Study on Ecological Compensation Mechanism of Watershed

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Abstract: Establishing perfect ecological compensation mechanism is an important way to realize sustainable development of river basin. Because there are obvious contradictions and conflicts between economic goals and resource goals, the upstream and downstream governments in the basin have typical game characteristics. In this regard, based on the externality theory, public goods theory and the establishment of the corresponding game model, this paper studies the basin ecological compensation mechanism, and discusses the resistance and difficulties encountered in the process of ecological compensation.

1. Introduction

With the rapid development of China's economic development, the problem of environmental pollution becomes more and more serious. Therefore, an ecological compensation mechanism compatible with incentives and constraints has gradually developed, which can effectively coordinate the relationship between economic development and environmental protection. The main problem in the process of watershed management in China is the difficulty of cooperation between upstream and downstream, and the dilemma of “upstream pollution, downstream suffering” or “upstream protection, downstream income”. In order to pursue rapid economic development, the upper reaches of the river basin are over-exploited, which affects the ecological security of the lower reaches and brings negative externalities. The upper reaches of the basin ensure that the lower reaches can enjoy a good ecological environment, and invest a certain amount of manpower and material resources to control pollution, thus forming positive externalities. No matter from which angle, it is not Pareto optimality in economic sense. To solve this problem, it is particularly important to establish a perfect ecological compensation mechanism.

2. Watershed Ecological Compensation Model

Basin ecological compensation mode refers to the design of corresponding institutional arrangements to determine the source of compensation funds, the subject, object and principle of ecological compensation, etc., on the premise of clear relationship and role among stakeholders in the basin. It refers to internalizing externalities caused by environmental pollution or positive externalities caused by environmental protection through certain institutional arrangements. Pigou proposed to solve externalities through government intervention (“Pigou tax”), while Coase proposed to solve externalities through marketization. Therefore, there are two modes of watershed ecological compensation: government compensation and market compensation.

2.1 Government Compensation Model

Financial vertical compensation is mainly realized by the central government or higher-level government through financial transfer payments, tax incentives, implementation of ecological compensation projects, and policy tilt. Through the basin compensation mode led by the central or higher-level government, the problem of excessive extraction of public resources can be effectively solved, and then the contradictions among administrative regions can be alleviated. Moreover, the superior government can save some transaction costs by virtue of its advantages in political status, so the compensation effect is often remarkable. But at the same time, due to the single source of compensation funds, there is often a problem of unsustainability.

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The horizontal transfer payment between governments is the compensation made by the downstream government for the upstream government's contribution to water environmental protection and governance. Cross-border pollution is an obvious problem in watershed ecosystem. For this kind of problem, it needs the cooperation between the basin governments. The upstream government protects the water ecological environment, while the downstream government benefits obviously.

2.2 Market Compensation Model

Market compensation mode means that the beneficiaries of watershed ecological services compensate the providers of ecological services by using market mechanism within the scope of environmental standards and laws formulated by the government. This model is obviously different from the government compensation model, which directly links the stakeholders in the basin and negotiates compensation issues by clarifying the value of ecological services. This model mainly relies on the power of market mechanism, and the government is not in a dominant position in this process. Ecological service is regarded as a commodity, and it is traded in the market by clarifying property rights, and the surplus party sells it to the scarce party. This model not only indirectly realizes the watershed compensation, but also ensures the sustainability of ecological services, and enlivens the market and optimizes the allocation of resources. Since Yiwu, Zhejiang Province, borrowed water from Dongyang in 2000 to alleviate the problem of insufficient water supply in Yiwu, China has gradually begun to explore the establishment and improvement of water rights trading market and emission trading market. Under the guidance of market transaction, internalizing the cost of negative externality of pollution can, to a certain extent, promote the producers in the river basin to change the production mode of high pollution and high energy consumption, and adopt some water-saving and low pollution production mode, so as to realize the protection of the watershed ecosystem.

Table 1 Comparative Analysis Of Ecological Compensation Modes in River Basins

Mode	Means of compensation	Compensation subject	Compensation standard
Government compensation model	Financial transfer payment, ecological compensation special fund, project support, policy tilt, etc.	Compensator: central government, superior government and downstream local government Compensated party: upstream local government	Corresponding compensation standards are formulated by government departments, and upstream and downstream governments can negotiate. Short-term effect is obvious, but it lacks sustainability.
Market compensation mode	Direct payment, water rights trading, emissions trading	Compensator: ecological service beneficiary Compensated party: ecological service provider	Beneficiaries and providers directly negotiate in the market to determine the compensation amount. Incentives are obvious and lack of stability.

3. Analysis of the Game Relationship between the Upstream and Downstream Governments in the Basin

As the manager of river basin (public resources), the government pursues the maximization of the interests of government departments. However, the government's goals are multiple, both in terms of economic benefits and social benefits. In the process of watershed management, the government can obtain the economic benefits brought by fiscal revenue and the social benefits of promoting industrial development and employment. But at the same time, it is necessary to act as the representative of the public interest when the environment is broken, control pollution, provide ecological services and protect the sustainable development of the river basin.

3.1 Static Game Analysis

In the static game, all actors make decisions at the same time, and when making decisions, they

often don't know each other's decisions and can only rely on their own guesses. In the basin ecological compensation game model, the related game subjects are the upstream and downstream governments in the basin. This paper assumes that both the upstream and downstream governments are rational subjects. There are two strategies for the upstream government: governance and non-governance. The downstream government also has two strategies: compensation and non-compensation. According to the cost-benefit analysis, the following variables are defined:

B_1--Gains from the upstream government's choice of non-governance strategy

B_2--The incremental benefits (social benefits) obtained by the upstream government under the governance strategy

C--The direct cost and the opportunity cost of indirect loss spent by the upstream government under the choice of governance strategy

k--Ecological compensation fee given by downstream government to upstream government

b_1--The income obtained by the downstream government under the strategy of no governance chosen by the upstream government

b_2--Positive externality spillover benefits obtained by downstream government under the governance strategy chosen by upstream government

The purpose of ecological compensation by the upstream and downstream governments is to protect the ecosystem in the basin and maximize the revenue in the administrative region. Now, assuming that the upstream and downstream governments in the basin have a complete understanding of each other's strategic space and revenue function, the basin ecological compensation game model becomes a static non-cooperative game model with complete information. Establish the following game model:

Table 2 the Income Matrix of the Static Game Model of Upstream and Downstream Governments

Upstream government			
		Governance	No governance
Downstream government	Compensation	(b_1+b_2-k, B_1+B_2+k-C)	(b_1-k, B_1+k)
	No compensation	(b_1+b_2, B_1+B_2-C)	(b_1, B_1)

From the game profit matrix, we can see that for the downstream government, when the upstream government chooses the governance strategy, the downstream government chooses to obtain more benefits than the compensation strategy: b1+b2>b1+b2- k. Therefore, in this situation, the downstream government tends to choose a non-compensation strategy, resulting in a “free ride” phenomenon. When the upstream government chooses the non-governance strategy, the downstream government chooses the compensation strategy to obtain less benefits than the non-compensation strategy: b1-k<b1. So no matter what strategy the upstream government chooses, for the downstream government, choosing not to compensate the upstream government is the dominant strategy of the downstream government.

For the upstream government, only when B2>C, that is, when the upstream government chooses to control pollution, the incremental income (social benefit) is higher than the upstream government’s direct input cost and indirect loss opportunity cost for water environment governance. The government's choice to treat water pollution will produce positive benefits. Regardless of whether the downstream government compensates or does not compensate, the upstream government's dominant strategy will be to control water pollution. However, in real life, the opportunity cost of upstream governments who choose to control water pollution and give up the development and utilization of water resources will be very large, often greater than the incremental benefits generated by water environmental protection, that is, B2<C. Therefore, when the downstream government chooses to compensate, B1+B2+k-C<B1+k, and the upstream government chooses not to govern. When the downstream government chooses not to compensate, B1+B2-C<B1, the non-governance strategy will become the dominant strategy of the upstream government. Therefore, (b1, B1) is the Nash equilibrium under the game model. The upstream government does not govern, and the downstream government does not compensate, and is trapped in a prisoner’s dilemma. The upstream government does not have the motivation to control water pollution, and the

downstream government also hopes to free rides and not compensate the upstream government. As a result, it falls into a vicious circle, water resources are over-extracted, ecological services are insufficiently supplied, and the water environment continues to deteriorate.

From the above game model, it can be seen that the horizontal compensation between upstream and downstream governments has no impact on the total income in the whole basin game process. In this case, the ecological compensation by the downstream government did not play its due role. At this time, it is necessary for the central government or higher-level government to intervene strongly, make vertical financial transfer payments, and introduce corresponding constraints, so as to change the above-mentioned income matrix and avoid falling into the “prisoner's dilemma”.

Static game analysis shows that horizontal transfer payments made by downstream governments to upstream governments often fall into a prisoner’s dilemma. Now, the introduction of the compensation amount given by the central or higher-level government: k2, and the introduction of corresponding constraints, will change the income matrix and increase the motivation and enthusiasm of the upstream government to control water pollution. At this time, as long as B2-C+k2>0, that is, the incremental benefits of environmental protection by the upstream government and the compensation provided by the superior government are greater than the direct cost of water pollution control and the opportunity cost of indirect loss. At this time, regardless of whether the downstream government compensates, the upstream government has the incentive to control water pollution. At this time, when the downstream government compensates the upstream government, it often has higher requirements for water quality and purchases ecological services from the upstream government. When B2-C<0, the downstream government negotiates with the upstream government on the amount of ecological compensation in the basin. Only when B2-C+k+k2>0, that is, when the sum of vertical transfer payment and horizontal transfer payment is greater than the difference between the upstream government's water pollution control costs and the benefits of water pollution control, the upstream government has the motivation to control water pollution . Similarly, when the downstream government makes a choice strategy, only when b2-k$\geqslant$0, that is, the downstream government enjoys a positive externality benefit greater than or equal to the compensation paid to the upstream government, the downstream government will have the motivation to choose the compensation strategy. Therefore, the amount of ecological compensation paid by the downstream government cannot exceed the external benefits it enjoys, and the remaining compensation costs will be borne by the upper-level government to ensure that B2-C+k+k2>0.

To sum up, to establish a perfect ecological compensation mechanism in river basins, we should proceed from the overall interests of the river basins, with the higher-level government (central government) and local governments as the common subjects of river basin compensation, and introduce corresponding constraints to ensure the smooth progress of ecological basin compensation behavior.

3.2 Analysis of Dynamic Game Model

Dynamic game is a kind of sequential game in which one party makes a decision first, and then the remaining party chooses its own strategy according to the decision of the other party. Now, it is assumed that the upstream has produced pollution, the upstream government has two strategies: governance and non-governance, and the downstream government has two strategies: claiming compensation and not claiming compensation. Define the following variables first:

B--Economic benefits of upstream government polluting water environment

C--The cost of upstream water pollution control

b--Income of downstream government under the governance strategy chosen by upstream government

c--Revenue lost by downstream government due to pollution by upstream government

k--Compensation claimed by the downstream government from the upstream government

In the case that the upstream government makes water pollution control, the downstream government will not demand compensation. The upstream government's revenue is B-C, and the downstream government's revenue is b. When the upstream government does not conduct water

pollution control, if the downstream government does not demand compensation, the upstream government's revenue is B, and the downstream government's revenue is b-c. When the upstream government does not conduct governance and the downstream government demands compensation, the upstream government's revenue is B-k, and the downstream government's revenue is b-c+k. From the game model, two important conclusions can be drawn: First, after the upstream government's watershed produces pollution, the downstream government requires compensation, and relevant laws and systems need to be improved so that the downstream government has a law to follow when requesting compensation. Secondly, as long as the compensation amount k required by the downstream government is greater than the cost of water pollution control by the upstream government, the upstream government has sufficient incentives to control water pollution.

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