Analysis of Pricing Theory and Composition of Forest Environmental Resources Based on Marginal Opportunity Cost

Chang-Ning GUO\textsuperscript{1,2,a}, Jian-Zhou YANG\textsuperscript{2,*}

\textsuperscript{1}College of Economics, Fujian Agriculture and Forestry University, Fuzhou, Fujian 350002 China
\textsuperscript{2}College of Management, Fujian University of Technology, Fuzhou, Fujian 350108 China
\textsuperscript{a}48560220@qq.com, *yjz300@163.com

**Keywords**: Forest environmental resources; Resource pricing; Marginal opportunity cost; Marginal production cost; Marginal user cost; Marginal external cost.

**Abstract.** The theory of marginal opportunity cost provides a better method for resource pricing. It can reflect the production cost user cost and environmental cost of the source utilization. It is consistent with the idea of sustainable development. The theory has been widely used in coal and water resources pricing. However there is fewer search on forest environment resources pricing especially no systematic research. This paper firstly reviewed the marginal opportunity cost theory and its application followed by a feasibility analysis of applying it to forest environmental resources pricing. Considering the characteristic of forest environment resources, the research proposed a specific pricing composition based on the marginal opportunity cost theory. It has laid a theoretical foundation for the future research based on the marginal opportunity cost of forest environmental resource pricing.

**Introduction**

Forest environmental resources refer to forest physical resources including forest land, trees, wild animals and microorganisms, as well as ecological service resources derived from the physical resources, which are the general term of external world relative to human beings\cite{1}. As the relatively special natural resource, the forest environmental resources have no tangible market for most of their value, and the market cannot solve their pricing problem. Therefore, we need to carry out the pricing research on forest environmental resources. The traditional thinking and method about pricing general natural resources is to calculate the various values of resources separately and then add them up. Specific calculation methods mainly include approaches of the direct market, shadow price, and opportunity cost. According to the current research, when specific methods of pricing natural resources is applied to pricing forest environmental resources, there are always different deficiencies. For example, some methods can only take certain aspects of the price structure into consideration, leading to deviations from the results, while others only can provide one limited assumption. The theory marginal opportunity cost provides a new perspective for the study of the pricing of forest environmental resources.

The theory marginal opportunity cost is the pricing theory for natural resources developed by the British environmental economist Pearce (Pearce 1989, 1996) and others on the basis of the marginal cost pricing. This theory abstracts and measures the resource utilization from the economic angle, including producers' production cost for gaining natural resources, as well as losses to others, society, the environment and the future due to the use of natural resources, thereby reflecting the impact of changes in natural resource utility and scarcity, and considering Intergenerational fairness. What's more, it as a relatively good resource pricing can provide direct theoretical and methodological basis for the study of forest environmental resource pricing, helping to solve the problem of confirmation and measurement of missing costs in the process of taking advantage of forest environmental resources, and remedy external diseconomy caused by neglecting resource utilization in traditional resource economics. Therefore, the theory is a breakthrough and new exploration of traditional resource and environment management reforms.
Analysis of Connotation and Composition of the Marginal Opportunity Cost for Forest Environmental Resources

Connotation of the Marginal Opportunity Cost for Forest Environmental Resources

The concept of opportunity cost is proposed by the neoclassical school of economics. It refers to the maximum benefit that can be obtained when given resources are only used for a certain purpose under the same other conditions[2]. Or it refers to some income is attained by use of given resources while other income is waived under the same other conditions.

In order to better express the connotation of opportunity cost, taking the evaluation of house value during the demolition of houses that people are familiar with as an example, suppose there is a three-story building, and before the demolition, the owner living on the third floor rents the first floor to the merchant for commercial activities, and rents the second floor to others to live. The house value is underestimated, if the assessment of the house value during the demolition is only based on the construction cost spent on the building. The homeowner is certainly not willing because that assessment does not include the owner’s other income due to the existence of the house, which likes rental income. Meanwhile, the assessment does not take into account the losses to the owner caused by the demolition of the house, that is, the owner has to pay the rent to live because the new house can not be built in time after the demolition. However, if the opportunity cost is used to measure the house value, the assessment should include the construction cost of the house, the decoration cost, the interest on loan for the house construction, etc., which is the marginal producer cost. Without the house, the owner and the descendants can no longer obtain the rent, which is the marginal user cost generating from loss of profits or other losses to the homeowner. If there is environmental pollution in the process of house demolition, it will cause losses to others which should also be included into the opportunity cost, that is the marginal external cost. Obviously, using the marginal opportunity cost to measure the house value as an important basis for the price when demolishing a house, it is a feasible and reasonable method to measure the full cost of using the house from the perspective of economics.

By the same token, using the opportunity cost to determine the price of forest environmental resources should include not only the production costs of the forest environment resources, but also the profits from the corresponding producers' effective use of this production cost. In addition, forest environmental resources have scarcity in the physical sense. When a unit of forest environmental resources is used, the opportunity is given up to use the resources in the future to obtain net income for the economic agent, so the cost should also include the agent's abandoned profit loss from the use of forest environmental resources. In addition, the loss from the use of forest environmental resources to society and others should also be included in the opportunity cost.

In the marginal opportunity cost, the margin is the concept of an incremental ratio, which is the ratio of the change in the unit's independent variables to that in the dependent variables. The opportunity cost of forest environmental resources not only changes with change of its output, but also with that of the scarcity degree of forest environmental resources. Generally, the unit opportunity cost of forest environmental resources gradually increases with time, so the price of forest environmental resources is not equal to the average opportunity cost, but equal to the marginal opportunity cost[3].

Therefore, the price of forest environmental resources should be equal to its marginal opportunity cost which theoretically reflects the full price paid by the entire society including producers when using a unit of forest environmental resources.

Analysis of Price Composition of Pricing of Forest Environmental Resources Based on the Marginal Opportunity Cost

According to the theory marginal opportunity cost, the marginal opportunity cost consists of marginal production cost, marginal user cost, and marginal external cost. It is believed that the concept of environmental cost can more accurately and better cover the consequences of external diseconomy of the management and utilization of forest environmental resources, including not only site productivity decline of the management process, and adverse effects by the application of
pesticides and pest control on the surrounding ecosystems such as forests, agriculture, rivers, and lakes, but also negative impacts on the life and property of the surrounding communities and socio-economic development, such as the loss of soil and water resources, changes in living environment and landscape damage after the utilization of forest environmental resources. This research plans to select "the marginal environmental cost" instead of "the marginal external cost" to analyze and study the economic loss from eco-environmental damage during the operation and use of forest environmental resources[4].

Theoretically, the price of forest environmental resources should be equal to its marginal opportunity cost, shown as a formula: \( P = MOC = MPC + MUC + MEC \).

The price composition refers to the composition of each factor that forms the price in the price.

The price composition of the pricing for forest environmental resources based on marginal opportunity cost is composed as follows:

1. **Marginal production cost (MPC)**

   The marginal production cost in the marginal opportunity cost of forest environmental resources is the part which can be most easily recognized by people, because to achieve natural resources, production costs must be paid, such as infrastructure, equipment, wages, and other inputs; even for the unattained natural resources, there are also production costs such as exploration costs, management costs and monitoring costs. The marginal production cost of forest environmental resources refers to the change in the total production cost brought about by the achievement of a unit of natural resources. The marginal production costs can be divided into short-term marginal production costs and long-term marginal production costs[5]. The former only involves variable costs, while the latter includes fixed costs and variable costs. Forest environmental resources have features of large inputs and the long cultivation period, so their marginal production costs should be long-term marginal production costs.

   The marginal production cost of forest environmental resources for planted forests should include:

   1. Direct production costs of forest environmental resources per unit area include the land rent, seedling fees for afforestation, labor costs, tending fees, management and maintenance costs, the infrastructure costs required to cultivate the forest environmental resources, such as the inputs of forest roads, management and protection shelters and fire lanes, as well as costs of new inputs after losses due to natural disasters (if purchase the forest insurance, it will be insurance costs plus various costs of new inputs - insurance compensation).

   2. Indirect production costs of forest environmental resources per unit area include costs of indirect investment such as preliminary planning, design, investigation, monitoring, and other management costs for the development of the forest environmental resources.

   3. Capital costs include interest, depreciation, etc., in which the interest on funds invested in the cultivation of forest environmental resources can be calculated based on the commercial loan interest rate for the same period.

   It should be noted that in the development of forest environmental resources, preliminary costs is much more than costs in the middle and late periods, so discount is required. The interest generated by the funds invested in the cultivation process will be transferred to the next year and become the new cost because of the long production cycle, turning into compound interest of the production costs of forest environmental resources.

   As for natural forests, if natural forests are cut down, for the sake of ecological protection and sustainable development, artificial afforestation is required, so the marginal production cost of forest environmental resources for natural forests should include reproduction costs (such as afforestation), management and maintenance costs and so on.

2. **Marginal user cost (MUC)**

   The marginal user cost of forest environmental resources refers to costs produced from the utilization of a certain unit of forest environmental resources cannot be reused by oneself or its future generations, which is also the abandoned maximum net profit that may be obtained by using the forest environmental resources in other ways, including the cost of using resources now instead of leaving them for future generations. It reflects the impact of the scarcity of forest environmental resources.
resources on their prices. The marginal user cost of forest environment resources is determined by its opportunity cost. To determine whether a natural resource has the marginal user cost, first that resource should have multiple choices or opportunities to use, and when there is only one choice, there is no opportunity cost. Some economic agents of forest environment resources will face the choice of using resources as public welfare forests or economic forests. In this case, by using the resources as economic forests, the economic agents can obtain the private marginal net income, also known as the opportunity cost, which is the marginal user cost of forest environmental resources used by the economic agents. Some economic agents of forest environmental resources will face the choice of whether to use the resource now or use it in the future. In this case, these economic agents can obtain the net income by using resources in the future instead of now. Based on the interest rate of the commercial bank or the discount rate of the central bank, discount the net income of these different periods to the present value which is the marginal user cost of forest environmental resources used by economic agents now.

Second, the natural resource must have the scarcity in a material sense. If the reason for relatively scarce natural resources available is not the too small absolute quantity, but too little investment into the achievement of the natural resources so that the developed resource products cannot meet the demand in the market. This scarcity is only in the economic sense, which can be resolved through more mining inputs, regardless of user costs. The scarcity in material sense is related to user costs. Forest environmental resources, as the important material basis for human beings, have the obvious material scarcity. According to historical records, forests account for about two-thirds of the Earth's area in the middle of the nineteenth century, but later, they are used and destroyed in succession, resulting in a serious shortage of current total forests.

Therefore, forest environmental resources have user costs, while inexhaustible wind energy and solar energy of renewable resources have no scarce, so their marginal user costs are zero.

(3) Marginal environmental cost (MEC)

Because the forest environment resources are of typical externalities, that is the forest environmental resources can bring beneficial effects to other economic agents, such as increasing the water supply for hydropower plants, purifying the air for regional residents, producing oxygen, and improving agricultural output by wind break and sand fixation, which are positive externalities; the current market mechanism does not effectively reflect these effects which beneficiaries do not need to pay for. On the other hand, exploitation and utilization of forest environmental resources can bring environmental losses to the surrounding residents and other third parties, and these losses, known as the external cost of exploitation and utilization of forest environmental resources, will not be compensated by developers of forest environmental resources, but borne by the victims or other third parties. Therefore, the marginal environmental cost of forest environmental resources refers to the impact of the use of the newly-added unit forest environmental resources on the ecological environment, that is all the environmental losses brought about by the operation and utilization of forest environmental resources, which can be determined through changes in the quality value of ecological environment.

The marginal environmental cost of forest environmental resources can be concluded into the following categories:

① External costs during the cultivation of forest environmental resources

The cost of environmental pollution is caused by the use of chemical fertilizers and pesticides during the forest cultivation. In China, especially during the cultivation of economic forests, the use of chemical fertilizers and pesticides has caused adverse effects on water environment, atmospheric environment, and biodiversity. At the same time, the process of pesticide application will cause damage to the health of farmers. These are all external costs in the production of forest environmental resource products.

② External costs incurred after the use of forest environmental resources

The use of forest environmental resources here specifically refers to the fact that forest physical resources are cut down. The measurement of external costs generated after the use of forest environmental resources refers to the calculation of losses to others caused by deforestation from
the perspective of economics. If the assessed forest environmental resources have not been felled, it is assumed that external costs can be got by calculating the loss of other people’s interests brought about by the logging.

In terms of the specific composition of losses in the operation and utilization of forest environmental resources, consulting the “Forest Ecosystem Services Assessment Standards” formulated by the State Forestry Administration and the research results of others at home and abroad, taking into account factors such as testability and importance, based on the characteristics of specific evaluation objects, this study proposes that the specific indicators for calculating the marginal environmental cost can be selected from the following indicators. See Table 1 for details.

The marginal environment cost depends not only on the severity of victims’ losses, but also on the victims’ assessment of the loss, that is the willingness of the victim to receive compensation.

In short, according to the price composition of the pricing of forest environmental resources, the price of forest environmental resources determined by the marginal opportunity cost is the comprehensive result of the labor value for forest environmental resources and the economic value of forest environmental resource eco-services.

Table 1. The Assessment System of the Marginal Environment Cost for the Use of Forest Environmental Resources.

<table>
<thead>
<tr>
<th>1st level indicator</th>
<th>2nd level indicator</th>
<th>3rd level indicator</th>
<th>Indicator meanings</th>
</tr>
</thead>
<tbody>
<tr>
<td>External costs during the cultivation of forest environmental resources</td>
<td>Chemical fertilizer and pesticide pollution</td>
<td>Groundwater pollution</td>
<td>Loss to groundwater pollution caused by using chemical fertilizers and pesticides</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Surface water pollution</td>
<td>Loss to surface water pollution caused by using chemical fertilizers and pesticides</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Food residue</td>
<td>Loss to food contamination caused by using chemical fertilizers and pesticides</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Impact of pesticides on biodiversity</td>
<td>Loss to the impact of biodiversity caused by the use of chemical fertilizers and pesticides</td>
</tr>
<tr>
<td></td>
<td>Health damage</td>
<td>Health damage</td>
<td>Loss to the health damage of forest workers caused by using chemical fertilizers and pesticides</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Regulation of water reduction</td>
<td>Loss caused by reduction of water capacity after utilization of forest physical resources</td>
</tr>
<tr>
<td></td>
<td>Soil erosion</td>
<td>Changes in water quality</td>
<td>Loss of changes in water quality after deforestation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soil loss</td>
<td>Loss caused by soil loss after deforestation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nutrient loss</td>
<td>Environmental loss caused by the impact of the logging on biological nutrient cycling</td>
</tr>
<tr>
<td></td>
<td>External costs incurred after the use of forest environmental resources</td>
<td>Carbon loss</td>
<td>Carbon loss caused by the logging and consumption</td>
</tr>
<tr>
<td></td>
<td>Reduced carbon sequestration</td>
<td>Deterioration of living quality</td>
<td>Loss caused by decline in quality due to reduced oxygen, reduced negative ions, increased pollutants, increased noise, and increased dust</td>
</tr>
<tr>
<td></td>
<td>Reduced oxygen release</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Impact on atmospheric environment</td>
<td>Loss to agricultural output</td>
<td>Loss causing agricultural production to reduce after the logging and utilization of forests</td>
</tr>
<tr>
<td></td>
<td>Reduced protection</td>
<td>Species loss</td>
<td>Loss to environment due to reduced animal diversity</td>
</tr>
<tr>
<td></td>
<td>Loss to biodiversity</td>
<td></td>
<td>Mainly referring to loss of sight caused by deforestation</td>
</tr>
<tr>
<td></td>
<td>Impact on ecological landscape</td>
<td>Loss to tourism</td>
<td></td>
</tr>
</tbody>
</table>
Conclusion
Through the analysis of this paper, it can be seen that the application of the marginal opportunity cost theory to carry out the pricing of forest environmental resources is feasible, and the price includes the production cost, the intergenerational cost and external costs caused by the use of forest environmental resources. The theory is a concept of full costs and has far-reaching significance for promoting forest environmental protection. Compared with other traditional methods, it has its advantages and characteristics. This paper has carried on the thorough analysis of the price composition of the forest environmental resource pricing, and puts forward the specific composition of the marginal production cost, the marginal user and the marginal environmental cost of the forest environmental resources, combining with the characteristics of the forest environmental resource. It lays a solid theoretical foundation for establishing the pricing model of forest environmental resources based on the marginal opportunity cost.

Acknowledgement
This research was financially supported by the National Science Foundation.

References