCNCF* = Oil Company Net Cash flow	*B* = Bonus (signature/production)
GS = Government Share	*NR* = Net Revenue	*R* = Royalty
CC = Capital Costs	*OC* = Operating Costs	*P* = Price
GR = Gross Revenue	*V* = Production Volume	*CR* = Cost Recovery
TI = Taxable Income	*D* = Depreciation	*TP* = Total Profit
TLCF = Tax Loss Carry Forward		

Equations linking the takes of the host government and IOC to PSC parameters

$$GT = (GNCF)/(GNCF + OCNCF) \times 100,$$
$$IOCT = 100 - GT,$$

where,

$$GNCF = R + GS + B + T,$$
$$OCNCF = NR - CC - OC - GS - B - T,$$
$$NR = GR - R,$$
$$GS = TP \times GS\,(\%),$$
$$GR = V \times P,$$
$$TP = NR - CR\,,$$
$$CR = OC + CC,$$
$$T = T\,(\%) \times TI,$$
$$TI = NR - CR - GS - B.$$

Figure 8. PSC takes model

and water depth, and the political and economic status of the host country are the major factors influencing an investment decision taken by an international oil company.[32] Accordingly, we chose the 'political and economic risk', the 'water depth', and the 'reserves status' to constitute the elements of the profile built for each contract. The following paragraphs discuss each factor in more details.

Political and economic risk

In our dataset, each contract or law corresponds to a specific country and was signed in a particular period. Hence, each contract could be subject to different political and economic threats even if it is in the same country. The political and economic risk factor can be 'low', 'moderate' or 'high'. We determine this by looking at the historical political and economic condition of the country at the specific date of the contract (or law). Table 1 presents the PSCs in the dataset with their corresponding date and the political and economic risk factor of the country at that date. The justifications for the noted political and economic risk levels for contract is based on various Internet resources.[33]

The status of hydrocarbon reserves

Hydrocarbon reserves are the estimated quantities of hydrocarbons that are claimed to be recoverable under existing economic and operating conditions.[34] All reserve estimates can be divided into two principal classifications: 'proven' and 'unproven' reserves. Proven

32 V Zanoyan, 'The Oil Investment Climate' (2004) 47(26) Middle East Economic Survey 1–10.

33 They include Wikipedia (<http://www.wikipedia.org/>), the Economist Intelligence Unit (<http://www.eiu.com>), and the Central Intelligence Agency World Fact Book <https://www.cia.gov/library/publications/the-world-factbook>. accessed 13 April 2009.

34 USEIA, Energy Glossary-R (2007) <http://www.eia.doe.gov/glossary/glossary_r.htm>. accessed 13 April 2009.

reserves are those reserves claimed to have a reasonable certainty (at least 90 per cent confidence) of being recoverable under existing economic and political conditions with the existing technology. Reserves are classified as unproven if technical, contractual or regulatory uncertainties preclude such reserves being classified as proven.[35] Table 2 shows the PSCs in the dataset with their corresponding date and the condition of the hydrocarbon reserves in the country at that date. The sources behind the hydrocarbon status information are the US Energy Information Administration and Index Mundi.'[36]

Water depth

Water depth is the depth of water in an area to be relinquished, explored or exploited. When the water depth becomes high (greater than 500 meters) in a given area, this area becomes less attractive to oil companies since water depth poses many technical challenges on exploration and exploitation.[37] Hence, in addition to political and economic risk level and the reserve status, water depth is considered to be the third factor for countries' profiling. Contracts within our dataset were categorized between 'deep' and 'not deep' water, based either on the information available within the contract itself or based on the literature.[35,38]

6. Contract profile factor analysis

Based on Section 5, contracts within our dataset can be divided into eight groups based on the political and economic risk level, the status of the hydrocarbon reserves and water depth. Our objective in this section is to statistically prove the validity of these two factors used for profiling. Table 4 contains the breakdown of the number of PSCs in our dataset.

From Table 4, it can be seen that all PSCs on unproven reserves are signed during high-risk periods. Table 4 also includes 30 PSCs from 23 countries are signed during high political and economic risk periods and 14 PSCs from 8 countries of our dataset were signed under low (and moderate) political and economic risk status. Under low political and economic risk status, 6 out of 14 contracts are signed on a deep-water area, whereas under high political and economic risk status, 24 contracts involve deep-water areas, where 17 of them are contracts for proven reserves and 7 contracts consider unproven reserves.

Tables 5 and 6 present the descriptive statistics of the PSC parameters under low and high political and economic risk level. The analysis of the profit share was done based on both, the sliding and the fixed scale PSC data. Table 5 shows adjusted volume ranges along with their respective descriptive statistics. The set of sliding scale profit gas is small to collect its statistics; this is why we will focus on profit oil split.

[35] SPE, 'Glossary of Terms Used in Petroleum Reserves Resources' (2005) <http://www.spe.org/spe-site/spe/spe/industry/reserves/GlossaryPetroleumReserves-ResourcesDefinitions_2005.pdf>. accessed 13 April 2009.

[36] See Zanoyan (n 32); Index Mundi, 'Crude Oil Production by Year' (2007) <http://www.indexmundi.com>. accessed 13 April 2009.

[37] Johnston (n 16).

[38] Bindemann (n 15).

Table 4. Number of PSCs in our dataset by reserves status and risk level

		Reserves Status		
		Proven	Unproven	Total
Risk Level	High	22 (17 deep, 8 not deep)*	8 (7 deep, 2 not deep)*	30
	Low	14 (6 deep, 8 not deep)	0	14
	Total	36	8	44

* Total (deep, not deep). The deep/not deep data do not necessary add up to the total. See footnote 6.

Table 5. Profit oil volume ranges and their statistics for high- and low-risk countries

Volume ranges thousand barrels per day(MBOPD)	Mean (%)		Standard Deviation (%)		P-value
	High	Low	High	Low	
0–10	57.12	60.87	17.93	23.79	0.726
10–20	58.85	63.72	17.34	23.46	0.642
20–30	61.47	66.58	15.87	24.14	0.628
30–40	63.21	68.01	15.5	25.34	0.661
40–50	64.87	68.01	12.73	25.34	0.768
50–60	68	68.58	12.84	23.92	0.954
60–70	68.42	68.58	12.27	23.92	0.987
70–80	69	68.58	11.95	23.92	0.967
80–90	71.25	68.58	10.07	23.92	0.787
90–100	71.67	68.58	9.89	23.92	0.754
>100	74.58	70.44	12.82	19.42	0.622

Table 6. Statistics for the contract's parameters in high and low risk countries

Parameter	Mean		Standard deviation		P-value
	High	Low	High	Low	
Royalty (%)	8.21	2.33	7.13	4.63	0.0534*
Cost Recovery (%)	58.3	68.75	37.83	28.38	0.729
Tax (%)	33.8	48.33	11.55	8.29	0.0057*
Exploration period (years)	7.3	5.44	2.05	1.4	0.023*
Production period (years)	23.25	27.86	5.2	8.6	0.786

* statistically significant at 5% level.

Table 6 presents a summary of descriptive statistics for the rest of the contract parameters. Table 4 also shows that 36 PSCs were signed under proven reserves whereas 8 of the PSCs in our dataset were signed under unproven reserves. The descriptive statistics of PSCs' parameters signed on proven and unproven reserves are shown in Tables 7 and 8. The descriptive statistics for PSC parameters for deep versus not deep water are shown in Tables 9 and 10.

The two-tail t-test was applied on each parameter data in order to assess whether its mean is affected at a statistically significant level by each of our three profiling factors. For example, the mean profit oil under high political and economic risk in the range 0–10 MBOPD is 57.12 per cent with a standard deviation of 17.93 per cent; under low risk, these numbers are 60.87 per cent and 23.79 per cent. Comparing these two means (using the computed standard deviation) with the t-test gives a P-value of 0.726 shown in Table 5. This indicates that political risk is not a significant factor for the profit oil in the 0–10 MBOPD range.

Overall we make the following conclusions based on the t-test for means:

(i) From Tables 5, 7 and 9, it can be seen that at a significance level of 5 per cent, the profit oil is affected by the status of the hydrocarbon reserves and not by the political and economic risk level, nor by the water depth. It can also be seen from Table 7 that the effect of the status of reserves is significant at small volume ranges and gets to be insignificant with a production larger than 50 thousand barrels per day, since getting to this production level automatically proves the reserves.

(ii) Tables 6, 8 and 10 indicate that the royalty is affected by the level of political and economic risk and the water depth and not by the reserves' status.

(iii) Tables 6, 8 and 10 show also that the exploration period is affected by the level of political and economic risk and not by the reserves' status, nor the water depth. Since during the exploration period, the oil company already bears the geological risk without any income during the whole exploration period, hence it has to take into consideration the political and economic risk level of the country.

(iv) Tables 6, 8 and 10 also indicate that the tax parameter is affected only by the country risk level. This could be the case since tax is related to the fiscal and political system of the country.

(v) Finally, Tables 6, 5 and 10, also indicate that all profiling factors are not significant for the cost recovered and the production period parameters. These parameters may be related to other factors not considered in our article.

7. Case study: Lebanon

The constant threat of instability and regional violence, the large budget deficit and the high government debt at around 160 per cent of GDP make it very difficult for Lebanon's economy to gain momentum. Lebanon is classified as a high political and economic risk

Table 7. Profit oil volume ranges and their statistics for countries with proven and unproven reserves

Volume ranges (MBOPD)	Mean		Standard deviation		P-value
	Proven	Unproven	Proven	Unproven	
0–10	58.98	48.5	20.17	2.12	0.05*
10–20	61.23	48.5	19.7	2.12	0.018*
20–30	64.1	48.5	19.1	2.12	0.004*
30–40	65.81	48.5	19.34	2.12	0.002*
40–50	66.92	48.5	17.83	2.12	0.001*
50–60	68.67	53.5	17.45	9.19	0.191
60–70	68.95	53.5	17.17	9.19	0.187
70–80	69.34	53.5	17.01	9.19	0.181
80–90	71.12	53.5	16.24	9.19	0.158
90–100	71.39	53.5	16.17	9.19	0.155
>100	73.78	56	15.04	12.73	0.266

* statistically significant at 5% level.

Table 8. Descriptive analysis of PSC parameters for proven and unproven reserves

Parameter	Mean		Standard deviation		P-value
	Unproven	Proven	Unproven	Proven	
Royalty (%)	5.83	5.91	6.45	7.21	0.981
Cost Recovery (%)	72.5	62.06	48.56	29.56	0.702
Tax (%)	40.14	38.75	8.93	13.37	0.753
Exploration period (years)	7.33	6.7	2.34	2.02	0.56
Production period (years)	31.25	25.29	13.15	6.95	0.44

country. The water depth in offshore Lebanon is of more than 500 meters which makes Lebanon a deep water exploration country.

The interest in the Lebanese hydrocarbons dates back to the 1950's. Some Lebanese oil and gas exploration began in the late 1947 and 1967 with the drilling of several wells across the country.[39] Then, exploration came to a halt when Lebanon's civil war began in 1975.[40] No exploration drilling has been made in offshore Lebanon to try to verify the condition of natural gas reserves in the Lebanese sea. Therefore, to date, Lebanon has no proven hydrocarbon reserves. However, the discoveries in neighbouring countries coupled with positive seismic studies bring Lebanon closer to the status of proven reserves. Finally, it is worth noting that referring to the Lebanese petroleum law, the

[39] FH Nader, 'The Petroleum Prospectivity of Lebanon: An Overview' (2011) 34(2) Journal of Petroleum Geology 135–56.
[40] Executive Magazine (n 6) 64–70.

Table 9. Profit oil volume ranges and their statistics for countries with deep and not deep water

Volume ranges (thousand barrels per day)	Mean		Standard deviation		P-value
	Deep	Not Deep	Deep	Not Deep	
0–10	58.9	57.5	18.43	23.27	0.917
10–20	60.87	61.25	17.43	21.75	0.976
20–30	63.52	65	15.8	21.21	0.903
30–40	65.04	67.5	15.31	23.98	0.856
40–50	66.47	71.25	12.76	17.5	0.838
50–60	68.79	71.25	12.28	17.5	0.806
60–70	69.14	71.25	11.75	17.5	0.833
70–80	69.65	71.25	11.43	17.5	0.872
80–90	71.58	76.25	9.68	11.09	0.484
90–100	71.93	76.25	9.51	11.09	0.515
>100	74.58	77.5	11.18	10.41	0.646

Table 10. Descriptive analysis of PSC parameters for deep and not deep water

Parameter	Mean		Standard deviation		P-value
	Deep	Not Deep	Deep	Not Deep	
Royalty (%)	8.83	2.38	7	4.89	0.005*
Cost Recovery (%)	66.43	61.82	33.61	28.22	0.7
Tax (%)	37.19	42	7.95	16.02	0.3
Exploration period (years)	6.95	6.58	2.27	1.63	0.57
Production period (years)	26.25	27	7.76	6.75	0.79

* statistically significant at 5% level.

Lebanese government is adapting the PSC as the type of contract that would organize and manage its hydrocarbon resources.

Suggestions

Our suggestions for the Lebanese PSC are based on the statistics for high risk, unproven reserves and deep-water countries. We will use a range based on the high-risk countries found in Table 6 for the parameters highly affected by the economic and political risk level; ie the tax and the exploration period. For royalty, we will use both factors: high political risk and deep water. The ranges are found based on drawing a 95 per cent confidence interval around the sample means for both the tax and the exploration period parameters.

For the parameters affected by the status of the reserves (ie the profit share), we use a 95 per cent confidence interval around the sample mean based on the countries with unproven reserves (Table 7) until the 50 thousand barrels production per day and the whole dataset for larger production volume. This is based on the P-values in Table 7 indicating that with 95 per cent confidence, the reserve status has significant effect on profit share for values up to 50 MBOPD. Table 11 shows the volumes ranges, the suggested profit oil share ranges and their corresponding suggested profit gas share using the ratios in Table A2 in the Appendix. For the PSC parameters that are found to be independent of the profiling factors (ie cost recovery and production period), we use a range based on the whole dataset regardless of the risk level, the status of reserves or water depth.

Then, the suggested ranges and values for a Lebanese model PSC are shown in Table 12. The bonuses (signature and production) are chosen to be zero since approximately all the signature bonus and production bonus in our dataset are equal to zero; this also can be a good incentive for international companies to invest in Lebanon.

Sensitivity analysis for Lebanon's case

Using the 'take' model in Section 4, we calculated the government and IOC takes. The calculations start with a base case, where the base values for the PSC parameters are assumed to be equal to the mean of each parameter in Tables 11 and 12. That is, we assume the royalty is 8 per cent, cost recovery is 60 per cent of the cost government, profit share is 62 per cent (mean of profit oil values from Table 5), tax is 34 per cent, and signature bonus is \$0. Additionally, we assume having an oil price of \$80. Then, a one-way sensitivity analysis was performed by changing each PSC parameter along some ranges (taken from Tables 11 and 12) while holding other parameters at their base values. The sensitivity analysis reveals the magnitude of impact each parameter has on the takes of the government and the IOC.

Figure 9 presents the takes of the government and the IOC (contractor) as a function of the profit share of the government. In Figure 9, the slope of the fitted line relating the government profit to the government take is 0.488, indicating a significant effect of profit share. Further sensitivity analysis was conducted on the different parameters of a PSC.[41] The ranges used for each parameter and the slope of the linear trend relating each parameter to the take of the government are shown in Table 13. Table 13 indicates that the government's profit share has the highest slope, thus the highest effect on the take of the government, followed by royalty and tax. Therefore, when negotiating a PSC, the government can be strict on setting profit share, conservative about royalty and tax.

8. Conclusion

The main objective of this study was to assist governments, in general, in structuring hydrocarbon contracts for offshore hydrocarbon potentials; the Lebanese government in particular. To achieve this objective, offshore hydrocarbon PSCs were collected, studied and analysed. Descriptive statistics on PSC parameters were established and sensitivity

[41] N Younes, 'On Structuring Offshore Hydrocarbon Production Sharing Contracts: Lebanon's Case' (MS thesis, Engineering Management Program, American University of Beirut 2010).

Table 11. Suggested profit oil and profit gas shares for Lebanon

Volume ranges (thousand barrels per day)	Government profit oil share (%)	Government profit gas share (%)
0–50	46.38–50.62	33.85–36.95
>50	57.62–86.88	46.47–70.06

Table 12. Suggested ranges and values for a Lebanese hydrocarbon PSC

Variables	Ranges and values
Royalty	5–13%
Cost recovery	50–70%
Tax	30–38%
Signature bonus	$ 0
Production bonus	$ 0
Exploration period	6.5–8 years
Production period	21–25 years

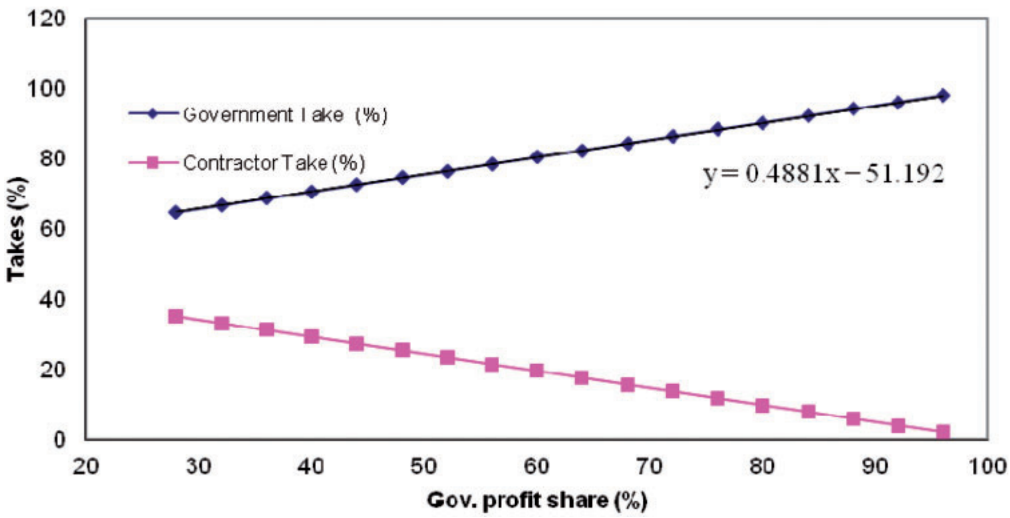

Figure 9. Sensitivity analysis on the government 'profit share'.

analysis was conducted. Our financial feasibility analysis concluded that the government's profit share split is the most critical parameter on its take; hence, it is the parameter that should be greatly taken into consideration.

In order to be able to provide suggestions on PSC parameters' values for Lebanon and other countries, we profile contracts and countries on the basis of political and economic

Table 13. Results of the sensitivity analysis

Parameters under simulation	Ranges (%)	Slope
Cost Recovery	62–100	(–0.188)
Royalty	0–23	0.327
Tax	26–54	0.363
Government Profit Oil	28–96	0.488

risk level, hydrocarbon reserve status and water depth. Then, contracts in countries similar to Lebanon's profile were analysed and quantitative suggestions of ranges for Lebanon's hydrocarbon PSC parameters were given.

To do the profiling accurately, we statistically test the effect of the profiling factors on the contract parameters. We find that the political and economic risk factor has a significant effect on royalty, tax and exploration period. We also find that the reserve status factor affects profit share only, and the water depth factor affects royalty only. The other parameters, cost recovery, signature bonus and production bonus, were not found affected by any of the three profiling factors. They may be related to additional factors not used within our study. Investigating these additional factors can be addressed in future work.

This study is useful for the Lebanese government since it yields a PSC with a reasonable combination of parameters for the case of Lebanon, comparable to similar countries. The results do not reflect actual deals but governmental opening bargains but they will enhance the bargaining position of the Lebanese government. In addition, our data, analysis and framework can be used by other countries, with different profiles, for recommending plausible PSC ranges.

Appendix A: The Difference between Gas and Oil PSC

Hydrocarbon contracts can either be oil-only contracts, gas-only contracts, or both oil and gas contracts. In our dataset, all contracts are either oil-only or oil-and-gas; no gas-only contracts were found. Our data set shows that the main difference between oil-only PSCs and oil-and-gas PSCs lies in the profit share split (fixed or sliding scale). Specifically, in our dataset, 30 out of 44 are oil-only contracts/laws and 14 out of 44 are oil-and-gas contracts/laws. In an oil-and-gas contract, all parameters have the same value for both types of hydrocarbons, except for profit share split where there are two profit shares, profit oil and profit gas. With fixed profit share parameter, the profit oil split share of the government is higher than its profit gas, for example, in the third generation Indonesian oil and gas law, the government profit oil is 71 per cent whereas the government profit gas is 42 per cent. In order to be able to compare production based sliding scale profit oil and profit gas, we first convert the volume ranges to the same unit and scale. The divergence between profit oil and profit gas lies within the ranges of volumes used and/or within the share itself. In both cases, one can conclude that profit oil is higher than profit gas. Table A1 provides examples of sliding scale profit share for more clarification, and Table A2 presents the average ratio of profit oil over profit gas.[42] This ratio is used to convert profit oil share of a PSC to the profit gas of the same PSC.

Table A1. Examples of government profit oil and gas shares

Contract	Government profit oil share		Government profit gas share		Findings
	MBOPD	Share	MCFD	Share	
Trinidad & Tobago—1996	0–10	60%	0–60	50%	Same ranges of volume production (1 MBOPD = 6 MCFD) but higher percentage share for oil
	10–25	65	60–150	50	
	25–50	70	150–300	55	
	50–75	75	300–450	60	
	>75	80	>450	65	
Qatar—1994	0–15	55%	0–130	55%	Same percentage for oil and gas profit share, but wider gas ranges
	15–30	60	131–260	60	
	30–45	65	261–390	65	
	45–60	70	391–520	70	
	>60	75	>520	75	

Table A2. Ratio of profit oil and profit gas shares

Ranges of profit oil and gas shares		Average Ratio (oil/gas)
MBOPD	MCFD	
0–10	0–60	1.43
10–25	60–150	1.38
25–50	150–300	1.3
50–75	300–450	1.25
>75	>450	1.23

42 This average ratio is obtained by averaging the ratios of the profit share of oil and gas in the same contract (ie oil-and-gas contracts).