Evaluation of marine spatial resources and its application to the establishment marine usage charge: case study of Xiamen, China

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While marine environmental destruction and marine resource over-consumption are urgent challenges facing us today, the value of marine spatial resources continues to be overlooked and undervalued. We have begun to reach the limits of the oceans and must now begin to utilize and govern them in a more sustainable way. Imposing usage charges in sectors that utilize marine areas for production or for waste disposal would be an efficient economic instrument to discourage waste, optimize distribution, promote conservation and provide funds to improve sea areas health. The essential task for establishing the usage charges for marine spaces is to estimate the value of marine areas. In this study, two operative models are developed to assess the value of marine spaces and the models are applied in order to evaluate the price of different types of marine spatial functions in Xiamen. This study could help decision makers to improve management of sea spatial resources. The principles for establishing the usage charges for marine spaces are also discussed.

Keywords: Marine usage charge, value of marine spaces, estimating model, Xiamen

Introduction

Marine spaces play an important role in coastal economic development and human well-being. From an economic perspective, ocean spaces are considered as essential production factors of marine economic activities, including port and shipping, real estate, tourism and recreation, aquiculture, and near shore industry. On the other hand, marine space is a vital environmental resources for natural ecosystems and habitats, and for accepting and assimilating human waste. However, the difficulty of fencing and policing them has left marine resources largely open to exploitation. In China, the practices of development and use of marine spaces are on the basis of 'first come, first serve'. In other words, whoever first discovers the area can develop and own the marine space (Xue, 1998, 1999). To date, users of the marine space resources have never needed to pay any resources fees or rent. These practices often result in sever overexploitation, competition and conflicts over resources, inefficiency and unfairness in the use of resources, which in turn has led to the abuse of marine spatial resources, destruction of functional integrity of the resource system, and degradation of the marine environment (Kuo, 1993).

In order to regulate the development and use of marine spaces, protect the interests of owner and users of marine spaces and further improve the sustainable use of marine spaces, *The Law of Sea Areas Use of People Republic of China* was implemented in 2002. The

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law regulates that the nation is the sole property right owner of marine areas and whoever wants to use sea spaces could acquire the user right after completing an application, undergoing examination and approval procedure and paying usage fees (Standing Committee of NPC, 2001). The newly introduced scheme, in which users pay for marine spaces, is one of innovative institutional agreements of the marine space management in China (Liu, 2002).

Usage charge for marine space is the rent income of owners from sea space by lease of the right to use a marine resource. The rent of marine spaces is the monetary price of marine spaces traded in the market. Nonetheless, rarely is there always a trade market available for marine spaces. The key question is to determine the mechanism for establishing usage charges when trade markets for marine spaces have yet to be fully developed.

The most critical step for designing the usage charge is to measure the contribution of marine spaces to marine related economic activities. In other words, the value of marine spaces needs to be measured and quantified. We are unaware, however, of any attempt to estimate the value of marine spaces or to estimate the usage charge, despite the fact that there is an extensive literature on the value of marine and coastal resources, including beaches, mangroves and coastal wetlands (Ledoux and Turner, 2002). Developing models to measure the economic value of marine spaces with usage charge for the marine spaces is the purpose of this research.

Methodology

It may be that the best approach to quantify the rent (price) of marine spaces is through market trade, such as an auction. However, the market for marine space trade is unavailable in most cases; therefore other mechanisms must be found to estimate the price. These mechanisms are also important even if there is a developed trade market. This is because the results from these mechanisms could be set as the base price for the auction of marine spaces. Following, we develop two separate models to estimate the price of marine spaces based on production factors and environmental capacity.

Assessing the price of marine spaces based on their production factors

The basic assumption of our model is that the total revenue from marine spaces is the outcome of all input factors, including capital, labour, government marine spaces and others, functioning altogether. The residual after deducting the investment, tax, normal profit and reward to labour from total revenue, is the contribution of the sea areas, known as the price of marine spaces. The conceptual framework of the model can be explained as:

$$p = R - I - O - T - v \tag{1}$$

where p = the accounting profit of consuming marine spaces; R = total revenue; I = investment; O = operating costs (including labour expenditure); T = tax and v = costs of acquiring marine spaces, that is, the price of sea areas. P, R, I, O, T, and v are known values.

If the return rate of investment is ρ, the profit will be equal to ρ times the total investment, that is,

$$p = \rho(I + O + v) \tag{2}$$

The tax could be analyzed from two parts: one part has no relationship with the price of marine spaces (the rate is t_1), the other part has relationship with price (the rate is t_2). Then,

$$T = t_1 R + t_2 v \tag{3}$$

Substituting the Eq. (2) and (3) to Eq. (1), we have the model of the price of marine spaces:

$$v = \frac{(1 - t_1)R - (1 + \rho)(I + O)}{1 + \rho + t_2} \tag{4}$$

Suppose S = the area of sea area (in m^2), r = discount rate and t = years of sea area use, the model to estimate the price of sea area per m^2, P_{pe}, using the annuity formula could be written as:

$$P_{\text{pe}} == \frac{(1 - t_1)R - (1 + \rho)(I + O)}{(1 + \rho + t_2)\frac{S}{r}\left(1 - \frac{1}{(1+r)^t}\right)} \tag{5}$$

In the above model, the value of discount rate, r, is 8% according to the long-term loan rate of bank. The return rate of investment ρ is the average return rate of investment, because the return rate of investment from each unique marine space user is different. Because the annual return rate of investment is about 10%, we could calculate the value of ρ is 20% using the discount rate 8% in a period of 15 years.

Model (5) can only be used to assess the price of marine spaces as production factors. For those marine spaces used as types that damaged the ecosystem function of marine areas, such as reclamation, quarrying, and waste discharge, other assessing techniques must be developed. A model to estimate the price of marine space used as waste discharge is discussed next.

Assessing the price of marine spaces based on their environmental capacity resources

Marine spaces are important environmental capacity resources. Acceptation and assimilation of waste water is one of the environmental functions of marine spaces. However, if the value of the environmental capacity of marine spaces is ignored in decision making for marine environment management, the marine environment will be further degraded. Imposing charges for the use of marine environmental capacity is an efficient economic instrument to protect the marine environment.

The basic assumption to assess the value (price) of the marine environmental capacity is: the price of marine environmental capacity is equal to consumed marine environmental capacity by discharger times the value of total marine environmental capacity divided by Q where Q is the water capacity of the studied marine spaces (m^3).

Suppose that the volume of discharged waste water is W_p (m^3), the concentration of pollutant of waster water is C_p (mg l^{-1}), the standard concentration for discharge is C_r (mg l^{-1}), and the background concentration of marine spaces is C_o (mg l^{-1}), then the used environmental capacity of the discharger could be explained as:

$$\frac{W_p \times C_p}{(C_T - C_o)}$$

Since there is no trade market for the environmental capacity resources, we use the replacement costs method to assess the value of the capacity in this research. Suppose that the volume of the capacity of the studied sea areas is x_i for pollutant i, and the cost of treating a unit pollutant i is c_i, then the value of the total environmental capacity of studied sea areas is:

$$\sum_{i=1}^{i=n} x_i c_i$$

Then, we could derive the model to assess the price of marine environmental capacity per m^{-2}, P_{ec}:

$$P_{ec} = \frac{W_p \times C_p}{(C_T - C_o)S} \times \sum_{i=1}^{i=n} x_i c_i / Q \qquad (6)$$

where S is the area that the discharger needs to diffuse the waster water, and i (= 1, 2, ... n) is the number of pollutants.

Case study: Xiamen

Located in the southeastern coast of Fujian Province, to the west of the Taiwan Strait, Xiamen covers a land area of 1,565 km^2 and a sea area of 340 km^2. Various human activities are found in Xiamen marine spaces, including aquaculture, shipping and port, tourism, discharge of waste water, infrastructure construction, and land reclamation. Xiamen residents' well-being heavily depends on its surrounding seas for natural resources, goods and services. Unfortunately, marine space challenges, including overexploitation, conflicts of resources use, destruction of marine environment and degradation of habitat are increasingly emerging in Xiamen marine spaces (Hong and Peng, 2002). Unquestionably, one of the fundamental causes behind these issues is that the value of sea areas is ignored or undervalued in marine management. We argue that economic instruments, such as the levy of usage fees of marine spaces, would be a promising solution to optimize the space distribution and resolve the conflicts of marine space use in Xiamen.

In this section, we apply model (5) and (6) to assess the price of different types of marine space use with the data collected from Xiamen. In the following, we first discuss the data sources of our analysis and then we detail the empirical estimation results. The procedures for compiling data and model computation in each sector are also explained.

Data

Since there are large numbers of marine space users in Xiamen, it is impossible to calculate the price of marine space for all users. The data of representative marine space users were investigated and were used to assess the price of different types of marine space use in this research. We assemble data for this study from various sources, including Xiamen municipal government agencies that are in charge of port, fisheries, tourism, environmental protection and statistics. In addition, we collected primary data from industry, sewage treatment plants and institutes. Column 2 of Table 1 lists the complete data sources for each type of marine use in the study.

Results

By inputting above data into Model (5) and Model (6), we could assess the prices of different types of marine space use. The last column of Table 1 shows the results.

Table 1. Data sources and estimation results

Sea areas use types	Data sources		Estimation results (yuan m^{-2} y^{-1})
Aquaculture			
Cage culture	Xiamen Statistics Bureau, 1992–2002, Aquatics Research Institute, 2004, Xiamen Marine and Fisheries Bureau		3.2
Hanging culture			0.04
Shoal culture			0.03
Port	China 4th navigational fairs Reconnaissance and Design Institute, 2003, China first navigational fairs Reconnaissance and Design Institute, 2003, Xiamen Port Bureau		4.92
Tourism	Xiamen East coastal tourism company, 1999		3.46
Near sea industry	Fujian Technology Innovation Associate, 1999		2.97
Waste discharge	Volume and Concentration of waste discharge, Diffusing areas	Xiamen Haicang Sewage Treatment Plant, Xiamen Xinglin Sewage Treatment Plant, Xiamen First Sewage Treatment Plant, Xiamen Second Sewage Treatment Plant	1.6
	Standard of discharge and background concentration	Xiamen Environment Protection Bureau	
	Volume of marine environmental Capacity, Volume of water capacity, Costs of pollutant treatment	Chen et al., 1999	

For aquaculture, we applied the data of average benefits and costs of Xiamen aquaculture to estimate the price. We estimated the prices for three categories of aquaculture, 3.27 yuan $m^{-2}y^{-1}$, because the benefits and costs vary within the subcategories.

With regards to the port, the estimated results of two representative users are 5.27 yuan and 4.56 yuan $m^{-2}y^{-1}$ (mean, 4.92 yuan $m^{-2}y^{-1}$).

Although there are a lot of tourism companies using marine spaces, most of them are small scale and have no complete data. Only the data from East Coastal Tourism were complete (Table 1).

Only one near shore industry project, Xiamen Shipbuilding Factory, applies to use marine space. We used the data of this project to assess the price of marine space for the near shore industry.

Moreover, we calculated the price of marine space based on their environmental capacity with the data of four sewage treatment plants listed in Table 1. The result in Table 1 is the average value of these four plants.

With the above results as the basic information, and considering other policy factors, we can establish the usage charge of marine spaces. It must be addressed that in this policy regime, the marine-using activities can not destruct the integrity of the marine ecosystem. For those activities affecting the marine ecosystem, for example, sea reclamation, the user must pay the ecological damage in addition to the usage charge.

Discussion and conclusion

The value of marine space resources has been ignored or undervalued for a long time, which has led to the waste of resources and the destruction of the marine environment. Imposing usage charges for marine spaces on those sectors that use marine spaces for production or for waste disposal is an efficient economic instrument to discourage waste, optimize the distribution, promote conservation and provide funds to improve marine space health. To establish marine space

usage charge would require the estimation of marine space value based on their production factors and environmental capacity. Two models are set up to complete the assessment of the price for different types of marine space use in Xiamen with the data from representative marine space users. Estimating the value of marine space is only the first step to establish the charge for marine space use. Besides the numeric value, the following issues should also be addressed in policy-making in relation to the charges for marine spaces:

The natural and socioeconomic conditions of marine space

Natural conditions and socioeconomic development levels are not uniform and these variants will affect the value of marine spaces. Therefore, we must zone the marine spaces according to their natural status and economic development levels at first, and then assess the price of different marine spaces.

Efficiency of the economy

Besides the value of marine space, the costs of users must be considered to establish the usage charge for marine spaces. Use in excess of the enduring capacity of users will discourage the users and then depress the efficiency of the economy.

Equity

The interests of vulnerable groups should be concerned in policy making. Generally speaking, marine spaces are basic production materials for aquaculture farmers. Their well-being can be easily deteriorated due to levy charges.

The development of the dominating industry

The development of dominating industry will drive the development of the entire economy and improve the locals' well-being and vice versa. Encouraging the development of local leading industry should be one of the principles in establishing the usage charge.

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