Infrastructure Cost Implications for East Siberian Oil Development

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The paper addresses a new approach to oil production tax benefit optimization centered on discounted cumulative values including taxes. Building on a simplified oilfield model, the author assesses government stimulus measures focused on fields with higher infrastructure costs.

Keywords: oil production, infrastructure, taxes, criteria, model, optimum.

1. TAX BENEFITS AS INVESTMENT

Under the existing field development tax regime, economic positions of the state and investors are largely different. An investor needs first to bring in an investment assuming future revenue. We can calculate relative investment efficiency ($RIE$) as the ratio of net discounted returns ($NPV$) to capital investments. On the contrary, the state can collect field development taxes as the sovereign without making any investments. That is only the case that an investor is around agreeing to develop a field, in particular when such investor is satisfied with relative efficiency of its field development. If no investors are found, the government will not collect any taxes.

If this is the case, provision of tax benefits for field development becomes imperative for the government [1]. In so doing the government assumes some characteristics of an investor. The amount of tax benefits represents its investment. The sum of the taxes is meant to be the absolute development efficiency for the government. Now we can calculate relative benefit efficiency ($RBE$) for the state as the ratio of tax collected to the amount of benefits granted.

Minimum amount of benefits required to start field development can either be determined by special tender or assessed in theory.

2. DISCOUNTED CUMULATIVE VALUES

Hereinafter, we will use the discounted cumulative values, such as $NPV$, to characterize field development over the entire field life, or:

$$NPV = DCO - DCT - DCT - DCC - DCR,$$

where discounted cumulative values of revenues, oil transportation cost, taxes, CAPEX and OPEX are on the right side of the equation.

Then:

$$DCC = \frac{NPV}{RIE},$$

It will be assumed here that the investor and the state have the same discount factor, $E=10\%$. If $DCT_{norm}=$ discounted cumulative taxes under normal tax regime, and $DB =$ discounted cumulative benefits, then produce:

$$DCT = DCT_{norm} - DB,$$

$$RBE = \frac{DCT}{DB}.$$

3. TARGET FUNCTIONS

Three target functions can be used: from the standpoint of (1) the investor, (2) the government (in a narrow sense), and (3) the society. $NPV$ value represents the target function for the investor, while for the state such function will be $DCT$.

A separate study is required to justify the form of public target function, $S$, and numerical values of the used coefficients. Only two assumptions apply here.

First, the public function, $S$, includes the sum of the investor and the government functions.

Second, multipliers are used in the public target function such as:
S = NPV + DCT + μ_T · DCTr + 
+ μ_C · DCC + μ_O · DCO ,

where μ_T, μ_C, and μ_O are transportation costs, capital investments and operating costs multipliers, respectively. For calculations, it is assumed that μ_C=μ_O=μ_T = 1.5. We will analyze only those projects for which S > 0 applies.

4. OPTIMIZATION CRITERIA FOR ALTERNATIVE PROJECTS

What is a practicality criterion to start field development from the investor’s standpoint (in a deterministic case)?

Criterion NPV > 0 is necessary but not sufficient. Let the investor have the best alternative project of capital consumption, ΔC, besides its absolute effect being equal f_C·ΔDCC (where f_C = closing efficiency of capital investments) [2]. If, due to some objective reason, the investor is unable to utilize both projects, then the field development selection criterion will be L_I > 0, where:

\[ L_I = NPV - f_C · DCC \]  

(6)

investor’s optimization criterion. The investor’s practicality criterion to invest into field development can be expressed by the condition:

\[ RIE > f_C . \]  

(7)

The state will not collect any taxes from field development if Eq. 6 condition is not met. Similarly, the government can have the best not yet utilized alternative way to introduce tax benefit with the efficiency, f_B, where f_B = benefit marginal efficiency. Then the selection criteria for that particular field will be L_G > 0 under constraints set by Eq. 6, where

\[ L_G = DCT - f_B · DB \]  

(8)

is benefit optimization criterion for the state. If the government is unable to introduce tax benefits every time when RBE > 0, then it shall set a threshold value for f_B in the long term and introduce benefits only when the following condition applies:

\[ ΔDCT > f_B · ΔDB \]  

(9)

where: f_C and f_B are Lagrange multipliers, and criteria \( L_I \) and \( L_G = \) optimization tasks' Lagrangians under constraints for cumulative capital investments, DCC, and cumulative benefits, DB.

5. OPTIMIZATION

In case that \( L_I > 0 \) applies under existing tax regime, the project has no need of any tax benefits. Conversely, the issue arises to optimize benefits under Eq. 6 constraint or by \( L_G \), or \( L_S \) criterion.

Assuming that the target function does not rise with growing tax benefits, the minimum benefit satisfying Eq. 6 will be an optimum case:

\[ DB_{min} = f_C · DCC - NPV_{Norm}, \]  

(10)

where \( NPV_{Norm} \) calculation excludes any benefit. In addition, \( DB_{min} \) is independent of any criterion used by the state.

To move forward, at least a simplified oilfield model is believed critical. Assuming that: DCO=c·DCP, DCTr=c_T·DCP, DCR=p·DCP, and DCTr_{norm}=h·DCR, where: DCP=discounted cumulative production, c and c_T = average relative operating and transportation costs, p=average oil price, and h=percentage of normal taxes in revenue.

Suppose production rate, m, is constant over the entire field development time span, produce

\[ DCP = \frac{mQ_0}{m+E}, \]  

(11)

where \( Q_0 = \) field recoverable reserves, i.e. cumulative production.

We can express capital investment, DCC, in terms of the following formula:

\[ DCC = (km + k\phi) · Q_0, \]  

(12)

where: k=relative capital investment in drilling and field infrastructure development; and k\phi=relative fixed (i.e. independent of production rate) infrastructure investments (into road construction, power transmission lines, and other construction). We assume that c, c_T, h, p, k, Q_0, k\phi are constants (independent of m).
Let benefit value \( DB \) be independent of \( m \), determined and communicated to the investor. Then the investor will select production rate, \( m \), that optimizes the \( L_t \) criterion:

\[
m = E \left( \sqrt{\frac{p'}{k'}} - 1 \right),
\]

(13)

where: \( p' = p(1-h) - c_T - c \),

\( k' = Ek(1 + f_C) \), provided, however, that \( L_t > 0 \), i.e.

\[
m \geq m_{\text{min}}(DB) = E \sqrt{\frac{(1+f_C)k_\phi - DB}{Q_0}}
\]

(14)

The unique characteristics of fixed costs stem from the fact that they are key for deciding on whether to start field development or not. However when the decision to start field development is made, \( k_\phi \) value does not impact on development project choices, in particular – on production rate, \( m \). This is also true of tax benefits if they are independent of annual production levels, i.e. production rate. The Eq. 13 is independent of both \( k_\phi \) and \( DB \). Hence, it appears meaningless to raise such benefits above the Eq. 10 level that is sufficient for favorable investment decision regarding the field.

6. TWO FIXED COST INTERVALS

The following equation applies to fixed costs, \( k_{\phi_0} \), at which the field begins to call for tax benefits:

\[
k_{\phi_0} = \frac{(\sqrt{p'} - \sqrt{k'})^2}{1 + f_C}
\]

(15)

Given \( k_\phi = k_{\phi_0} \), produce \( L_t = 0 \) and optimum production rate (Eq. 13), \( m = m_{\text{min}}(0) \).

On the interval \( 0 < k_\phi < k_{\phi_0} \) it could be assumed that \( DB = 0 \), \( L_t = DCT \), as supplementary to \( RIE > f_C \), \( L_t > 0 \) and \( m \geq m_{\text{min}}(0) \). For this interval IRR formula is independent of tax benefit payment time:

\[
IRR = m \left( \frac{p'}{k_\phi + km} - 1 \right),
\]

(16)

where \( m \) is calculated from Eq. 13.

On the interval \( k_\phi > k_{\phi_0} \) it could be assumed that \( DB = DB_{\text{min}} \), then \( RIE = f_C \) and \( L_t = 0 \). We express \( DB \) through field characteristics. Taking into Eqs. 13 and 15, produce

\[
DB = (1 + f_C) \cdot (k_\phi - k_{\phi_0}) \cdot Q_0
\]

(17)

Note that in accordance with Eq. 17, if \( f_C = 0 \), then tax benefit would be not higher than fixed costs. Multiplier \( (1 + f_C) \) can be viewed as an investment risk discount, in this case regarding the infrastructure costs.

If Eqs. 1, 13, and 17 are taken into consideration, \( NPV \) produces

\[
NPV = f_C \cdot Q_0 \left[ \frac{\sqrt{k'} \cdot (\sqrt{p'} - \sqrt{k'})}{1 + f_C} + k_\phi \right]
\]

(18)

Also can calculate two more values of fixed costs, \( k_{\phi_1} \), assumed to have great importance.

Here, \( k_{\phi_1} \) is determined as fixed costs, \( k_\phi \), for which the benefit, \( DB \), equals fixed costs, \( k_\phi \cdot Q_0 \)

\[
k_{\phi_1} = \frac{(\sqrt{p'} - \sqrt{k'})^2}{f_C} = k_{\phi_0} \cdot \left( 1 + \frac{1}{f_C} \right)
\]

(19)

When \( k_\phi = k_{\phi_2} \), the benefit, \( DB \), equals capital investments, \( DCC \)

\[
k_{\phi_2} = \frac{(\sqrt{p'} - \sqrt{k'}) \cdot (\sqrt{p'} - \sqrt{k'})}{f_C \cdot (1 + f_C)}
\]

(20)

7. NUMERICAL EXAMPLE OF TAX BENEFIT

Fig. 1 shows development characteristic dependence of tax benefit value for a conditional field (here: \( Q_0 = 1 \) million t, \( k = $360/t/year, c = $45/t, \) and \( k_\phi = $5/t \)). It is assumed that: oil price, \( p = $730/t; c_{T_B} = $50/t; h = 70\%; \) and \( f_C = f_B = 100\% \).
The $L_i$ criterion has its maximum (Eq. 13) for production rate of 3.12% per year.

The $L_i$ criterion becomes positive for the tax benefit at $3 million, and from this point the taxes, $DCT$, and public criterion, $S$, along with all field development characteristics become positive as well (these values are also conditionally shown for benefits under 3). On this diagram, $NPV$ and $DCC$ are largely similar.

On the Fig. 1 diagram, $IRR$ and $RIE$ curves are linked to the right-hand scale. Both $IRR$ and $RIE$ reflect the relative investment efficiency, however $IRR$ applies to a single year and $RIE$ – to the entire field development period. The diagram shows a maximum $IRR$ value (that grows from 26.1% to 32.6% along with raising tax benefits from $3 billion to $5 billion) when the benefit is realized almost immediately. Minimum $IRR$ (20.7%) is possible for a too late granted benefit. In this case, $RIE$ ranges between 100% and 115%.

The benefit efficiency, $RBE$, was found to exceed its 20-fold level.

Fig. 2 shows characteristics of development project with best production rate, $m$, (Eq. 13) for various fixed costs, $k_{\Phi}$. The fixed costs: $k_{\Phi_0}=3.5$, $k_{\Phi_1}=7.0$, and $k_{\Phi_2}=18.3/t$. 

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Fig. 1. Field development economic characteristic vs. tax benefit levels

Fig. 2. Field development economic characteristic vs. fixed costs, $k_{\Phi}$
No benefit is required for \( k_\phi < 3.5 \) /t; and in this interval, \( RIE > f_c \). When \( k_\phi > 7 \) /t, the investor is granted with minimum benefit, \( DB \) (Eq. 17), where \( RIE = f_c \) and \( L_i = 0 \); i.e. when \( f_c = 100\% \), \( NPV \) and \( DC \) have the same values. Benefit \( DB \) for \( k_\phi > 3.5 \) /t exceeds the fixed costs, but when \( k_\phi > 7 \) /t, the investor is granted with minimum benefit, \( DB \) (Eq. 17), where \( RIE = f_c \) and \( L_i = 0 \); i.e. when \( f_c = 100\% \), \( NPV \) and \( DC \) have the same values. Benefit \( DB \) for \( k_\phi > 7 \) /t exceeds the fixed costs, but when \( k_\phi > 7 \) /t, the benefit value would exceed all capital investments, \( DC \). Public target function, \( S \), was found to grow with rising capital investments, \( k_\phi \).

8. A CASE OF STATE-OWNED INFRASTRUCTURE

We can consider a case when infrastructure for tendered subsoil blocks is built by the state and no tax benefits are assumed. In this situation, both the development characteristics for the investor and the society apply to the case of zero infrastructure costs. The efficiency formula (dashed line on Fig. 3) used by the state will change

\[
RBE = \frac{DCT}{k_\phi Q_0}, \tag{21}
\]

When \( k_\phi > 6.68 \) /t, or efficiency of the state infrastructure investment, \( RBE \) (Eq. 21), exceeds benefit efficiency, \( RBE \) (Eq. 4). When \( k_\phi < 6.68 \) /t, the benefit practices, \( DB \), become more preferable for the government.

Efficiency of the state-driven infrastructure investments, \( RBE \) (Eq. 21), becomes lower than the investor’s capital investment efficiency, \( RIE \) (Eq. 2) (in this case it equals 1.6), under \( k_\phi > 75 \) /t. For \( k_\phi > 180 \) /t, the benefit efficiency, \( RBE \), turns negative. Thus, when the state is building a field infrastructure, the infrastructure investment time interval that the upstream production could be started increases 2–3 times for problem blocks.

However we need to note that the new infrastructure is often associated with greater risks. Additional analysis of underlying risk patterns under uncertainty is believed critical when choosing the most appropriate incentives approach under \( k_\phi > 6.68 \) /t.

9. CONCLUSIONS

Stimulating new field development through granting tax benefits has proved a highly viable solution economically. Benefits would be likely unnecessary when the infrastructure costs per 1 ton of reserves are low. The benefits efficiency tends to fall with higher infrastructure costs.

10. REFERENCES


11. BIOGRAPHY

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