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THE GAME ANALYSIS OF THE CITY CONSTRUCTION LOCATION DECISION IN THE CONTEXT OF BUILT LONG DISTANCE OIL AND GAS PIPELINES

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Abstract: With the continuous expansion of city area, there are safety risks in the long distance oil and gas pipelines which built in the outskirts of the city. For security reasons, there should be a safe distance between the long distance oil and gas pipelines and the border of city. So the government should choose another place to development of city construction, it will have an impact on the city construction plan. Based on this, in the process of city construction, it is a question worth exploring for the government to make a location decision of city construction when faced to the long distance oil and gas pipelines. The study uses the theory and the method of game theory to establish a dynamic game model of complete information of pipeline operators and the government. It also establishes a three stage dynamic game model after the technological innovation implemented by the pipeline operators. And it researches the factors which affect the government's decisions. Finally it concludes the sub-game perfect Nash equilibrium game, and provides the decision-making basis for the conflict of long distance pipelines and city construction.

Keywords: Long Distance Pipelines; Urban Construction; Game Theory

1. Introduction

With the construction and operation of China's oil and gas transportation projects, China has built a network of long distance pipelines spread all over the country and are connected with the overseas pipelines. The construction of long distance oil and gas pipeline network, not only satisfies the people's demand for energy, but also conducive to the development of social economy. Taking into account the accidents of oil and gas pipelines may cause, such as environmental pollution, casualties and other major incidents, the "oil and gas pipeline protection law", "oil pipeline engineering design specification" (GB 50253-2003) (2006) and other laws and regulations in China ruled the distance between the oil and gas pipelines and the buildings, railways, ports, national key cultural relics and some other buildings. However, with the continuous expansion of the city, the pipelines which have been built in the outskirts of the city come to be near the buildings in the inner cities. Under this background, how should the government make the urban construction location decision is the need to study this problem.

2. The Applicability of Game Analysis

In the process of building the city, facing the built oil and gas pipelines, the government has two kinds of decision: one is to choose another construction site, another option is to have a consultation with the pipeline operators, the pipeline operators removes the pipelines to leave the site for city construction Similarly, the pipeline operator also has two kinds of decision making: one is to remove the pipelines, another is to remove the pipelines. Therefore, in this decision, pipeline operators and the government has formed the situation of the game. In the course of the game, the government and the pipeline operators have to know the strategic space and strategies under the combination of strategies of each other. But in the process of the game, the government should make their own decision after the pipeline operators' decisions, there is a sequence of two game decision, so, the game is a dynamic game model of complete information..

3. City Construction Site Selection Game Model

3.1. Model Building

In the model, making Γ = {1, 2,,, n} is the set of participants, setting U for stretched form. Initial knot pick up game, the end nodes of U set U/Z (U) made up by n + 1 disjoint subsets P0, P1,... Pj... , Pn. For each j $\in$ Γ, Pj is the decision-making knot of participants j. For each node of P0, there is a corresponding probability distribution density values from it. And for each endpoint z $\in$ z (U), corresponding to a n-dimensional pay off g (z) = (g1 (z), g2 (z),..., gn(z)), and gj (z) is j's payoff (j = 1, 2,..., n). Because all participants j know all decisions together, this is a dynamic game model of complete information which two decision makers are in.

In this game model, the participants have two sides, pipeline operators and the government, in the process of game analysis, we ignore other factors such as tax benefits. therefore, Γ = {1, 2}, n = 2, the game initial knot starts from pipeline operators, the end node z $\in$ z (U) corresponds to a two-dimensional vector.

3.2. Assumptions

Here, we make the assumption that the pipeline operator is A, the government is B, because they are both rational, the operators are not willing to pay the huge costs of the pipelines relocation, and the government wants go on the urban construction according to the urban construction plan. Known from the analysis above, the information of this game is complete, the operator A on the premise of knowing the government has two kinds of decision to choose: removing the pipelines or not.. When the operator decides not to remove the pipelines, the government B also has two kinds of decisions: constructing at the former site or an alternate address. In decision-making of government B, when the operators choose not to remove the pipelines, the government may still choose to construct at the former site. The causes of the problem may are: (1) The administrative corruption leads to be constructed at the former site, especially for the real estate development projects which have a good condition of location; (2)The incomes of the alternate site construction is far below the former site, and the pipeline safety risk assessment is not accurate; (3) The government macroscopic overall consideration, to achieve greater economic and social benefits. The construction must be built in the former site. In fact, in the process of actual operation, the three situations exist. Therefore the dynamic game model is not perfect; we can continue to deepen it in the further research. In this game model, we introduce the probability γ, when the operator chooses not to remove pipelines, the government will choose an alternate site to construct in the probability γ. On the other hand, the probability of the former site is 1-γ. The dynamic game model of complete information with the stretched form as shown in Figure 1.

3.3. The Game Analysis

In this game, the first formula of each node's earnings the benefit of operators, the second formula expresses the government's benefit. Y said all basic incomes of the government acquired from the transmission of the pipelines. P expresses the interests pipeline operators acquired in the process of pipeline operation. R expresses the pipeline potential security risks losses caused by the damage to the society which the government assumes. C expresses the cost of the pipeline removing assumed by operator A. W represents the expectations loss of pipeline safety accidents caused by pipeline operators. Because the work of the pipeline safety accidents may not completely offset the losses caused by the accident, the cost of removing assumed by the pipeline operators C turns into positive externality coefficientα($0 < \alpha \le 1$), namely: when the distance of pipeline and city conforms to safety regulations, the government will have an additionalαC social benefits. Therefore, if the operators choose to remove the pipelines, the earnings for it are P - C - W. When the operator chooses not to remove the pipelines, the government may also choose to build in the former site, the government will get an extra income Q, but at the same time it also will take an expectation loss S because of the pipeline safety accidents. Therefore, in this case, the government's revenue is - R - S + Q + Y. If the government chooses an alternate site to construct, the earnings of it is -R + αC + Y.

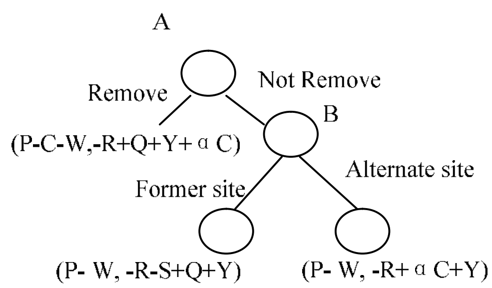

Figure 1. Pipeline dynamic game model of the operating enterprise and the government

For this game model, using backward induction to solve its perfect sub-game Nash equilibrium results, and analyzes the factors influencing the government decisions.

First, in the second stage, because the government will consider the public interests, when the operator chooses not to remove the pipelines, the probability of the government's choice which construct at the former site should be larger than the probability of alternate site 1-γ,so $\gamma > 1-\gamma \ge 0$, and get $1/2 < \gamma \le 1$. So, the actual benefit of operator A should be: P – W. When the government chooses to construct at the former site, its benefit is - R - S + Q + Y. Therefore, for A, the actual benefit of no removing is greater than the benefit of the removing. As for an rational enterprise, with no account of other factors, the operator will choose not to move the long distance oil and gas pipelines which has been built.

Second, in the first stage, if the operator chooses to remove the pipelines, the actual benefit for A is $P - C - W$, the benefit for government is $- R + \alpha C + Q + Y$.
From the analysis above, for government, if the benefit of an alternate is greater than the benefit of the former site, because of its rationality, the government will choose an alternate site to construct, so $- RC + \alpha Y > - R - S + Q + Y$, namely $\alpha C > Q - S$. So, whether αC is larger than $Q - S$ is the key to the government's choice of construction. According to the analysis above, we can obtain the only sub-game Nash equilibrium of the game is $(P - C - W, - R - S + Q + Y)$.

3.4. Three-stage Dynamic Game After Technological Innovation

Known from the analysis above, the operator A does not take the initiative to remove the built pipelines, therefore, on the basis of the model above, bringing in technical innovation of the operator A. When operator A develops technical innovation, the government will give it a certain funds for support M. Since the funds for government can not support for the full cost of the technical innovation G, therefore, $M < G$. When the operator develops technical innovation, on the other hand it can reduce the probability of pipeline safety accidents, makes the probability of pipeline safety accidents as low as possible, assuming that it can reach the ideal state, the probability of the pipeline safety accidents decreases to zero. So it improves the social profit (pipelines and the city are not together, namely social gains the maximum profit), so as it improves the value of α, make α is close to 1.
Based on the assumptions above, the stretched form as shown in Figure 2:

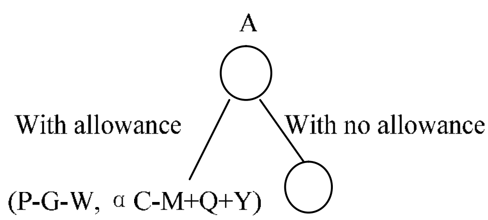

Figure 2. Three-stage dynamic game model after technical innovation

It can be concluded by stretched form that when $G - M \to 0$, rational operator A will choose technical innovation, or when the $P - G + M < P - W$, namely the $G\text{-}M > W$, whether the operator chooses relocation or not, it should choose technical innovation. For the government, if $\alpha C - M + Q + Y > - R - S + Q + Y$, namely $M - \alpha C < R + S$, the government should choose to provide operator with technical innovation and then make the construction site decision. So the key to decide whether the government provide the operator with technical innovation funds is whether $M - \alpha C$ is smaller than $R + S$, if $\alpha C - M + Q + Y < - R - S + Q + Y$, namely $\alpha C - M < - R$, S, $M - \alpha C > R + S$, the government would not choose to provide the operator A with technical innovation, then it turns back to the previous model, make the strategy according to the compare of αC and $Q\text{-}S$.

4. Countermeasures

This research uses the theories and methods of game theory to analyze the government's construction site decision when faced to the long distance oil and gas pipelines which have been built before. And we get the following main conclusions:
(1) The Nash equilibrium of the game are decided by the cost of relocation C, social impact coefficient α, the operation risk of operator W, the operation risk of government R and S, and the explicit and implicit profit of government, namely Y and Q. When the participants make the decision, they should fully consider these factors;
(2) the government as a representative of the social benefit master, it's confidence limit(the size of the q value degree)of constructing at the alternate site when the operator chooses not to remove the pipelines will be a serious influence for the result of the game;
(3) the size of the conversion coefficient of αis the key index for government's decision-making when the operator chooses not to remove the pipelines..
Based on the above research, the following Suggestions:
(1)The operator should strengthen the security maintenance and management work in the operational place, in order to reduce the social loss R and operator's losses W caused by the pipeline safety accidents. Therefore, the government should do a good job in supervision and handling of pipeline operation irregularities.
(2) The government should improve their own management mechanism to increase the confidence limit of constructing an alternate site when the operator chooses not to remove the pipelines. And make the probability of constructing in the former site comes to the minimum, the government should reform the system from the following two aspects: first, to perfect the government itself to build a clean government, avoid corruption and makes itself really represents the interests of the public. Second, strengthening the scientificalness of government's decision-making. When the government makes decisions, it should fully consider the interests of all parties, to avoid too much emphasis on economic benefits and make decisions which have huge potential hazards for society.
(3) Improving the utilization of pipeline construction fundα. When the operator chooses remove or the government chooses an alternate construction site, we should enhance the conversion efficiency of pipeline construction capital α, and to make $\alpha \to 1$.
(4) The operator should grasp the preferential policy, and adheres to the technical innovation to reduce the probability of pipeline safety accidents by technical measures.

(5) The government should increase the relocation subsidies. Because the pipelines relocation will be an additional expense for the operators, for a rational pipeline operator, it will not choose to remove the pipelines. But if the government gives the operator some allowances for removing the pipelines, the operator may choose relocation for considering the future development, such as the reconstruction.

5. Conclusion

Firstly, the research is based on fully market-oriented game analysis; both sides are equal and rational. But in terms of current situation in our country, and for the major oil companies in China, such as Petro China, Sinopec and CNOOC are large state-owned enterprises. When face to the public interests, these companies tend to sacrifice part of their own interests and assume some social responsibilities.

Secondly, for facilitating the model building, we incorporate some factors properly, for example, in considering the potential risks expectation losses of operator C', it already contains the accident treatment costs, pipes, recovery cost, expenses for administrative punishments which all assumed by the operator.

Further more, when the operator chooses not to remove the pipelines. The study does not research the probability of alternate site construction q.

Lastly, in the practical work, the pipeline operators can make full use of the chance of the periodic maintenance and remove the pipelines, so that the government and the pipeline operators can reached the maximum common benefits, and achieve the win-win situation.

On the basis of this study, the follow-up studies may research the game process when the government gives the operators allowances for the pipelines relocation, as well as the game process between the pipeline operators and the government and so on.

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