The Journal of Applied Sciences Research

Journal homepage: http://www.journals.wsrpublishing.com/index.php/tjasr

Online ISSN: 2383-2215

Original Article

Financial Instruments Impacts on Extraction Path (in Buy Back Contract Setting)

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ARTICLE INFO

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How to cite this article:
Varahrami, V. 2014. Financial Instruments Impacts on Extraction Path (in Buy Back Contract Setting). *The Journal of Applied Sciences Research.* 1(3): 200-204.

Article History:
Received: 30 October 2014
Revised: 17 November 2014
Accepted: 20 November 2014

ABSTRACT

In this paper, I want to survey owner source country policies on extraction path. I assumed that a contract is written between owner source country and investor company. Investor and owner country want to maximize their profit from contract. Owner country can affects on extraction and exploration paths with its concluded contract.

Keywords: Gas contracts, Investor Company, Owner Source Company, Buy Back Contract, Financial Instruments.

INTRODUCTION

In this paper, I said source owner country regulates a contract with Investor Company. Investor extracts from source and should pay share to owner country. Owner country uses from different methods for determining share, independent of production and percent of production.

Which in buy back contracts, share is determined as percentage of production. In his paper I want to survey effects of these two payments methods on extraction and exploration paths. Therefore I use from control theory for extract conditions.

There are only two major studies about South Pars Gas Field, as; Van Groenendaal and Mazraati (2006) discussed risk factors in buy back contracts in South Pars Gas Field. They reveal that if oil or gas price drops below a certain threshold then large reduction in foreign country investment is accrued.

Ghandia and Linb (2012) focus on Iran's buy back contract and survey optimality of production decisions. They use a dynamic optimization method for modeling optimal production of buy back contracts in Soroosh and Nowrooz.

Buy Back Contract of Gas Producing Model

In buy back contract setting for gas extraction and envelopment, as a contract signed between country and Investor Company, exploration and drilling activities is stated by investor. Due the contract, Investor Company must pay fixed amount for host country as it is exploited proven gas reserves. It is assumed that, extraction cost is $C_1(S)Q$ and it's development cost is $C_2(w)$, where S is known as gas reserves, Q is extraction rate and w is drilling efforts. Since gas price is determined with cost-push method, and so that it may be written as $P = a - bQ + \gamma$, where P is gas price and γ is scarcity rent. G is host country's share from profit of extraction which is independent of production (Elgsaeter *et al.*, 2011 and Leighty and Lin, 2012).

The profit of the investor company at any time period is denoted as $V = [PQ - C_1(S)Q - C_2(W) - G]$ and it's discounted value is represented $\pi_t = V(t)e^{-\delta t}$, where δ is discount rate and $e^{-\delta t}$ is a discount factor and $C_1(S)$ is an average extract cost as a inverse function of remained gas reserves. The aim of an investor company is to maximize the utility function as a concave of discountended profit over the time period of contract in order to analyze the time path of drilling. Therefore this model with this constraint is summarized as follows:

$$U\{\int_0^N [\pi(P,Q,S,w,G)]dt\} \tag{1}$$

Host country wants to maximize it's welfare from income of contract. "X" is income of contract which is concave function of "I". "I" is contract value which is function of "V" (value of source) and which "α" is type of project financing. We assume that welfare is concave function of "X", "X" is concave function of "I" and "I" is concave function of "V". Therefore host country's welfare is summarized as:

$$\int_0^N W[X(I(V,\alpha)) + G] f(v)dv = \overline{W} \tag{2}$$

Therefore Investor Company maximize it's utility from contract subject to owner source country's welfare as below:

$$MaxU\{\int_0^N [\pi(P,Q,S,w,G)]dt\}$$

St:

$$\int_0^N W[X(I(V,\alpha)) + G] f(v)dv = \overline{W}$$

$$\dot{S} = \dot{y} - Q \tag{3}$$

$$\dot{y} = f(w,y)$$

$$S \geq 0, Q \geq 0, w \geq 0, y \geq 0$$

With current Hamilton method, we have:

$$H = U[(a - bQ + \gamma)Q - C_1(S)Q - C_2(w) - G] + \lambda_1(f(w,y) - Q) + \lambda_2 f(w,y)$$
$$+ \lambda_3[\overline{W} - W[X(I(V,\alpha)) + G] f(v)dv] \tag{4}$$

I maximize (4) equation respect to Q, S, w, y:

$$\frac{\partial H}{\partial Q} = \frac{\partial U}{\partial A}[a - 2bQ + \gamma - C_1(S)] - \lambda_1 - \lambda_3 \frac{\partial W}{\partial Q} = 0 \tag{5}$$

$$\frac{\partial H}{\partial S} = \delta\lambda_1 - \dot{\lambda}_1 - \frac{\partial U}{\partial A} C_1'(S)Q = 0 \tag{6}$$

$$\frac{\partial H}{\partial w} = \frac{\partial U}{\partial A}\frac{\partial A}{\partial w} + \lambda_1 f_w + \lambda_2 f_w = 0 \Rightarrow \frac{\partial H}{\partial w} = (\lambda_1 + \lambda_2) f_w - \frac{\partial U}{\partial A} C_2'(w) = 0$$
(7)

$$\frac{\partial H}{\partial y} = -\delta\lambda_2 + \dot{\lambda}_2 + (\lambda_1 + \lambda_2) f_y = 0 \tag{8}$$

Therefore in this state extraction and exploration path is:

$$\dot{Q} = \frac{\frac{\partial U}{\partial A} C_1'(S)Q - \delta[\frac{\partial U}{\partial A}(a - 2bQ - C_1(S) + \gamma) - \lambda_3 \frac{\partial W}{\partial Q}] - \frac{\partial U}{\partial A} C_1'(S)\dot{S}}{\lambda_3 \frac{\partial^2 W}{\partial Q^2} - \frac{\partial^2 U}{\partial A^2}\frac{\partial A}{\partial Q}(a - 2bQ + \gamma - C_1(S)) + \frac{\partial U}{\partial A} 2b} \tag{9}$$

$$\dot{w} = \frac{\delta[\frac{\partial U}{\partial A} . \frac{C_2'(w)}{f_w} - \lambda_1] + \dot{\lambda}_1 - f_y[\frac{\partial U}{\partial A} . \frac{C_2'(w)}{f_w}]}{\frac{\partial^2 U}{\partial A^2} . \frac{\partial A}{\partial w} . \frac{C_2'(w)}{f_w} + \frac{\partial U}{\partial A}[\frac{C_2'' f_w - C_2' f_{ww}}{f_w^2}]} \tag{10}$$

In (9) and (10) equations, G is owner source country's share which independent of production and can not affect on $\dot{Q}$ and $\dot{w}$.

In other side, owner country wants to maximize it's welfare subject to investor company too (Pyndyck, 1978; 1980). Then I should extract extraction and exploration paths in this condition. Therefore we have:

$$MAX \int_0^N W[X(I(V,\alpha)) + G] f(v) dv$$

St:

$$U\{\int_0^N [(a - bQ + \gamma)Q - C_1(S)Q - C_2(w) - G]e^{-\delta t} dt\} = \overline{U}$$

$$\dot{S} = y - Q \tag{11}$$

$$\dot{y} = f(w, y)$$

$$S \geq 0, Q \geq 0, w \geq 0, y \geq 0$$

With current Hamilton, we have:

$$H = \int_0^N W[X(I(V,\alpha)) + G] f(v) dv + \lambda_3[\overline{U} - U\{\int_0^N [(a - bQ + \gamma)Q - C_1(S)Q - C_2(w) - G]e^{-\delta t} dt\}] + \lambda_1(f(w,y) - Q) + \lambda_2 f(w,y) \tag{12}$$

Then:

$$\frac{\partial H}{\partial Q} = -\lambda_3 \frac{\partial U}{\partial A}[a - 2bQ + \gamma - C_1(S)] - \lambda_1 + \frac{\partial W}{\partial Q} = 0 \tag{13}$$

$$\frac{\partial H}{\partial S} = \delta\lambda_1 - \dot{\lambda}_1 - \lambda_3 . \frac{\partial U}{\partial A} C_1'(S)Q = 0 \tag{14}$$

$$\frac{\partial H}{\partial w} = (\lambda_1 + \lambda_2) f_w - \lambda_3 . \frac{\partial U}{\partial A} C_2'(w) = 0 \tag{15}$$

$$\frac{\partial H}{\partial y} = -\delta\lambda_2 + \dot{\lambda}_2 + (\lambda_1 + \lambda_2) f_y = 0 \tag{16}$$

In this condition:

$$\dot{Q}=\frac{\lambda_3.\frac{\partial U}{\partial A}C_1'(S)Q-\delta[-\lambda_3\frac{\partial U}{\partial A}(a-2bQ-C_1(S)+\gamma)+\frac{\partial W}{\partial Q}]+\lambda_3\frac{\partial U}{\partial Q}C_1'(S)\dot{S}}{-\frac{\partial^2 W}{\partial Q^2}-\lambda_3\frac{\partial^2 U}{\partial A^2}\frac{\partial A}{\partial Q}(a-2bQ-C_1(S)+\gamma)-\lambda_3\frac{\partial U}{\partial Q}2b} \tag{17}$$

$$\dot{w}=\frac{\delta[-\lambda_3\frac{\partial U}{\partial A}.\frac{C_2'(w)}{f_w}+\lambda_1]+\delta\dot{\lambda}_1-\frac{f_y}{f_w}[\lambda_3\frac{\partial U}{\partial A}.C_2'(w)]}{-\lambda_3.\frac{\partial^2 U}{\partial A^2}.\frac{(C_2'(w))^2}{f_w})+\lambda_3.\frac{\partial U}{\partial A}[\frac{C_2''f_w-C_2'f_{ww}}{f_w^2}]} \tag{18}$$

Therefore equilibrium of extraction is intersection of (9) and (17) equations and equilibrium of exploration is intersection of (10) and (18) equations which maximize owner country's welfare and investor company's utility.

Now if share of owner country is percent of production, then $\dot{Q}$ in this condition, which owner country maximize it's welfare respect to investor company's utility welfare (Pyndyck, 1981). We have:

$$\dot{Q}=\frac{\frac{\partial U}{\partial A}C_1'(S)Q-\delta[\frac{\partial U}{\partial A}(a-2bQ-t-C_1(S)+\gamma)-\lambda_3\frac{\partial W}{\partial Q}]-\frac{\partial U}{\partial A}C_1'(S)\dot{S}}{\lambda_3\frac{\partial^2 W}{\partial Q^2}-\frac{\partial^2 U}{\partial A^2}\frac{\partial A}{\partial Q}(a-2bQ-t+\gamma-C_1(S))+\frac{\partial U}{\partial A}2b} \tag{19}$$

But in this condition if investor company maximize it's utility respect to owner country's welfare therefore extraction path is:

$$\dot{Q}=\frac{-\delta[-\lambda_3\frac{\partial U}{\partial A}(a-2bQ-C_1(S)+\gamma-t)+\frac{\partial W}{\partial Q}+t\frac{\partial W}{\partial(tQ)}]+\lambda_3.C_1'(S)[\frac{\partial U}{\partial Q}\dot{S}+\frac{\partial U}{\partial A}.Q]}{-\frac{\partial^2 W}{\partial Q^2}+\lambda_3\frac{\partial^2 U}{\partial A^2}\frac{\partial A}{\partial Q}(a-2bQ+\gamma-t-C_1(S))-\lambda_3.\frac{\partial U}{\partial A}.2b} \tag{20}$$

Equilibrium in this state is instruction of (19) and (20) equations and rate of share is affected on equilibrium extraction.

As results, I can say that Owner country uses from different methods for determining share, independent of production and percent of production. As I raveled, in (19) and (20) conditions rate of share is affected on equilibrium extraction.

CONCLUSION

In this paper, I survey effects of two payments methods on extraction and exploration paths. I reveal that owner source country can affect on extraction and exploration paths. Therefore it it's rules can affected on investor company's motives from extraction from source.

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