Development of Cost Function for Municipal Solid Waste Management in Taiwan

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1. Introduction

Waste accounting system has aroused a lot of attention in recent decades. Except for the goal of waste reduction, a cost-efficient waste management system will be an important target for developing a material-recycling society. It is argued that integrated environmental cost benefit analysis, including waste terms, should be established at financial, environmental and social aspects 3). As a preliminary research on waste accounting system, this study firstly aims at developing a function of administrative operation maintenance cost for municipal solid waste (MSW) in Taiwan, considering the costs associated with the administrative collection, transportation, recycling, treatment and disposal processes for MSW. Influencing factors would be analyzed in the cost function. Secondly, a short-term projection for MSW operation maintenance cost up to 2011 would be conducted by coupling with the Estimation Model System of MSW discards established in the authors’ previous study 3). Possible ranges of the required administrative cost on MSW operation and maintenance would be forecasted based on the assumed scenarios. The estimation flow is represented as Fig. 1. The MSW cost forecasting would be helpful for decision makers in constructing the integrated waste accounting system and in facilitating MSW management policies.

Fig. 1 Estimation flow of projection of required MSW operation maintenance cost.

2. MSW Cost Function

In this study, the cost involving administrative MSW affairs, including collection, transportation, recycling, treatment and disposal by the municipalities is defined as the MSW operation maintenance cost. It encompasses the operation cost, man-power fees and miscellaneous items during the above-mentioned processes, excluded the initial construction cost for treatment and disposal facilities. The general form of waste cost function can be represented as follows:

\[ y = f(x_{m}^T \beta_{m}) + \varepsilon \]  

(1)

where \( y \) denotes the row vector of waste cost variable; \( x_{m} \) is a column vector of explanatory variables related to \( y \); \( f(\cdot) \) is the function of \( x_{m} \) on \( y \); \( \beta_{m} \) is the column vectors of the parameters; \( \varepsilon \) denotes the row vector of the error term. The estimators of parameters (coefficients) would represent the marginal effects of the variables on the explained variable in the equations.

Primarily, MSW management cost comprises of two elements: the initial construction cost and the operation maintenance cost. The initial construction cost of MSW management system may be influenced by the design capacity of MSW treatment and disposal facilities, the types and quantities of MSW, the treatment technology options, etc. 3) On the other hand, the throughput of MSW, represented by the quantity of MSW generation, would be collected and recycled by the municipalities, afterward transported to the intermediate treatment facilities, and disposed at the final disposal sites. Also, the technological level of intermediate treatment facilities would be an influencing factor of the operation maintenance cost of MSW 3). The increasing public environmental consciousness and the MSW policy effects would result in the increasing recycling programs and the reduction of MSW generation, and thus affect the MSW management cost on both the initial construction cost and the operation maintenance cost. However, hardly any studies considered the policy effects in the waste cost functions.

3. Case Study

Taiwan is selected as the study area because the MSW management system has been rapidly developed in recent decades. The treatment technology of MSW discards has altered from landfilling to incineration due to the limited land resources in Taiwan. In order to promote the MSW reduction and efficiency of the incinerators, many MSW policy measures have been executed in the recent two decades. Such transaction of MSW management system brings about the change of MSW management cost. This study aims at developing the operation maintenance cost of MSW for the municipalities using the official environmental statistics from 1989 to 2007 3). It is important to clarify the effects of policy measures, the option of treatment technology and the quantity of throughput of MSW (i.e. MSW generation) on the MSW operation maintenance cost simultaneously. In order to develop a rational MSW cost function, some variables are considered as described in Table 1.

Two cost functions are constructed both in level and log-level terms for the annual total and average operation maintenance cost of MSW. The functions are solved by using the simultaneous equation system approach, so that the endogeneity of them could be accounted for. The estimation results are presented in Table 2. The parameters of the cost functions in log-level formulation are more significant and with rational signs. Thus Model 2 was regarded as the final model.

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The quantitative relationship among the variables defined in Model 2. The operation maintenance cost of MSW is diseconomies of scale with the quantity of MSW generation since the coefficients are positive. The reason may be that the decentralized MSW management system at a prefecture level does not result in an economically efficient management scale. The positive signs for the incineration variables imply that the incineration indeed signifies the total and average operation maintenance cost of MSW. In contrast, the negative signs for recycling variables designate that executing MSW policy measures leads to the decreases on both total and average operation maintenance cost of MSW although some additional budget are required. For the municipalities, the increasing recycling activities would promote the MSW reduction, and thus it reduces the required cost for appropriate treatment and disposal of MSW.

Next, the established MSW operation maintenance cost function is coupled with the Estimation Model System of MSW discards, which considered socioeconomic changes, consumer behavior and MSW policy effects. Rational forecasts of MSW discards were generated under the assumed scenarios (Scenario A: business as usual (2005 as reference); Scenario B: low consumption level; Scenario C: high consumption level) up to 2011\(^2\), and the quantity of MSW generation would be equal to that of MSW discards dividing the recycling rate. Using the projected quantity of MSW discards and assumed recycling rate of MSW generation, the ranges of the required operation maintenance cost for the municipalities could be projected. Fig. 2 presents the estimates and forecasts of the operation maintenance cost of MSW under the three scenarios. It is observed that the total and average operation maintenance cost of MSW would be significantly mounted under the assumed scenarios with optimistic economic development.

4. Conclusion

This study presents a methodology for developing a cost function for MSW management system with regard to collection, transportation, recycling, treatment and disposal processes. Analysis results show that the operation maintenance cost for MSW is diseconomies of scale with the quantity of MSW generation at the financial aspect. The reason may be due to the inefficiency of the decentralized MSW management system. Regional MSW management systems are suggested to improve the current situation on both cost efficiency and capacity planning as argued by Weng et al.\(^2\). Besides, such cost on MSW management would contribute to a large potential environmental benefit on, for example, resource utilization, environmental preservation and mitigation of pollutions associated with MSW treatment and disposal, etc. The environmental benefit should be estimated in the overall waste accounting system at the next stage. Further, the established cost function is coupled with the Estimation Model System of MSW discards developed in the authors’ previous work, and thus the potential ranges of such cost are forecasted up to 2011, with the MSW discards data projected by the previous study. The developed cost function and its forecasts could provide important information for decision makers for further planning of MSW management system.

5. Reference