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Survey Affects of Effective Factors on Contracts for Development of South Pars Gas Field

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ABSTRACT

Exploration and extraction contracts are the main tool for using foreign new technologies for development of offshore oil and gas resources. Some factors such as risk aversion of owner country and foreign company, oil and gas price and asymmetric information have effects on value of contracts. These factors are so important in developing of contracts for extraction from offshore resources as South Pars Filed in Iran, exactly in some contracts such as buyback contracts.

1. Introduction

National Iranian Oil Company has used buy-back contracts for developing offshore oil and gas resources. A buy-back contract is defined between National Iranian Oil Company and International Oil or Gas Company, which foreign company should invest in Iran and repayment is based on percentages of production of offshore resource.

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. In this paper we introduce factors which affect on value of exploration and extraction contracts between National Iranian Oil Company and foreign company for developing of offshore gas resource of South Pars Gas Field.

2. Effective factors on value of gas contracts

Some countries use contracts with international oil and gas companies for development of offshore resources. National Iranian Oil Company uses buy back contracts with foreign oil and gas companies for developing Iran's oil and gas field, which this contract has enabled Iran to benefit from international technical and financial capabilities.

Usually in exploration and extraction contracts, value of contract is touched from value of resource, value of products, economical and political condition of region and environmental policies.

Value of resource is the main factor that affects on value of contract. Upper gas and oil price can increase value of contracts and sanctions can decline value of international contracts.

3. Modeling effective factors on value of expansion contracts

Owner of offshore resource wants to maximize social welfare subject to the constrained related to overall foreign company's utility function. This objective of the owner of these resource is as follows:

$$\int_0^N W[I(V,\alpha)]f(v)dv \quad (1)$$

Where $I(V,\alpha)$ is value of contract (value of foreign company investment), V is value of reserves, N is contract maturity date of contract and α is function of foreign country project financing and it is assumed to be varied along with contract horizon. Foreign company's utility function, as a function of capital gain illustrated by , is given as follows:

$$\int_0^N U[g(V,\alpha)]f(v)dv = \overline{U} \quad (2)$$

Where $g(V,\alpha)$ must be positive in order to be acceptable by foreign company for investing in drilling and extraction.

Therefore owner of offshore wants to maximize social welfare subject to foreign company utility constraint:

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

s.t

$$\int_0^N U[g(V,\alpha)]f(v)dv = \overline{U}$$

For solving the above problem, the lagrangian function can be written as:

$$L = \int_0^N [W[I(V,\alpha)] - \lambda U[g(V,\alpha)]]f(v)dv + \lambda\overline{U} \quad (3)$$

Taking the first derivative of equation (3) with respect to V, the outcome will be:

$$\frac{\partial L}{\partial V} = \frac{\partial W}{\partial I}.\frac{\partial I}{\partial V} - \lambda\frac{\partial U}{\partial g}.\frac{\partial g}{\partial V} = 0 \quad (4)$$

$$\Rightarrow \frac{\partial L}{\partial V} = \frac{\partial W}{\partial V} - \lambda\frac{\partial U}{\partial V} = 0$$

we have:

$$\lambda = \frac{W_V[I(V,\alpha)]}{U_V[g(V,\alpha)]} \quad (5)$$

Obtain λ from (4), this is a ratio of marginal social welfare of host country to the marginal utility of resource company with respect to the value of contract that is value of contract can be variable until maturity date, for example, it's value is less during drilling process that is varies until the maturity date of contract, because owner influences of some factors.

If α which is function of foreign country project financing, changes then it's effects on the lagrangian function can be written as:

$$\frac{\partial L}{\partial \alpha}=\frac{\partial W}{\partial I}.\frac{\partial I}{\partial \alpha}-\lambda\frac{\partial U}{\partial g}.\frac{\partial g}{\partial \alpha}=0$$
$$W_I[I(V,\alpha)].I_\alpha(\alpha)-\lambda U_I[g(V,\alpha)].I_\alpha(\alpha)=0 \quad (6)$$
Or $I_\alpha(\alpha)\{W_I(I(V,\alpha)-\lambda U_g[g(V,\alpha)]\}=0$

In condition (6), if $I_\alpha(\alpha)\succ 0$ then $W_\alpha[I(V,\alpha)]=\lambda U_\alpha[g(V,\alpha)]$. Therefore $\lambda=\frac{W_\alpha[I(V,\alpha)]}{U_\alpha[g(V,\alpha)]}$ and considering (5), the relation $\frac{W_V[I(V,\alpha)]}{U_V[g(V,\alpha)]}=\frac{W_\alpha[I(V,\alpha)]}{U_\alpha[g(V,\alpha)]}$ will be obtained. It implies that changes in α and V, the utilities (W, U) will changed, but their ratios become constant. In optimal point α^*, changes in social welfare (because of improvement of better foreign country project financing) are more.

4. Absolute risk aversion of owner of offshore resource and foreign company

Absolute risk aversion is defined as changes of slope of utility function with respect to slope of utility function, then for owner country and foreign country, absolute risk aversion is defined as:

[1] $$ARAG=-\frac{W_{VV}[I(V,\alpha)]}{W_V[I(V,\alpha)]} \quad (7)$$

[2] $$ARAF=-\frac{U_{VV}[g(V,\alpha)]}{U_V[g(V,\alpha)]} \quad (8)$$

For extraction last equations:

$$W(I(V,\alpha)=F(V,\alpha)$$
$$U[V-I(V,\alpha)]=U(g(V,\alpha))=G(V,\alpha)$$
$$L=\int_0^N[F(V,\alpha)-\lambda G(V,\alpha)]f(v)dv+\lambda\overline{U}$$
$$F_V-\lambda G_V=0 \quad , \quad F_V=W_I.I_V \quad , \quad G=U_g(1-I_V)\rightarrow\lambda=\frac{W_I.I_V}{U_g(1-I_V)} \quad (9)$$
$$\Rightarrow F_{VV}-\lambda G_{VV}=0 \quad , F_{VV}=W_{II}(I_V)^2+I_{VV}W_I\,, \quad G_{VV}=U_{gg}(g_V)^2+g_{VV}U_g$$
$$\Rightarrow W_{II}(I_V)^2+I_{VV}W_I=\lambda[U_{gg}(1-I_V\ )^2-U_gI_{VV}]$$
$$IF \quad I_{VV}=0\Rightarrow\frac{{I_V}^2}{(1-I_V)^2}=\frac{\lambda U_{gg}}{W_{II}} \quad ,\frac{I_V}{1-I_V}=K(V)\rightarrow[K(V)]^2=\frac{K(V)W_IU_{gg}}{W_{II}U_g}$$

then:

[1] Absolute Risk Aversion of Government
[2] Absolute Risk Aversion of Firm

$$\frac{[K(V)]^2}{K(V)} = \frac{\frac{U_{gg}}{U_g}}{\frac{W_{II}}{W_I}} = \frac{ARAF}{ARAG} = a \Rightarrow K(V) = a \rightarrow \frac{I_V}{1-I_V} = a$$

$$\Rightarrow I_V = \frac{1}{1+\frac{1}{a}} \tag{10}$$

If a=1 and ARAG=ARAF, then $\frac{\partial I}{\partial V} = \frac{1}{2}$. If a>1 and ARAG<ARAF, then $\frac{1}{2} \le \frac{\partial I}{\partial V} < 1$ and if a<1 and ARAG>ARAF, then $0 < \frac{\partial I}{\partial V} \le \frac{1}{2}$.

If owner country is more risk averse than foreign country, then $\frac{\partial I}{\partial V}$ is limited to zero and then company's investment is independent to the contract value, and does not change with changes of value source, but if gas or oil company is more risk averse then $\frac{\partial I}{\partial V}$ is more than zero and value of contract is variable.

Now, we want to modeling sign of $I_{VV} = \frac{\partial^2 I}{\partial V^2}$. As condition (9):

$$W_{II}(I_V)^2 + I_{VV}W_I = \lambda[U_{gg}(1-I_V{}^2) \ -U_g I_{VV}]$$

$$\rightarrow W_{II}(I_V)^2 + I_{VV}W_I = K(V)\frac{W_I}{U_g}[U_{gg}(1-I_V{}^2) - U_g I_{VV}]$$

$$\Rightarrow I_{VV} = \frac{K(V)(1-I(V)^2)\frac{W_I}{U_g}U_{gg} - W_{II}(I_V)^2}{W_I[1+I(V)]}$$

$$\Rightarrow I_{VV} = I\frac{W_I U_{gg}}{W_I U_g} - \frac{W_{II}(I_V)^2}{W_I(1+I_V)} \tag{11}$$

$$\Rightarrow I_{VV} = -I_V ARAF + \frac{I_V}{1+\frac{1}{I_V}} ARAG$$

$$\Rightarrow I_{VV} = I_V[-ARAF + \iota ARAG]$$

As equation (11), sign of $\frac{\partial^2 I}{\partial V^2} = I_{VV}$ is touched from $\iota ARAG - ARAF$, now if $\iota ARAG > ARAF$ then value of contract is convex respect to value of resource and if $\iota ARAG < ARAF$ then value of contract is concave respect to value of resource.

5. Oil and gas price

If oil or gas price which extracted from resource rises or declines, then value of contract can be changed. If oil or gas price in "m" condition increases then value of contract will increase, therefore $I_m(V,\alpha) > I_n(V,\alpha)$ then rewrite (4):

$$W_V[I_m(V,\alpha)] = \lambda_m U_V[V - I_m(V,\alpha)] \quad (12)$$

$$W_V[I_n(V,\alpha)] = \lambda_n U_V[V - I_n(V,\alpha)] \quad (13)$$

If price rises from $P_n(V)$ to $P_m(V)$, then $I_m(V,\alpha) > I_n(V,\alpha)$ and $[V - I_m(V,\alpha)] < [V - I_n(V,\alpha)]$ therefore $W_V[I_m(V,\alpha)] < W_V[I_n(V,\alpha)]$.

Assume capital gain in “m” condition is $[V - I_m(V,\alpha)] = g_m(V,\alpha)$ and capital gain in “n” condition is $[V - I_n(V,\alpha)] = g_n(V,\alpha)$, because $g_m(V,\alpha) < g_n(V,\alpha)$ therefore $U_V[g_m(V,\alpha)] > U_V[g_n(V,\alpha)]$.

If price changes, $U_V[g(V,\alpha)], W_V[I(V,\alpha)]$ will change and then absolute risk aversion of owner country and foreign country will be changed.

As we said $W_V[I_m(V,\alpha)] < W_V[I_n(V,\alpha)]$ and $U_V[g_m(V,\alpha)] > U_V[g_n(V,\alpha)]$. We assume that $W_{VV}[I_m(V,\alpha)] = W_{VV}[I_n(V,\alpha)], U_{VV}[g_m(V,\alpha)] = U_{VV}[g_n(V,\alpha)]$ (Leland, 1978). Then we rewrite $\frac{ARAG}{ARAF}$ for "m" and "n" conditions and summarize it as $\frac{U_V[g_m(V,\alpha)]}{W_V[I_m(V,\alpha)} > \frac{U_V[g_n(V,\alpha)]}{W_V[I_n(V,\alpha)]}$.

Assume that $\frac{W_V[I_m(V,\alpha)]}{U_V[g_m(V,\alpha)} = a_m$ and $\frac{W_V[I_n(V,\alpha)]}{U_V[g_n(V,\alpha)]} = a_n$, therefore (as above line) $a_m > a_n$, $1 + a_m > 1 + a_n$ and $\frac{1}{1+a_m} < \frac{1}{1+a_n}$.

As (13) condition, we conclude that:

$$\frac{\partial I_m(V,\alpha)}{\partial V} < \frac{\partial I_n(V,\alpha)}{\partial V} \quad (14)$$

At least we can conclude that if price of oil or gas increases (in "m" condition) owner country is more risk avers than foreign country and then changes in value of contract respect to value of resource is low.

6. Asymetric information

Before drilling and exploration, owner country has less information respect to foreign company. IN (V) is a function related to information about reserves in a reservoir. In asymmetric information condition, maximize social welfare of owner country subject to utility of foreign country, then:

$$\text{MAX} \int_0^N W[I(V,\alpha) - B(IN(V)]f(v)dv, I^*(V,\alpha) = I(V,\alpha) - B(IN(V))$$

s.t

$$\int_0^N U[V - I(V,\alpha) - B(IN(V))]f(v)dv = \overline{U} \quad (15)$$

Owner country maximizes (22) subject to V, then:

$$W_V[I(V,\alpha) - B(IN(V))] = \lambda U_V[V - I(V,\alpha) - B(IN(V))] \quad (16)$$

$I^*(V,\alpha) < I(V,\alpha)$ and as (14) condition $\frac{\partial I^*(V,\alpha)}{\partial V} > \frac{\partial I(V,\alpha)}{\partial V}$. Therefore asymmetric information between owner country and foreign company will cause to change value of contract, and then value of contract will be changed respect to value of resource.

These factors are so important in developing of contracts for extraction from offshore resources as South Pars resource in Iran, exactly in some contracts such as buyback contracts.

7. Conclusion

Contracts for development of extraction and exploration are so useful because these contracts discourage foreign countries for investment in Iran and we can use from their new technologies.

In this paper we reveal some factors which affect on value of contract for development exploration and extraction. At lease we conclude that if owner country of offshore resource be more risk adverse respect to foreign company then changes of contract value respect to resource value is zero and value of contract will be fixing. We introduce other factors such as oil and gas price and asymmetric information as factors which affect on $\frac{\partial I}{\partial V}$.

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