Solving the Benefit Game Equilibrium of State-owned Forest Right Reform Based on Computer Lagrange Law

Wenqi Sun*, Xiaomei Zhang
Northeast agricultural university, Harbin 150040, China
sunwenqi800@163.com

Abstract

This paper constructs the benefit game model of state-owned forest tenure reform. This model mainly includes the participation of the participants in the game model of the state, the forestry enterprises and the state-owned forest workers. Participants choose strategies for investing and not investing in forestry (policies) for forestry. The game function is the benefit of each game. There are three types of game relations: government and forestry enterprises, government and state-owned forest workers, forestry enterprises and state-owned forest workers. Through the construction of the benefit game model, the computer Lagrangian method is used to determine the balance between the interests of the various stakeholders, so as to coordinate the tripartite interests and ensure the smooth progress of the reform of state ownership. It is necessary to coordinate from the political, economic, legal and moral aspects.

Keywords: Computer Lagrange law, Reform of forest rights, Game, Interest

1. INTRODUCTION

State-owned forest is the main distribution area of China’s forest. Due to the special status of forest resources, since the founding of state-owned forest for the country has made outstanding contributions. But at the same time, the overall development of state-owned forest areas is slow, due to the impact of the planned economic system, coupled with long-term “two dangerous” serious problems, weak economic base (Liu and Cao, 2010). For the local government and the central government, the state-owned forest areas of the crisis plagued the two levels of government. State-owned forest industry is the product of the planned economy in the early days of the founding of the People's Republic of China, and provided a lot of timber support for the national economic construction.

State-owned forest industry enterprises to carry out a series of economic reform. However, the deep-seated problems within the enterprise have not been resolved (Zhang, 2009). These issues mainly include three aspects. First, the forest industry enterprises also have the government functions, and its social burden is heavy (Yang and Zhang, 2014); the second aspect, the forest industry enterprises is difficult to effectively monitor the forest resources (Zhang, 2007); third, state restrictions on harvesting trees. The forestry business economy is very difficult, because their income comes from logging. The decline in the economic strength of forestry enterprises has been unable to support the huge social expenditure.

The proportion of employees in the forest area of the state-owned forest area in China is larger than that of the whole forest. With the depletion of resources, a large number of state-owned forest workers lost their jobs. Their skills are single, then re-employment opportunities are very limited, and thus a large number of state-owned forest workers are in the laid-off state of unemployment. And because of the years of economic decline in the forest economy, as well as the lack of social security, a considerable number of unemployed people are living in poverty (Zhang, 2007; Wan, 2009; Hu, 2011).

At present, the interests of state-owned forest areas more and more prominent, to the degree of daylight. If the conflict is not resolved as soon as possible, it will certainly bring huge losses to the government, forestry enterprises and forest workers and the masses. This situation is likely to lead to social crisis (Liu and Cao, 2012). Therefore, it is necessary to establish a coordination mechanism of interests, so that each stakeholder can get the maximum value of their own interests.
This paper constructs the benefit game model of state-owned forest tenure reform. The game model defines the participants in the state, forestry and forest workers. There are three main forms of game relationship: government and forestry enterprises, government and forest workers, forestry enterprises and forest workers. Through the construction of the interests of the game model, and to determine the interests of the interests of the main balance between stakeholders, so that our goal is to coordinate the tripartite interests, and to ensure the smooth progress of state-owned forest rights reform.

2. GAME MODEL

2.1 Definition of Game Elements

Interest is the driving force of forest reform. One of the ultimate ends of the reform is to achieve the balance of interests. In the actual game, the total interest and the interests of the main input is related. Due to the actual institutional factors and risk factors, it is not possible to ensure that the input of each stakeholder is positively related to the gain, in which case the Nash equilibrium does not always exist. Participants usually choose their own strategy based on a certain probability. It is called the mixed strategy Nash equilibrium, that is, through a certain probability to choose their own strategies, so that the other side of the expected income equal. It makes the other party lose the will to change the strategy, so as to achieve equilibrium. The game model is constructed as follows:

Participants: The participants in the game model are government (G), forestry enterprise (E) and forest worker (W). Game information is the information that the player has to know about the choice strategy, such as the information about the game side; we assume that the information is known.

Strategy set: the central government, local government, forestry enterprises and forest workers choose the strategy for (investment, not invested).

The incomes of the game side of the income function, that is, the game side make the decision after the gains and losses: the government (how much investment income, do not put the loss of how much), forestry enterprises (how much investment income, not how much loss) and forest workers (how much investment income, not how much loss). There are three forms of game relationship: government-forestry enterprises, government-forest workers, forestry enterprises-forest workers. Then the investment here refers to the cost of reform, which includes many aspects. For example, the government is implementing natural security projects, he needs to invest costs. He may get more economic and ecological benefits, but because of institutional and risk factors, he may not be able to get more income. For example, that forest workers are more active in labor, then the input is the labor of workers, that is, labor costs.

2.2 Benefit Game Model between Government and Forestry Enterprises

<table>
<thead>
<tr>
<th>Table 1</th>
<th>The payment matrix for government and forest enterprises in the game with different pure strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>forestry enterprise (E)</td>
</tr>
<tr>
<td></td>
<td>invest (c)</td>
</tr>
<tr>
<td>government (G)</td>
<td></td>
</tr>
<tr>
<td>invest (a)</td>
<td>G5, E1</td>
</tr>
<tr>
<td>no invest (1-a)</td>
<td>G6, E2</td>
</tr>
</tbody>
</table>

Table 1 shows the payment matrix of the government (G) and the forestry enterprise (E) game corresponding to the different pure strategy combinations. Government (G) choose to invest in the probability of a, then choose not to enter the probability of (1-a). C denotes the probability that the forestry enterprise (E) chooses to input, then the probability of selecting no invest is (1-c).

The expected return when the government chooses to invest is:

\[ U_{gt2} = [G5c+G7 (1-c)] \]  

(1)

Expected return when the government don’t choose to invest is:
The expected return when the forest enterprise chooses to invest is:

\[ U_{et1} = [E1a+E2(1-a)] \]  

(3)

Expected return when the forest enterprises chooses not to invest is:

\[ U_{et*1} = [E3a+E4(1-a)] \]  

(4)

Government (G) income function is:

\[ U_{g2} = a[G6c+G8(1-c)] + (1-a)[G6c+G8(1-c)] \]  

(5)

The income function of forestry enterprises (E) is:

\[ U_{e1} = c[E1a+E2(1-a)] + (1-c)[E3a+E4(1-a)] \]  

(6)

2.3 Government and Forest Workers’ Interests Game Model

Table 2 The payment matrix for government and forest workers in the game with different pure strategies

<table>
<thead>
<tr>
<th>government (G)</th>
<th>invest(a)</th>
<th>no invest(1-a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>invest(h)</td>
<td>G9, W1</td>
<td>G10, W2</td>
</tr>
<tr>
<td>no invest(1-h)</td>
<td>G11, W3</td>
<td>G12, W4</td>
</tr>
</tbody>
</table>

Table 2 shows the government (G) and forest workers (W) game corresponding to different pure strategy portfolio payment matrix. The probability that the government (G) chooses to invest is a, then the probability of choosing no invest is (1-a). H indicates the probability that the forest worker (W) chooses to invest, then the probability of selecting no invest is (1-h).

The expected return for government choosing the investment is:

\[ U_{gt3} = [G9h+G11(1-h)] \]  

(7)

The expected return for government choosing the no investment is:

\[ U_{gt*3} = [G10h+G12(1-h)] \]  

(8)

The expected income for forest workers to choose invest is:

\[ U_{wt1} = [W1a+W2 (1-a)] \]  

(9)

The expected income for forest workers to choose no invest is:

\[ U_{wt*1} = [W3a+W4 (1-a)] \]  

(10)

Government (G) income function is:

\[ U_{g3} = a[G9h+G11(1-h)] + (1-a)[G10h+G12(1-h)] \]  

(11)

The income functions of forest workers (W) is:

\[ U_{w1} = h[W1a+W2(1-a)] + (1-h)[W3a+W4(1-a)] \]  

(12)
2.4 Article The Game Model of Workers’ Rights and Interests in Forestry Enterprises and Forest

Table 3 shows the payment matrix for forestry enterprises (E) and forest workers (W) games corresponding to different pure strategy combinations. H indicates the probability that the forest worker (W) chooses to invest, then the probability of selecting no invest is (1-h). C represents the probability that the forestry enterprise (E) chooses to invest, then the probability of selecting no invest is (1-c).

Table 3 The payment matrix for center government and local government in the game with different pure strategies

<table>
<thead>
<tr>
<th>Forest enterprises (E)</th>
<th>Forest workers (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>invest(c)</td>
</tr>
<tr>
<td></td>
<td>no invest(1-c)</td>
</tr>
<tr>
<td>invest(h)</td>
<td>E9, W9</td>
</tr>
<tr>
<td>no invest</td>
<td>E10, W10</td>
</tr>
</tbody>
</table>

The expected income of the forestry enterprise to choose invest is:

\[ U_{et3} = [E9h + E11(1-h)] \] 
(13)

The expected return for forestry companies to choose no invest is:

\[ U_{et*3} = [E10h + E12(1-h)] \] 
(14)

The expected income for forest workers to choose invest is:

\[ U_{wt3} = [W9c + W10(1-c)] \] 
(15)

The expected income for forest workers to choose no invest is:

\[ U_{wt*3} = [W11c + W12(1-c)] \] 
(16)

The income function of forestry enterprises (E) is:

\[ U_e3 = c[E9h + E11(1-h)] + (1-c)[E10h + E12(1-h)] \] 
(17)

The income function of forest workers (W) is:

\[ U_w3 = h[W9c + W10(1-c)] + (1-h)[W11c + W12(1-c)] \] 
(18)

Based on the construction of the game model of the three parties' interests of the state, the forestry enterprise and the forest worker, the mixed game is used to determine the final result of the triangular benefit game.

2.5 Mixed Strategy Nash Equilibrium Solution

The following solution to this game is mixed with the Nash equilibrium.

First seek the government (G), forestry enterprises (E) and forest workers (W) choose to invest and no invest expectations:

\[ U_{gt} = U_{gt2} + U_{gt3} = [G5c + G7(1-c)] + [G9h + G11(1-h)] \] 
(19)

\[ U_{gt*} = U_{gt*2} + U_{gt*3} = [G6c + G8(1-c)] + [G10h + G12(1-h)] \] 
(20)

\[ U_{et} = U_{et1} + U_{et3} = [E1a + E2(1-a)] + [E9h + E11(1-h)] \] 
(21)
Thus three equations can be obtained:

\[ [G5c+G7 (1-c)]+[G9h+G11 (1-h)] = [G6c+G8(1-c)]+[G10h+G12(1-h)] \]  
\[ [E1a+E2(1-a)]+[E9h+E11(1-h)] = [E3a+E4(1-a)]+[E10h+E12(1-h)] \]  
\[ [W1a+W2(1-a)]+[W9c+W10(1-c)] = [W3a+W4(1-a)]+[W11c+W12(1-c)] \]

So as to solve the solution of the system (a, c, h), solution:

\[ a=(M2M6M8-M3M5M8-M9M2+M1M5M9)/(M2M4M8+M1M5M7)=A \]  
\[ c=M9/M8-M7/M8A \]  
\[ h=M6/M5-M4/M5A \]

among them: N1=0; N2=0; N3=0; N4=0; N5=0; N6=0.

M1=G5-GG7+G8; M2=G9-G10-G11+G12; M3=G8-G7+G12-G11; M4=E1-E2-E3+E4; M5= E9-E10-E11+E12; M6=E4-E2+E12-E11; M7=W1-W2-W3+W4; M8=W9-W10-W11+W12; M9= W4-W2+W12-W11.

### 3. EQUILIBRIUM ANALYSIS OF INTEREST GAME

#### 3.1 Nash Equilibrium Solution

In the case of complete information static game, the mixed strategy Nash equilibrium in government (G), forestry enterprise (E) and forest worker (W) game is (a, c, h). The probability that the government chooses to invest is a, the probability that the forestry enterprise chooses to invest is c, the probability that the forest worker chooses to invest is h. It is clear that the value of a, c, h depends on the proceeds of each game, that is, the number of gains determines the probability of size for government (G), forestry (E) and forest workers (W) to choose invest and no Invest.

According to the above formula (19-24), it can be seen that the government (G), forestry enterprises (E) and forest workers (W) are related to the probability of each participant to choose to invest. We can replace (a, c, h) into these formulas to solve the expected value.

If we consider the complete information dynamic game, it is clear that both the government (G), the forestry enterprise (E) and the forest worker (W) will consider the expected value of the investment and no invest. Only if the expected value of invest is greater than the expected value of no invest, he will first take the investment strategy, instead take the no invest strategy. Then, after the first party to take action, the rest will be based on the corresponding situation to make the appropriate strategy. Obviously when the interests of the parties cannot be reasonably allocated, the expected value of invest is less than the expected value of no investment, then the participant obviously will not choose to invest this bad strategy.

#### 3.2 Maximum Benefit Value Solution

In order to further analyze the mixed Nash equilibrium, this section solves the maximum benefit value of the stakeholder.

##### 3.2.1 Solve the Process
First determine their own income function, so as to determine the extreme value of their earnings. Combined with the purpose of the study, to solve under what circumstances Ug, Ue, Uw can get the maximum. The problem is transformed into a three-dimensional function to find the extreme value of the problem, the use of Lagrangian method to solve.

Create helper function:

\[ Z(a, c, h) = F(a, c, h) + \lambda \varphi(a, c, h) \]  \hspace{1cm} (31)

Where \( \lambda \) is a constant to be determined, called the Lagrangian multiplier, and the constraint is:

\[ \varphi(a, c, h) = a + c + h - 1 = 0 \]  \hspace{1cm} (32)

The interest function is:

\[ U = F(a, c, h) \]  \hspace{1cm} (33)

Then:

\[ U_g = U_g1 + U_g3 = a[G5c + G7(1-c)] + (1-a)[G6c + G8(1-c)] + a[G9h + G11(1-h)] + (1-a)[G10h + G12(1-h)] \]  \hspace{1cm} (34)

\[ U_e = U_e1 + U_e3 = c[E1a + E2(1-a)] + (1-c)[E3a + E4(1-a)] + c[E9h + E11(1-h)] + (1-c)[E10h + E12(1-h)] \]  \hspace{1cm} (35)

\[ U_w = U_w1 + U_w3 = h[W1a + W2(1-a)] + (1-h)[W3a + W4(1-a)] + h[W9c + W10(1-c)] + (1-h)[W11c + W12(1-c)] \]  \hspace{1cm} (36)

Then:

\[ Z_g(a, c, h) = F_g(a, c, h) + \lambda \varphi(a, c, h) = U_g + \lambda \varphi(a, c, h) \]  \hspace{1cm} (37)

\[ Z_e(a, c, h) = F_e(a, c, h) + \lambda \varphi(a, c, h) = U_e + \lambda \varphi(a, c, h) \]  \hspace{1cm} (38)

\[ Z_w(a, c, h) = F_w(a, c, h) + \lambda \varphi(a, c, h) = U_w + \lambda \varphi(a, c, h) \]  \hspace{1cm} (39)

Now to solve, \( \varphi(a, c, h) = a + b + c + h - 1 = 0 \), when the function of the extreme value problem. For \( Z_g(a, c, h) \) to take partial derivative, and make the value of 0, available equations 1:

\[ \frac{\partial Z_g(a, c, h)}{\partial a} = \frac{\partial U_g}{\partial a} + \lambda \frac{\partial \varphi(a, c, h)}{\partial a} = 0 \]  \hspace{1cm} (40)

\[ \frac{\partial Z_g(a, c, h)}{\partial c} = \frac{\partial U_g}{\partial c} + \lambda \frac{\partial \varphi(a, c, h)}{\partial c} = 0 \]  \hspace{1cm} (41)

\[ \frac{\partial Z_g(a, c, h)}{\partial h} = \frac{\partial U_g}{\partial h} + \lambda \frac{\partial \varphi(a, c, h)}{\partial h} = 0 \]  \hspace{1cm} (42)

For \( Z_e(a, c, h) \) to take partial derivative, and make the value of 0, available equations 2:
For $Z_w(a, c, h)$ to take partial derivative, and make the value of 0, available equations 3:

$$\frac{\partial Z_w(a, c, h)}{\partial a} = \frac{\partial U_w}{\partial a} + \lambda \frac{\partial \phi(a, c, h)}{\partial a} = 0 \quad (46)$$

$$\frac{\partial Z_w(a, c, h)}{\partial c} = \frac{\partial U_w}{\partial c} + \lambda \frac{\partial \phi(a, c, h)}{\partial c} = 0 \quad (47)$$

$$\frac{\partial Z_w(a, c, h)}{\partial h} = \frac{\partial U_w}{\partial h} + \lambda \frac{\partial \phi(a, c, h)}{\partial h} = 0 \quad (48)$$

Together with the following constraints:

$$\phi(a, c, h) = a + c + h - 1 = 0 \quad (49)$$

We can find the solution of the three equations at this time of $(a_i, c_i, h_i)$, and when $(a_i, c_i, h_i)$ was put into $U_g$, $U_e$, $U_w$, we can get extreme values, which can determine the interests of the main stakeholders of their own.

### 3.2.2 Results and Discussion

The reform of state-owned forest right is an adjustment and distribution of the existing distribution system of benefits. The successful reform is to balance the interests of the various stakeholders. According to the interest game model constructed in this paper, we can see that in the case of complete information static game, the mixed strategy Nash equilibrium in government, forestry enterprises and forest workers is $(a, c, h)$. The value of $a, c, h$ depends on the proceeds of each game, that is, the amount of the income of the parties determines the government, forestry enterprises and forest workers to choose the forestry economy (policy) and the probability of no investment.

The number of interests of the main stakeholders is related to the interests of the main investment. However, in the real economic life, due to the actual institutional factors, investment and output risk factors and other reasons, cannot ensure that the interests of various stakeholders and the benefits are positively related. In this case, the Nash equilibrium does not always exist.

In this paper, we construct the maximum income function of the stakeholder, and the respective stakeholders can determine the respective income value through the function under different policy conditions, and also can clarify the profit value of the other party. When the interests of the main body in the forest reform in the proceeds to reach the maximum or extreme value of the case, the forest reform is undoubtedly smooth and feasible. This paper studies the influence of the reform of the state-owned forest right on the interests of the various stakeholders, and explores the policies and measures to realize the coordinated development of the three parties' interests of the state, enterprises and workers. In the whole forest reform, the government, the forestry enterprise and the workers all want to satisfy their own interests. Obviously, in order to make the reform of the forest right smoothly, So that the interests of various stakeholders is equal to or close to its maximum earnings or earnings extreme.
4. INTEREST COORDINATION FORM

In order to achieve a certain purpose, people need to adjust their own ideas and behavior. These adjustments are conscious and conscious. The process of adjustment is the process of interest coordination. Under the premise of the legitimacy of personal interests, people carry out the coordination of interests. This is an adjustment to people's value orientation and values. System has always been with the changes in the environment, in a certain stage of reasonable and effective system, with the economic situation changes, will become obstacles to economic development (Hu, 2011). Therefore, the rationality of the system is relative.

4.1 Economic Coordination

The contradiction between people is more reflected in the contradiction between interests. The contradiction of economic interests is one of the focuses of the interests of the main competition. In order to make social benign development, we need to establish a sound economic system, legal system. It can use the system form to coordinate the contradiction between the interests of the main, which makes the interest system to maintain a relatively balanced and reasonable pattern.

The development of the pilot work of state-owned forest right in Yichun shows that the state should make the determination of state-owned forest tenure reform, that is, through the effective division of forest rights, to ensure that the rights of different forest owners, the boundaries of responsibility clear. We establish an effective mechanism for coordinating interests, so as to mobilize the enthusiasm of forestry enterprises and forest workers, to promote the in-depth implementation of state-owned forest rights.

4.2 Political Coordination

Economy is the foundation, politics is superstructure. Politics is a concentrated reaction of the economy. Politics reflects the fundamental interests of all sectors of economic relations. According to the theory of the state, the state is based on the rule of violence, it can be integrated use of various political coordination means to balance the interests of the main contradiction between the main. Appropriate government intervention is necessary, such as through the construction of water conservancy, construction of roads, and truly run the public education, social security, law and order, in order to regulate social interests.

After the implementation of forest rights reform in state-owned forest areas, the social security work in forest areas is in urgent need of national policy support. For example, the identity of workers has changed, some workers both retain the identity of the forest workers. At the same time he was a forest operator. Some workers are out of the status of state-owned workers, and completely transformed into independent forest operators. The government will constantly adjust and improve the forest area of social security compensation mechanism. The government should properly solve the minimum living security needs of state-owned forest workers, through the establishment of old age, medical insurance and other basic risk prevention system.

4.3 Legal Coordination

Legal coordination and political coordination is extremely close, the law is a national implementation of political rule tool, is the ruling class will reaction. The state through the development of various laws coordinate people's interests, clear their rights, responsibilities, interests, maintenance of social and economic order, social order. And the state use the law to monitor the implementation of social and public affairs, to safeguard the social members of the property safety, personal freedom.

4.4 Moral Coordination

When a person's behavior does not touch the laws and regulations under the premise, if the interests of others, then the law is powerless. Many people will use legal loopholes to make harm to the interests of others behavior; the law does not have any binding capacity. At this point the moral coordination will play a role in coordinating the interests of the people. The use of moral coordination means can be achieved mainly by education, traditional culture, customs, public opinion and other means. People gradually form a healthy moral concept, in order to coordinate the relationship between people. Moral coordination is not mandatory, it can only be realized by virtue of people voluntarily.
Therefore, in the course of the reform of state-owned forest tenure, the government should not only pay attention to the economic and political level, but also give full consideration to the construction of ecological culture. Harmonious and prosperous ecological and cultural system can promote the concept of ecological civilization in state-owned forest areas, and ensure the sustainable development of forestry ecological system and forestry industry system and ensure the smooth implementation of forest right reform.

5. CONCLUSION

Through the application of static and dynamic game method to establish the state, business and staff expected return, and get a mixed strategy balance. The results show that: (1) In the case of complete information static game, the mixed strategy of government, forestry enterprises and forest workers is (a, c, h). The value of a, c, h depends on the proceeds of each game, that is, the amount of the income determines the government, forestry enterprises and forest workers on the forestry political and economic investment and no investment probability. (2) both the government (G), the forestry enterprise (E) and the forest worker (W) will consider the expected value of the investment and no invest. Only if the expected value of invest is greater than the expected value of no invest, he will first take the investment strategy, instead take the no invest strategy. Then, after the first party to take action, the rest will be based on the corresponding situation to make the appropriate strategy. Obviously when the interests of the parties cannot be reasonably allocated, the expected value of invest is less than the expected value of no investment, then the participant obviously will not choose to invest this bad strategy. When the interests of the main body in the forest reform in the proceeds to reach the maximum or extreme value of the case, the forest reform is undoubtedly smooth and feasible. It is necessary to coordinate from the political, economic, legal and moral aspects.

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