2-11 Evaluation of the Policy Effect of the Pay-as-You-Throw (PAYT) Systems on Household Solid Waste Reduction and the Potential Environmental Impacts -A Case Study in Taiwan

Yu-Chi Weng[1], Takeshi Fujiwara[1], Sue-Jane Lin[2], and Hwong-Wen Ma[3]

[1]*Solid Waste Management Research Center, Okayama University, Japan*

[2]*Department of Environmental Engineering, National Cheng Kung University, Taiwan, R.O.C.*

[3]*Graduate Institute of Environmental Engineering, National Taiwan University, Taiwan, R.O.C.*

ABSTRACT

On the basis of the "Polluter Pays Principle," several municipalities have charged the waste treatment fee based on the volume of household waste which the citizens discard, i.e. the Pay-as-You-Throw (PAYT) system, to eliminate the quantity of household solid waste (HSW) generation. This study aims to evaluate the policy effects of the PAYT in Taipei City, Taiwan, regarding the fees and the socio-economic attributes. Meanwhile, the mitigation of environmental impacts resulted from HSW reduction would be evaluated. In addition, a questionnaire survey is conducted in Taipei City (with the PAYT) and Tainan City (without the PAYT) to examine the citizens' acceptability in terms of the PATY measure and to investigate the citizens' willingness-to-pay (WTP) for the HSW management services. According to the research outcomes, the optimal charging level is to be discussed for a better HSW generation/discards reduction. Consequently, the administrative and civic concerns and the modeling results of the PAYT policy is concluded by using the SWOT analysis. Concrete proposals for the prospective improvements are made in aid of the modification of current practices.

1. Introduction

In order to achieve the goal of waste reduction, waste charging systems have been attempted to be implemented worldwide based on the "Polluter Pays Principle (PPP)." Several types of Waste charging systems for household solid waste (HSW) have been applied to many regions, e.g., the flat rate system and the container tag fee system. Except for considering the PPP, the waste charging system also aims at facilitating the behavior of waste generators in the context of waste reduction by using economic instruments. Theoretically the total fees would be equal to the administrative costs for MSW management services, regarding both internal and external costs. The waste charging system could aid required financial funds for maintaining HSW management systems and, simultaneously, achieve the goal of waste reduction.

In the early 1980's, the PPP was applied to environmental regulations in Taiwan. For most local municipalities, the waste treatment and disposal fee is charged with respect to the amount of water consumption. Nevertheless, such waste charging system seemed to be failed on waste reduction while not many citizens were aware of their paying for waste treatment and disposal. To deal with such deficiency, in Taiwan the pay-as-you-throw (PAYT) system, charging the fee with respect to the waste volume, has been implemented firstly in Taipei City since July, 2000. Till today, however, only 3 among around 300 municipalities adopt this system for waste charging. In order to modify the waste charging in Taiwan, it is imperative to examine the feasibilities and policy effects of the operating PAYT systems. Therefore, this study firstly aims at analyzing the policy effect of

the PAYT system in Taipei City where sufficient waste data regarding the PAYT is available. Meanwhile, other influencing factors of HSW discards in Taipei City would be exploited so that efficient policy measures for waste reduction could be proposed. Secondly, this study makes an attempt to estimate the environmental impacts, mainly the greenhouse gas (GHG) emission, associated with the HSW reduction. In addition, the possibility of the implementation of the PAYT for other areas is surveyed in this study as well, and Tainan City is selected for the study area. Therefore, thirdly, hearing survey to the governmental officials as well as questionnaire investigation to the citizens will be implemented. The citizens' willingness-to-pay for HSW management services is investigated in Taipei City and Tainan City. The WTP functions at two cities are to be established with regard to the respondents' socio-economic attributes. Consequently, the aforementioned outcomes would be integrated by using the SWOT analysis. The major research flow is shown as the following figure.

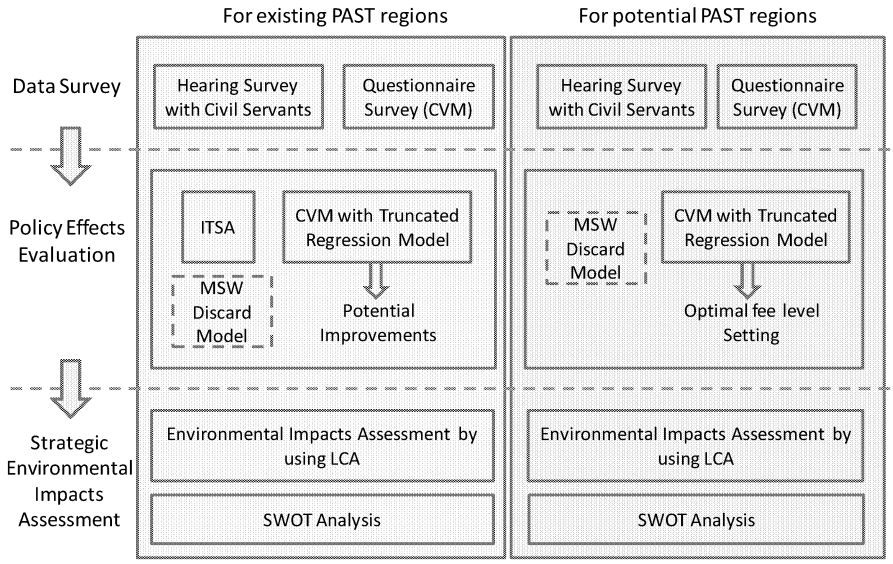

Fig. 1 The research flow of this study.

2. Research Methods

In this study, several quantitative and qualitative methods are attempted to be conducted interestedly. Firstly, the time series analysis modeling will be used in analyzing the reduction effect of the PAYT policy measure.

Time series analysis has been widely applied in system behavior analysis. In particular, the intervention time series analysis (ITSA) is a powerful tool for analyzing the impact of a specific event, e.g., the implementation of a policy measure or an extreme climate episode. Therefore, this study makes an attempt to apply the ITSA model to analyze the waste reduction effect of the PACT system in Taipei City. The general form of an ITSA model could be represented as Eq. (1) (Box et al., 1994).

$$Z_t = \theta_0 + \sum_j \frac{\omega_j(B)B^{b_j}}{\delta(B)} I_{j,t} + \frac{\theta(B)}{\varphi(B)} a_t \tag{1}$$

where Z_t is a random series of interest; θ_0 is the constant; $I_{j,t}$ is the intervention variable (dummy); $\delta(B)$ and $\omega_j(B)B^{b_j}$ are the step impact function and impulse function, respectively; $\varphi(B)$ is the autoregression operator; $\theta(B)$ is the moving average operator; a_t is a white noise.

When performing ITSA, the series of interest have to be transformed or differenced into a stationary one, and, normally, the order of autoregression and moving average could be decided by examining the autocorrelation function (ACF) and the partial autocorrelation function (PACF), respectively. The policy effect of a specific could be defined in a particular manner, a step function or an impulse function for example, and then be examined by the

model. The effect of the PAYT policy will be represented by the coefficient of the policy dummy variable.

In this study, the environmental impact of the HSW discards considers the GHG emission from the treatment and disposal of HSW discards. The estimation is based on the IPCC 2006 manual (IPCC, 2006). In addition, some local parameters are referred to Weng et al. (2009). However, the GHG emission from the collection and transportation process is beyond the research boundary of this study. It would be further estimated in the extension of this study.

Afterward, questionnaire based on the contingent valuation method (CVM) is attempted to investigate the public awareness and their WTP regarding the HSW management services which is reflected by the charging rate of the PAYT policy measure. In principle, the respondents' WTP is assumed as a function of their socio-economic and personal attributes, e.g. the income level, the education level. Also, the public environmental awareness will affect their WTP for HSW management services. Besides, this study tries to use the truncated regression approach to prevent from the invalid bidding. Invalid samples and zero-bidding samples will not be included in the regression analysis (Carson, 2000; Saz-Salazar and Rausell-K¨oster, 2008).

At the end, the overall research outcomes would be integrated by the SWOT analysis. The SWOT analysis that examines the strengths, weaknesses, opportunities and threats of the objective issue in question is applied in this study. With regard to municipal solid waste management (MSWM), the SWOT analysis has been applied to formulate practicable strategies for specific topics (Srivastava et al., 2005; Liu and Matsumoto, 2009). In dealing with multi-stakeholder situations, the SWOT could generate proposals from a wide range of perspectives. Therefore it is a useful tool for analyzing multi-dimension issues. Regarding environmental problems, each aspect of the information must be included to seek for the optimal solutions. The procedure of a normal SWOT analysis is presented in Table 1. In the SWOT analysis, Strength and Weakness analyze the internal factors, which influence the capacity and conditions for development; on the other hand, Opportunity and Threats involves external factors that reflect the conditions of the circumstances.

Table 1. Activity worksheet for SWOT analysis (Srivastava et al., 2005)

Factors		Questions
Internal	Strengths	○ What are the advantages? ○ What can programme do as well? ○ What are the factors supporting the programme?
	Weaknesses	○ What could be improved? ○ What is not done properly? ○ What should be avoided? ○ What obstacles prevent progress? ○ Which elements need strengthening? ○ Where are the complaints coming from? ○ Are there any real weak links in the chain?
External	Opportunities	○ Where are the good chances facing the programme? ○ What are the interesting trends? ○ What benefits may occur? ○ What changes in usual practices and available technology on both a broad and narrow scale may occur? ○ What changes in Government Policy related to MSW Management (as advocacy-campaign) may be possible? ○ What changes in socio-economic patterns, MSWM practices, life-style, economic standards of project beneficiaries may occur?
	Threats	○ What obstacles do programme face? ○ Are the required support and necessary facilities for the programme available? ○ Is the changing technology threatening the programme? ○ Do the stakeholders show their interest and willingness for supporting the programme?

3. The Results and Discussions

In order to examine the policy effects of the PAYT system in Taipei City, the monthly HSW discards data would be analyzed. In this study, the HSW discards is defined as the summation of the waste discharged by the household, the general waste directly transported to the treatment facilities (HSW collected individually), and the general disaster waste while the last term was included in the past statistics of HSW before 2005. Fig. 2 shows the time series of the historical trend of the HSW discards.

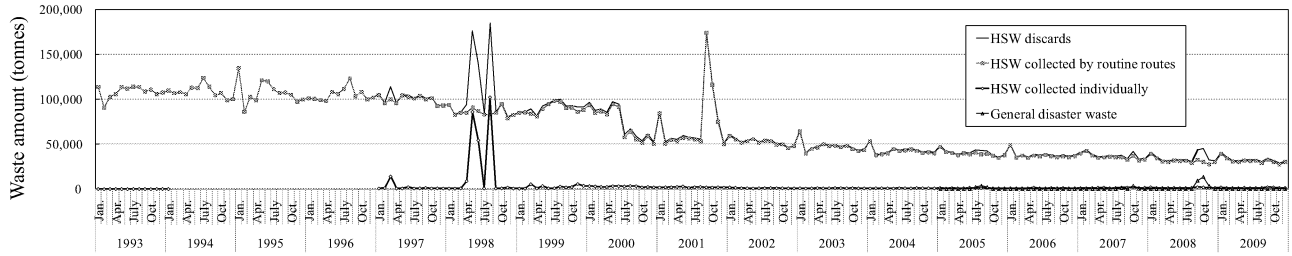

Fig. 2 Historical time series of the monthly HSW amounts in Taipei City: Jan. 1993 – Dec. 2009. (n=204)

Apparently, several large peaks could be observed, majorly reflecting the influences of floods caused by extremely meteorological episodes. Meanwhile, periodical peaks could be found around the traditional Chinese New Year vacations when large housecleaning activities would be held for almost the households in Chinese society. In this sense, the disaster effect and lifestyle factors have to be considered in the development of the ITSA model. Table 2 gives the definitions of variables in this study, and the official data is collected for the model development.[3, 4] The activation of each intervention variable is assumed to impose an impulse impact on HSW discards at the same time period.

Table 2. Descriptions of the variables in the models.

Variable	Description
$HSW_{g,t}$	The quantity of HSW generation in Taipei City in the t –th month (tonnes). (the summation of the waste discharged by the household, the general waste directly transported to the treatment facilities, and the general disaster waste)
$HSW_{d,t}$	The quantity of HSW discards in the t-th month (tonnes). (the amount of HSWg,t minus that of the recycled food waste)
$PAYT_t$	A dummy variable for the PAYT policy; the value is 1 after July 2000 and 0 otherwise.
CNY_t	A dummy variable for the Chinese New Year (CNY); the value is 1 when the CNY occurs in month t and 0 otherwise.
$Rain350_t$	The number of extremely torrential rain (>350 mm per day) event in month t.

Two models for $HSW_{g,t}$ and $HSW_{d,t}$ are developed in this study using the data from Jan. 1993 to Dec. 2009. The estimation is performed by using TSP®5.0. After performing the ACF and the PACF plotting, the first-order differentiating is taken for both the series to confirm the stationarity of the series. The optimal model structures are found, and the parameter estimators are reported in Table 3. The estimators of the two models are statistically significant and efficient according to the model diagnoses. Thereby, the two models could well quantitatively describe the system behaviors of the two series of interest, considering the policy effects, climate conditions and the lifestyle in Taipei City simultaneously.

Table 3. OLS estimations for the ITSA models.

Explanatory variable	Explained variable:	
	Model 1	Model 2
	$\Delta(HSW_{g,t})$	$\Delta(HSW_{d,t})$
$\Delta(HSW_{g,t-1})$	-0.546 (-9.58**)	
$\Delta(HSW_{g,t-2})$	-0.271 (-4.75**)	
$\Delta(HSW_{d,t-1})$		-0.546 (-9.58**)
$\Delta(HSW_{d,t-2})$		-0.270 (-4.74**)
$PAYT_t$	-2234..23 (-1.97*)	-2283.04 (-2.03*)
CNY_t	7379.12 (3.54**)	7383.37 (2.15*)
$Rain350_t$	13382.8 (9.09**)	121753 (9.11**)
LM heter.	1.38	1.38
Durbin-h statistic	-1.33	-1.32
R^2	0.477	0.477

Note: Values in the parentheses denote the *t* statistics; * and ** denote significance at the 10% and 5% levels, respectively.

The coefficients (parameter estimators) of the explanatory variables quantify the impacts of the explanatory variables on the explained ones. From the results of Table 2, several important policy implications could be observed:

● The PAYT system is proved to be efficient in reducing HSW discards in Taipei City, and its policy effects are quantified by the developed models with statistically significances. This would be encouraging for the potential PAYT municipalities. Though similar observations have been indicated by Chao[5], this study provides more significant evidences statistically for the arguments.

● Intensive 3R activities with particular emphases on “reuse” and “recycling” could be promoted during the Chinese New Year periods while usable goods and furniture might be replaced and discarded for New Year decoration and events.

● Efficient plans of natural disasters prevention would prevent HSW reduction to a great extent while flood disaster would result in a great deal of HSW discarding in Taipei City where underground spaces are intensively utilized. In addition, different impacts of the rainfall scales on HSW discards are identified.

From the coefficient of the PAYT policy measure in the Model 1 in Table 3, the HSW reduction effect of the PAYT policy is around 27,936.48 tonnes per year. Afterward, the reduced HSW discards is assumed to eliminate the GHG emission from waste incineration process. Mainly the HSW discards in Taipei City is treated by incineration. Therefore, the IPCC 2006 Manual is applied for the GHG estimation from waste incineration. As mentioned in Section 2, some required domestic parameters are set up according to Weng et al. (2009). In addition, the impact of the electricity generation from waste incineration on GHG emission is not considered yet. The estimation results are shown in Table 4.

Table 4. The reduction of GHG emission due to the PAYT policy effect in Taipei City.

Incineration	CO_2					CH_4	N_2O
total (Gg CO_2-eq./yr)	total (Gg/yr)	Paper (Gg/yr)	Plastics (Gg/yr)	Leather (Gg/yr)	Textile (Gg/yr)	(Gg CO_2-eq./yr)	(Gg CO_2-eq./yr)
8.85	8.47	0.064	8.39	0.005	0.01	0.0001	0.38

At the next step, a CVM survey is to investigate the WTA for HSW services and to seek for the optimal charging level. The total costs for HSW services are declared in the questionnaire from both the internal financial and external environmental perspectives. Regarding the investigation way, we think that more rational results would be obtained by post mails than by telephone interviews because the respondents can have sufficient time to make the responses (Whittington et al., 1992). The survey is conducted by 1,000 post mails in Taipei City and Tainan City, respectively. The questionnaires are distributed and recovered during 14-27, Dec. 2010. Spatially random sampling is performed with regard to the population weight among the administrative wards.

Consequently, the respondent ratio is 10.4% in Taipei City, and 7.2% in Tainan City. In fact, the respondent ratios are small, and there are some potential influencing factors lowering the ratios:

(1) PAYT as a debate in the mayor election of Taipei City

The candidates hold opposite opinions on the PAYT in the mayor election last November. In order not to be influenced by the election, the questionnaire survey was postponed to some extent. However, it seems that some citizens may reject the politically sensitive investigation in this period.

(2) Doubt on mail fraud

In fact, some questionnaire receivers may criticize that if the questionnaire is a mail fraud or a CM because it is quite popular in Taiwan.

(3) Christmas season

In order to eliminate the political influences, the questionnaire survey is postponed. Therefore, the survey period is quite close to the Christmas card season so that the questionnaire receivers may neglect the replying.

Regarding the rationality of the PAYT, as shown in Fig. 3, both the respondents in Taipei and Tainan Cities agree with that charging the fee by waste volume is fairer than by other bases. However, few respondents think it would be convenient for charging by water or electricity utilization, though unreasonable.

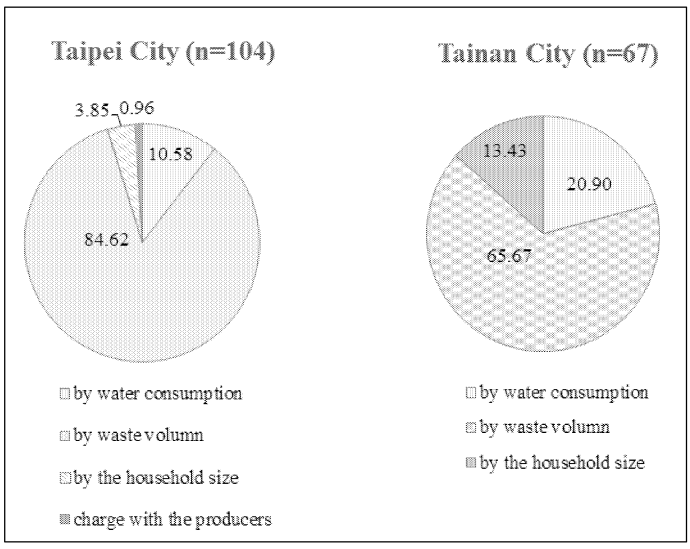

Fig. 3 The public opinion on the charging bases.

Though 65.27 % of the respondents in Tainan City approve that PAYT is rational, the opinions for the feasibility of the implementation of PAYT in Tainan City is quite contrary: around 45.6 % of the respondents think PAYT is feasible, while 28 %, infeasible (see Fig. 4). The reason may be that the respondents think the citizens are

not willing to change the current pattern of waste charging system. Still, the local municipality could account for the installation of PAYT since the waste reduction effect of the PAYT in Taipei City is proved to be significant in the established ITSA model in this study.

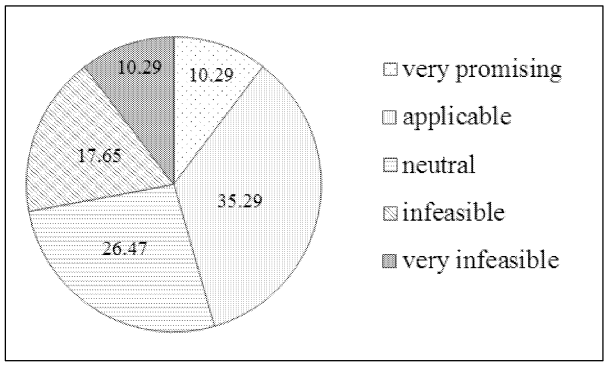

Fig.4 The public opinion on the feasibility for implementing PAYT in Tainan City (n=68) (where PAYT system is not introduced now)

Also, the questionnaire makes an attempt to ask the respondents if they know how much the fee level is or not, before bidding for the potential external costs. As shown in Fig. 5, in fact, more than 50 % of the respondents in both cities do not know precisely about the fee level of the current charging systems, leading to the uncertainty of the CVM results. Actually, when CVM is conducted, there would be a technical limitation that people are difficult to evaluate their WTP unless they are well realized the environmental impacts and the associated cost/benefit items.

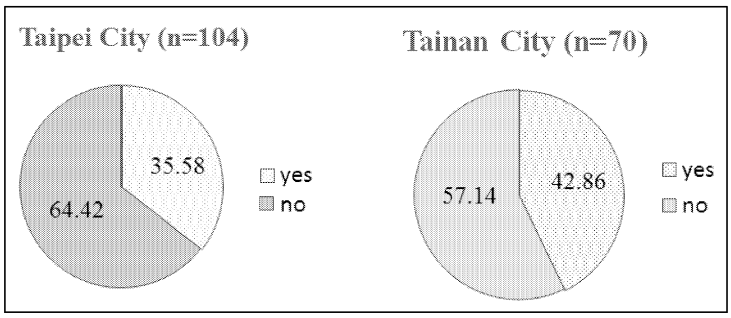

Fig. 5 The public awareness on the current fee level: Do they know how much they pay?

After informing the respondents about the current fee levels, the majority of the respondents express that the current fee levels are adequate in both cities, as shown in Fig. 6. However, the results indicate that around 20 % of the respondents argue that the fee should not be levied, indicating that the PPP is rejected by a portion of citizens. Those respondents think that the government should not charge the waste treatment/disposal because they claim that the municipalities should take all the responsibility tackling waste problems. Such result implies that the PPP for the citizens should be further discussed and clarified. The responsibility for the waste generators at the household side should be further emphasized. Still, the majority of the respondents approve that the household waste generators should take this responsibility, and the economic instruments could play positive roles in HSW reduction.

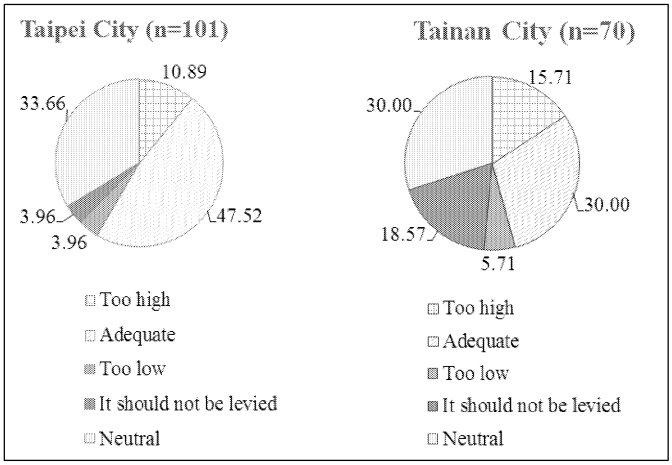

Fig. 6 The public opinions on the fee levels.

Subsequently, in order to integrate the aforementioned outcomes, the SWOT analysis of the PAYT in Taiwan is conducted, and the results are presented in Table 5.

Table 5. The SWOT analysis of the PAYT policy measure.

Category		Influencing Factors
Internal	Strengths	□ The PAYT system is proved to be effective in HSW reduction in the case study of Taipei City, and thus the related environmental burdens would be eliminated. □ The policy arouses the public concern on waste management issues effectively and thus the environmental awareness is promoted rapidly.
	Weaknesses	○ Frequent inspection is required for the policy implementation. ○ Much more waste separation at sources is expected. ○ Trans-county waste discarding, even illegal dumping, might be occur. ○ The inconvenience of the PAYT is argued. ○ The manpower of municipalities for the promotion of PAYT seems to be insufficient. ○ Some citizens argue that the collection bags would contribute to the waste generation to some extent.
External	Opportunities	▸ Lots of recycling activities with the PAYT would promote the recycling/reuse industry.
	Threats	△ Fake collection bags might appear in the market. △ The PPP is not well accepted by a part of citizen. (The clarification of responsibility)

4. Conclusion

In order to modifying the waste charging systems in Taiwan, this study applies an ITSA model for HSW discards in Taipei City, considering the policy effects, climate conditions and the lifestyle, simultaneously. Based on the PPP, the PACT system is proved to be efficient in waste reduction in the case study of Taipei City. However, more evidences should be found in other operating PACT systems in Taiwan given that sufficient data is available. In addition, such methodology is proved to be useful to analyze the mechanisms of HSW discards in a highly

developed metropolitan area. The outcomes of this study could aid decision makers for further planning of the waste charging systems in Taiwan. Nevertheless, the consumption is excluded in the modeling due to the deficiency of monthly consumption data. A more holistic ITSA model could be established with that data. In addition, the optimal fee level for PACT systems should be further studied at the next stage.

Regarding the implications and the future extensions and of this study, firstly, the research outcomes suggest that HSW management is associated with the development of infrastructure, regarding, flooding mitigation for example. The CVM is difficult to be implemented given that the public is well informed by the required in-depth knowledge, but it could serve as an education tool as well in the survey process. In addition, the detailed internal and external cost/benefit items should be further studied. Besides, the future research will focus on the related life cycle assessment and uncertainty analysis.

5. Reference

Bilitewski, B., From traditional to modern fee systems, *Waste Manag., 28* (*12*), 2760-2766 (2008).

Box, G. E. P., Jenkins, G. M. and G. C. Reinsel, *Time Series Analysis: Forecasting and Control*, Prentice Hall, Englewood Cliffs, *NJ* (1994).

Carson, R.T., Contingent valuation: a user's guide, *Environ. Sci. Technol*. *34* (*8*), 1413-1418 (2000).

Central Climate Bureau, R.O.C., Online Meteorological Database, (2010). Available from: < http://www.cwb.gov.tw/> (in Chinese)

Chao, C. L., Time series analysis of the effects of refuse collection on recycling: Taiwan's "Keep Trash Off the Ground" measure, *Waste Manag*., *28* (*5*), 859-869 (2008).

Department of Environmental Protection, Taipei City Government, Online database of Monthly Environmental Statistics in Taipei City (2010). Available from: < http://www.epb.taipei.gov.tw/report/bulletin.aspx> (in Chinese)

IPCC, IPCC Guidelines for National Greenhouse Gas Inventories Volume 5 Waste (2006). Available from: <http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol5.htm>.

Liu, J. and T. Matsumoto, SWOT Analysis for discussion of success factors and obstacles on Eco-industrial Park Projects in several Asian countries, *J Global Environ. Eng.*, *14*, 27-36 (2009).

Saz-Salazar, S. D. and P. Rausell-K¨oster, A Double-Hurdle model of urban green areas valuation: Dealing with zero responses, *Land. Urban Plan.*, *84* (*3-4*), 241-251 (2008).

Srivastava, P. K., Kulshreshtha, K., Mohanty, C. S., Pushpangadan, P. and A. Singh , Stakeholder-based SWOT analysis for successful municipal solid waste management in Lucknow, India, *Waste Manag.*, *25* (*5*), 531-537 (2005).

Whittington, D., Smith, V. K., Okorafor, A., Okore, A., Lui, J.-L., Giving respondents time to think in contingent valuation studies: a developing country application. *J Environ. Econ. Manag.*, *22* (*3*), 205-225 (1992).

Weng, Y. C., Fujiwara, T. and Y. Matsuoka, Estimation of greenhouse gas emission from the treatment and disposal of municipal solid waste and its policy implication: A Taiwan case study, *J Global Environ. Eng.*, *14*, 47-55 (2009).