

# **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<sup>1)</sup>, Takeshi Fujiwara<sup>2)</sup>, Sue-Jane Lin<sup>3)</sup>, Hwong-Wen Ma<sup>4)</sup>

*1) Division of Environmental Engineering, Faculty of Engineering, Hokkaido University, Japan*

*2) Waste Management Research Center, Okayama University, Japan*

*3) Department of Environmental Engineering, National Cheng Kung University, Taiwan, R.O.C.*

*4) Graduate Institute of Environmental Engineering, National Taiwan University, Taiwan, R.O.C.*

## **ABSTRACT**

In accordance with the “Polluter Pays Principle,” many municipalities have charged citizens a waste treatment fee based on the quantity of waste. The waste charging system is designed to reduce the amount of household solid waste (HSW) generated. This study aimed to evaluate the policy effects of the waste charging systems in several municipalities in Taiwan, particularly with regard to the fees and the socio-economic attributes in different regions. Consequently, the research outcomes exploited the future policy direction for HSW reduction. In the meantime, the mitigation of environmental impacts resulted from HSW reduction was evaluated.

## **KEYWORDS**

Household Solid Waste Reduction, Waste Charging System, Policy Effect, Environmental Consciousness

## **INTRODUCTION**

Insufficient and inadequate treatment/disposal of household solid waste (HSW) is a critical urban environmental problem and may bring about critical environmental pollution. The control of HSW generation is of great importance among the urban environmental management issues. HSW generation is expected to be eliminated by a series of economic instruments in line with the “Polluter Pays Principle (PPP).” For this reason, the charging on the HSW generators for waste treatment and disposal has been implemented in many countries (Chao, 2008; Reichenbach, 2008; Sakai et al., 2008; Weng and Fujiwara, 2010). Several types of waste charging systems for household solid waste (HSW) have been applied, e.g., the flat rate system and the container tag fee system (Bilitewski, 2008). In addition to the consideration of the PPP, the waste charging system aims at facilitating the behavior of waste generators in the context of waste reduction by using economic instruments. Conventionally the total fees would be equal to the administrative costs for MSW management services, mainly internal costs. The waste charging system could aid required financial funds for maintaining HSW management systems and achieve the goal of waste reduction.

In the early 1980’s, the PPP was applied to environmental regulations in Taiwan (Weng et al., 2009). 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 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 around 30 among near 320 municipalities have adopted this system for waste charging, and most of them just implemented PAYT since 2010. In order to promote and facilitate the waste

charging in Taiwan, it is imperative to examine the feasibilities and policy effects of the operating PAYT systems. By using the intervention time series analysis model, the implementation of PAYT in Taipei City has been proved to reduce the HSW generation apparently (Chao, 2008; Weng and Fujiwara, 2010). While the PAYT charges the amount of HSW treatment and disposal, the measure also provides economic incentives on the HSW separation during the collection process and, thus, the citizens' environmental consciousness are improved to some extent.

PAYT is expected to be applied to other regions in Taiwan, in substitution of the other waste charging systems, while its acceptability by citizens is still in question. By conducting questionnaire surveys to the citizens, based on the contingent valuation method (CVM), in two cities where different waste charging systems are launched, the first objective of this study was to know the citizens' attitude about the feasible style of current waste charging systems in Taiwan. The conventional fee level of PAYT mainly accounts for the internal costs, and thus the overall costs may be underestimated. Nevertheless, recently, the external costs are argued to be taken into consideration so that the overall impacts associated with waste management could be concerned (Weng and Fujiwara, 2011). The willingness-to-pay (WTP) functions for HSW management WTP functions at two cities are to be established with regard to the respondents' socio-economic attributes. Afterward, the environmental impacts, mainly the greenhouse gas (GHG) emission, associated with the HSW reduction in Taipei city would be estimated. Consequently the aforementioned outcomes would be integrated by using the SWOT analysis. The major research flow is shown as the following figure.

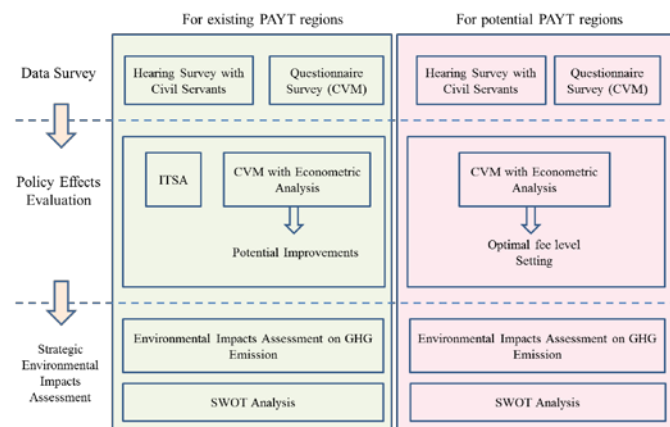


Fig. 1 The research flow of this study.

## 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 (Box et al., 1994). Therefore, this study makes an attempt to apply the ITSA model to analyze the waste reduction effect of the PAYT system in Taipei city. When performing ITSA, the series of interest have to be transformed or differenced into a stationary one, and 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.

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-Köster, 2008).

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.

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). 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.

## RESULTS AND DISCUSSION

### 1. The ITSA Modeling

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. Examining the data, the influences of floods caused by extremely meteorological episodes and the periodical peaks around the traditional Chinese New Year vacations would be considered in the ITSA modeling. In this sense, the disaster effect and lifestyle factors have to be considered in the development of the ITSA model. Table 1 gives the definitions of variables in this study, and the official data is collected for the model development. The activation of each intervention variable is assumed to impose an impulse impact on HSW discards at the same time period.

Table 1. 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 $HSW_{g,t}$ 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<sup>®</sup>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 as follows. 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. Using the consistent data from the questionnaire survey, two WTP functions were established for the case study areas. The modeling results are shown as follows:

- For monthly HSW generation in Taipei city

$$\Delta(HSW_{g,t}) = -0.546 \times \Delta(HSW_{g,t-1}) - 0.271 \times \Delta(HSW_{g,t-2}) - 2234.23 \times PAYT_t + 7379.12 \times CNY_t + 13382.8 \times Rian350_t$$

(-9.58\*\*)
(-4.75\*\*)
(-1.97)
(3.54\*\*)
(9.09\*\*)

$$Adjusted R^2 = 0.477; LM\ heter. = 1.38; Durbin-h\ statistic = -1.33; 204\ Observations$$

where values in the parentheses denote the t statistics; \* and \*\* denote significance at the 10% and 5% levels, respectively.

- For monthly HSW discards in Taipei city

$$\Delta(HSW_{d,t}) = -0.546 \times \Delta(HSW_{d,t-1}) - 0.270 \times \Delta(HSW_{d,t-2}) - 2283.04 \times PAYT_t + 7383.37 \times CNY_t + 12175.3 \times Rian350_t$$

(-9.58\*\*)
(-4.74\*\*)
(-2.03\*)
(2.15\*)
(9.11\*\*)

*Adjusted R*<sup>2</sup> = 0.477; *LM heter.* = 1.38; Durbin-h statistic = -1.32; 204 Observations

The coefficients (parameter estimators) of the explanatory variables quantify the impacts of the explanatory variables on the explained ones. From the previous results, 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 statistical significances. This would be encouraging for the potential PAYT municipalities. Though similar observations have been indicated by Chao (2008), 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.

## 2. WTP Function

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, 84.62 % of 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. In addition, 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. 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.

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. Furthermore, 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.

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. 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.

Using the consistent data from the questionnaire survey, two WTP functions were established for the case study areas. The modeling results are shown as follows:

● Taipei City

$$WTP_{Taipei,i} = 0.085 \times Income_i + 0.110 \times Educ_i + 0.287 \times EXCCon_i \quad \forall WTP_{Taipei,i} \geq 0.45$$

(2.19\*\*)                      (1.99\*)                      (3.03\*\*\*)

$R^2 = 0.877$ ;  $F = 102.37^{***}$ ;  $BP = 4.22^{**}$ ;  $DW = 0.68$ ; 46 valid observations

● Tainan City

$$WTP_{Tainan,i} = 0.078 \times Income_i + 0.923 \times Educ_i + 2.984 \times EXCCon_i \quad \forall WTP_{Tainan,i} \geq 3.5$$

(0.34)                      (2.56\*\*)                      (3.93\*\*\*)

Adjusted  $R^2 = 0.939$ ;  $F = 118.79^{***}$ ;  $BP = 1.37$ ;  $DW = 1.26$ ; 23 valid observations

where  $WTP_{Taipei,i}$  denotes the WTP value for the respondent  $i$  in Taipei City (New Taiwan Dollar (NT\$) at 2010 prices per liter HSW);

$WTP_{Tainan,i}$  is the WTP value for the respondent  $i$  in Tainan City (NT\$ at 2010 prices per 1m<sup>3</sup> water consumption);

$Income_i$  denotes the respondent  $i$ 's household monthly income level (0: 0~20,000 NT\$ at 2010 prices; 1: 20,000~30,000 NT\$ at 2010 prices; 2: 30,000~50,000 NT\$ at 2010 prices; 3: 50,000~100,000 NT\$ at 2010 prices; 4: > 100,000 NT\$ at 2010 prices);

$Educ_i$  represents the respondent  $i$ 's education level (0: lower than high-school level; 1: high-school level; 2: undergraduate level; 3: graduate level);

$EXCCon_i$  is the degree that the respondent  $i$  agree with the payment for the potential external (environmental) cost associated with HSW management (1: favor / very favor; 0: neutral / disfavor);

values in the parentheses denote the  $t$  value;

\*, \*\* and \*\*\* denote significance at the 10%, 5% and 1% levels, respectively.

In the model development, the WTP threshold values were set as the current fee levels of the two cities while the most valid samples approve the current fee level in which only the internal financial costs are considered. Thus, the influences of the respondent's personal attributes on the fee level regarding both internal and external costs could be identified in the functions. According to the modeling outcomes, significant and positive parameter estimates indicate that the respondent's household income level, personal education level and his/her acceptance for paying the HSW management costs that account for the financial and environmental costs, i.e. the "real" costs, would be influencing factors of their WTP for HSW management services. The increase of the income level, education level and the enhancement of the public acceptance of the payment of environmental costs are associated with the increase of the WTP bidding. Still, detailed cost structure information of HSW management should be provided in the questionnaire so that the respondents could give a rational WTP value.

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 2.

Table 2. The reduction of GHG emission due to the PAYT policy effect in Taipei city.

Incineration	CO <sub>2</sub>					CH <sub>4</sub> (Gg CO <sub>2</sub> -eq./yr)	N <sub>2</sub> O (Gg CO <sub>2</sub> -eq./yr)
	total	Paper	Plastics	Leather	Textile		
(Gg CO <sub>2</sub> -eq./yr)	(Gg/yr)	(Gg/yr)	(Gg/yr)	(Gg/yr)	(Gg/yr)		
8.85	8.47	0.064	8.39	0.005	0.01	0.0001	0.38

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 3.

Table 3. The SWOT analysis of the PAYT policy measure.

Category		Influencing Factors
Internal	Strengths	<ul style="list-style-type: none"> <li>□ 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.</li> <li>□ The policy arouses the public concern on waste management issues effectively and thus the environmental awareness is promoted rapidly.</li> </ul>
	Weaknesses	<ul style="list-style-type: none"> <li>○ Frequent inspection is required for the policy implementation.</li> <li>○ Much more waste separation at sources is expected.</li> <li>○ Trans-county waste discarding, even illegal dumping, might be occur.</li> <li>○ The inconvenience of the PAYT is argued.</li> <li>○ The manpower of municipalities for the promotion of PAYT seems to be insufficient.</li> <li>○ Some citizens argue that the collection bags would contribute to the waste generation to some extent.</li> </ul>
External	Opportunities	<ul style="list-style-type: none"> <li>□ Lots of recycling activities with the PAYT would promote the recycling/reuse industry.</li> </ul>
	Threats	<ul style="list-style-type: none"> <li>△ Fake collection bags might appear in the market.</li> <li>△ The PPP is not well accepted by a part of citizen. (The clarification of responsibility)</li> </ul>

## SUMMARY AND FINAL REMARKS

In order to modify the waste charging systems in Taiwan, this study firstly 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 PAYT system is proved to be efficient in waste reduction in the case study of Taipei city. In addition, the WTPS functions were established by using the truncated regression method. The optimal fee level for PAYT systems could be further studied at the next stage. The 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. Consequently the outcomes of this study indicate that the PAYT would be an efficient policy measure on the reduction of HSW discards and the associated GHG emission. With regard to the benefit of PAYT, PAYT could be applied to other metropolitan areas and other developing countries.

## REFERENCES

- 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>>.
- Saz-Salazar, S. D. and P. Rausell-Koster, 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).
- Weng, Y. C. and Fujiwara, T., Examining the Effectiveness of Municipal Solid Waste Management Systems: An Integrated Cost-Benefit Analysis Perspective with a Financial Cost Modeling in Taiwan, *Waste Manag.*, 31, 1393-1406 (2011).

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

Yu-Chi Weng <sup>○</sup>, Takeshi Fujiwara, Sue-Jane Lin, Hwong-Wen Ma

2013.02.02

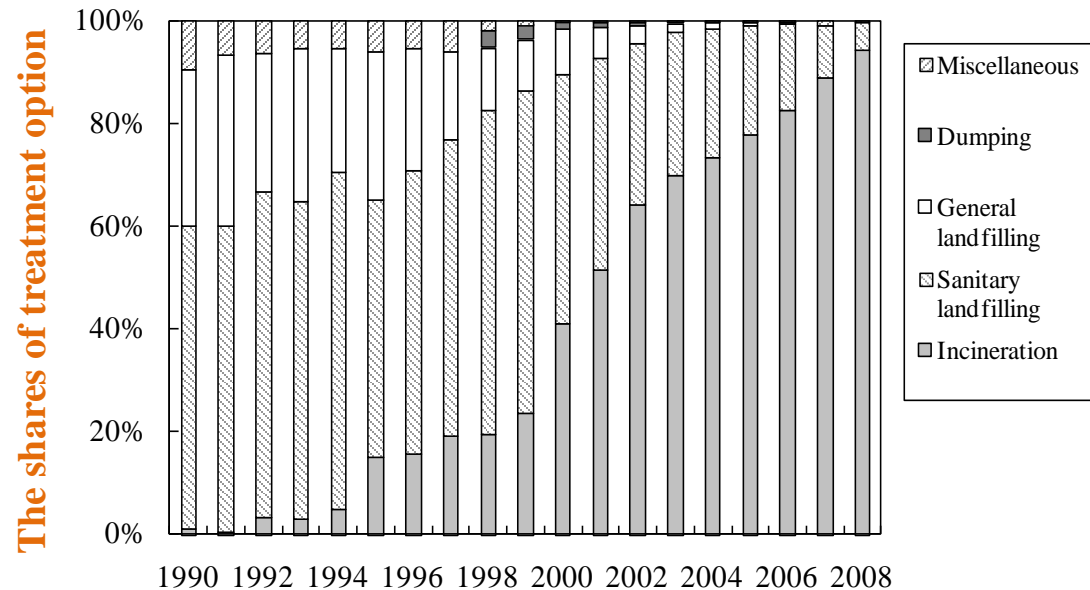
# Main Contents

- Background
- Research Objectives
- Research Methods
- Research Outcomes
- Final Remarks



# Background

- The main waste treatment technology is incineration due to the limited land resources.



- Still, since the 1990's, the **3Rs activities** have been implemented to establish a “**zero-disposal**” society.

# HSW Management Implementation in Taiwan

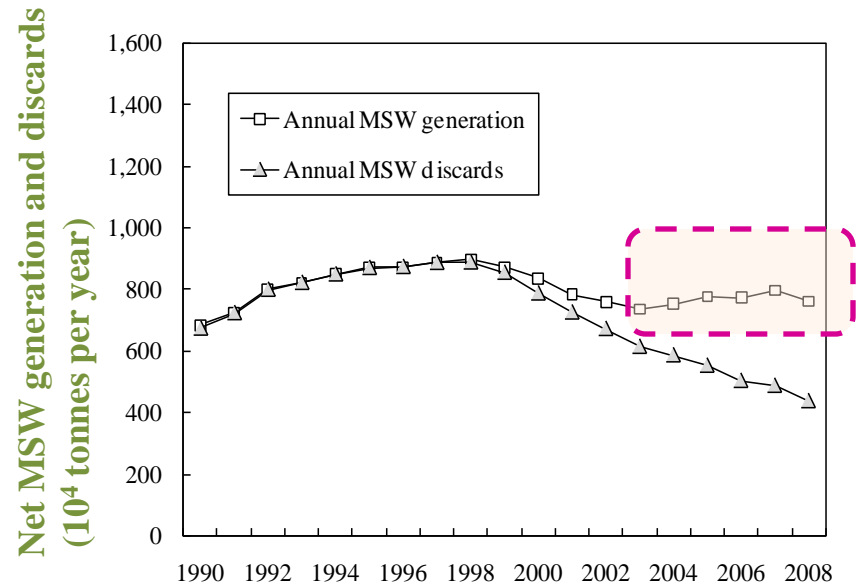
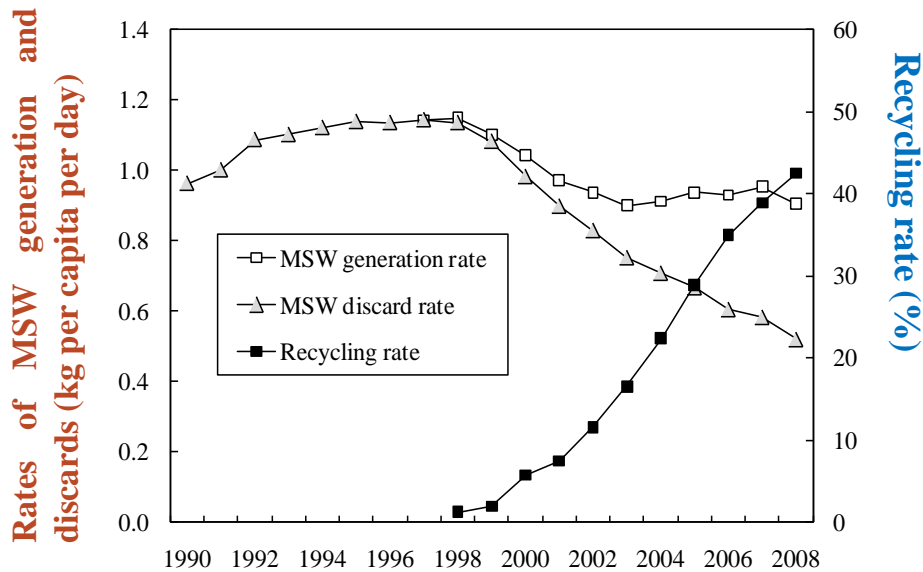
## Keep Trash off the Ground



## PAYT charging by the collection bags



# Historical Trend of the Municipal Solid Waste (MSW) Generation, Discards and Recycling Rate in Taiwan: 1990-2008



- Most of the HSW service costs are supported by the governments.
- PPP does not play an important role in the current MSW management systems.

# The Implementation of PAYT Systems of HSW

- The Pay-as-You-Throw (PAYT) system, charging waste generators with his/her waste volume, based on the “**polluter pays principle (PPP)**”.
- It aims at facilitating the behavior of waste generators 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 PAYT is getting popular **worldwide** and **proved efficient** in waste reduction, particularly in Japan (more than 50% municipalities).

# The Implementation of PAYT of HSW in Taiwan

- In Taiwan, the revision of Waste Clean-up Act issued the **PPP** in 1991.
- Conventionally, in Taiwan, the MSW service fees is charged based on water consumption upon the administrative conveniences.
- Since 2000, only **18** among 319 municipalities attempt to change the counting basis by the waste volume, including **Taipei City**, 16 cities in **Taipei Prefecture** (**9 starts since last July**), and one city (Sheng-Gane Township) in **Taichung Prefecture**.

# Research Objective

- The study firstly aims to establish a methodology to find an adequate management approach for controlling the MSW generation by using the PAYT system.
- The **optimal fee level** is to be exploited for achieving efficient MSW reduction.
- The **policy effect** and the associated **environmental impacts** are to be analyzed.

# Research Methods

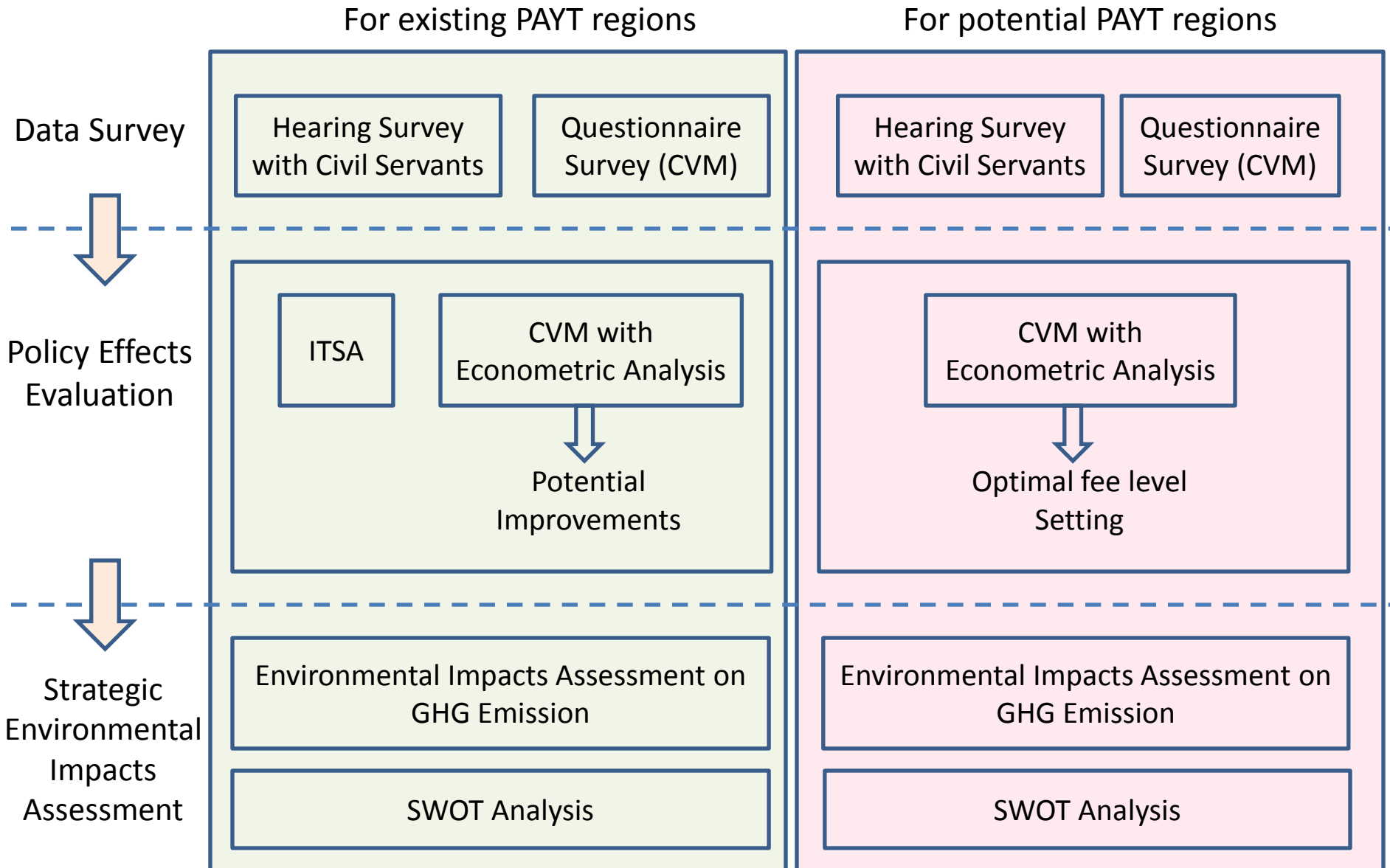
- **Data Collection**

- Hearing Survey with the local civil servants
- Questionnaire for the citizens for investigating their willingness to pay (WTP) in terms of the HSW management fee

- **Data Analysis**

- Intervention Time Series Analysis (ITSA)
- HSW Policy Assessment on GHG Emission
- Contingent Valuation Method (CVM) with Econometric Analysis
- SWOT (the **s**trengths, the **w**eaknesses, the **o**pportunities, and the **t**hreats ) Analysis

# Research Flow



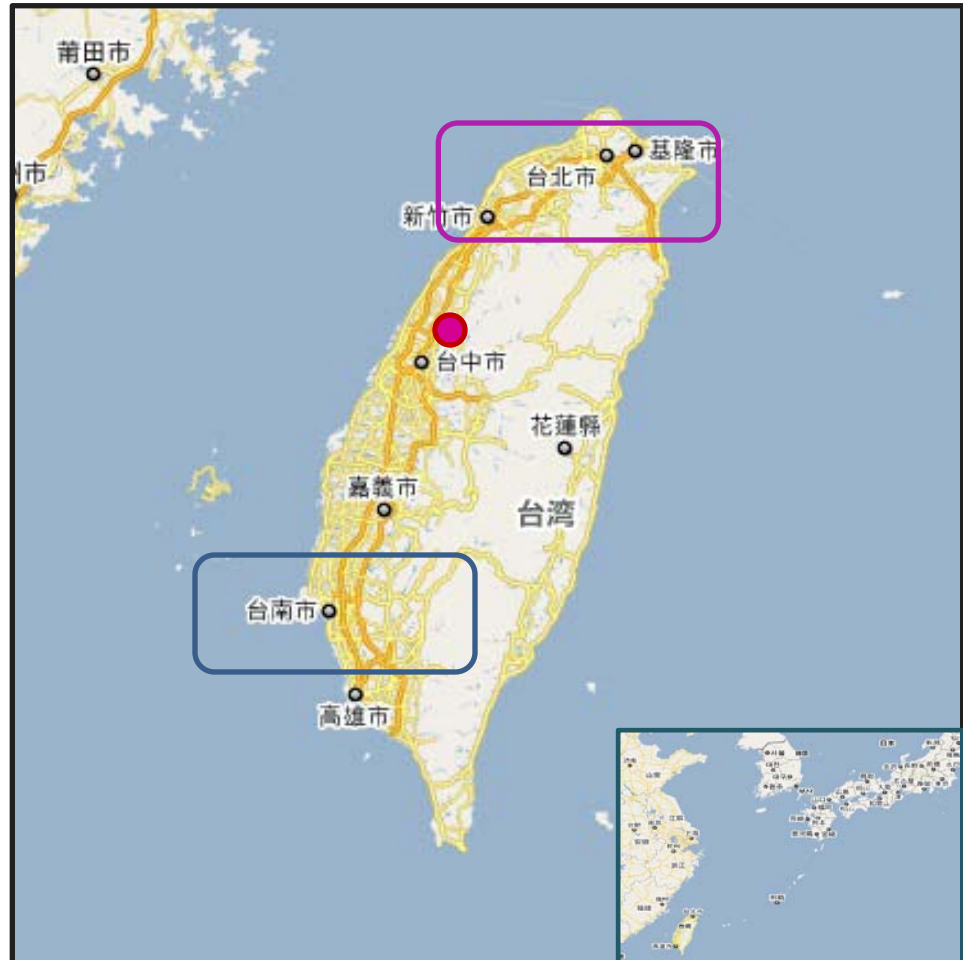


# The Research Outcomes

- Collaboration Networks in Taiwan
- Case Study in Taipei and Tainan city
  - ✓ The ITSA Modeling
  - ✓ The Hearing Survey
  - ✓ The CVM Survey with Econometric Analysis

# Case Study Area

- Mainly, Taipei City (where PAYT is installed) and Tainan City (without PAYT) would be selected as the case study area.
- Other cities with PAYT would be analyzed as well.



# A. Collaboration Networks

- As consultants, **Prof. Sue-Jane Lin** (National Cheng Kung University) and **Prof. Hwong-Wen Ma** (National Taiwan University) would join our research, involving the policy evaluation and LCA studies.

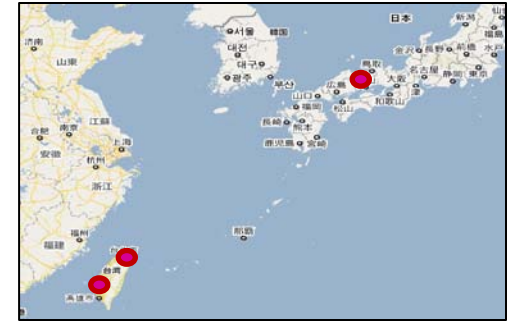


Source: Google map, 2010.



## A. Collaboration Networks (II)

- The civil servants of Taipei City, Taipei County and Tainan City provide lots of practical opinions to the research group.
- Field trips of the MSW collection process and disposal sites were conducted in the first year study.



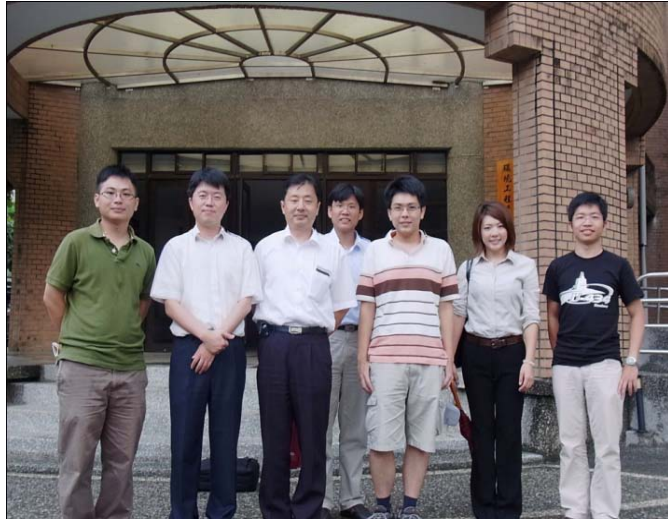
Source: Google map, 2010.



An operating landfill that tackle disaster waste in Taipei City, Taiwan.

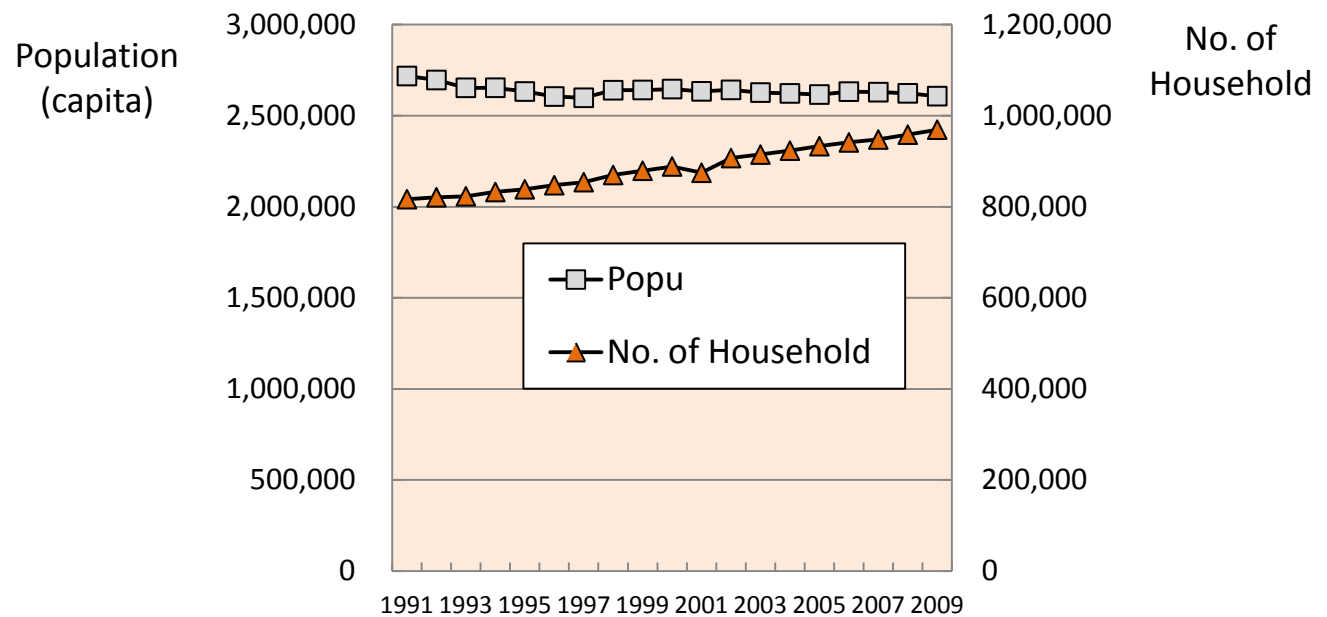
Cultural landscape in a remediated landfill in Taipei City, Taiwan.

# Project Meeting with Research Partners



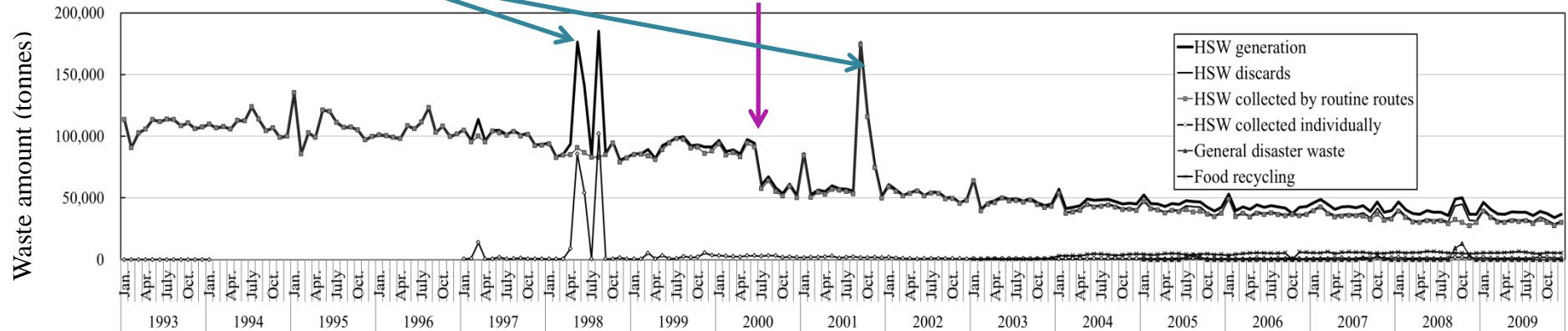
## B. An ITSA Modeling in Taipei City (I) - Basic Information

- Area: 271.80 km<sup>2</sup>;
- Population density: 9,593 capita/km<sup>2</sup>;
- Rainfall: 1669.2 mm/yr;
- Average temp.: 23.4 °C.

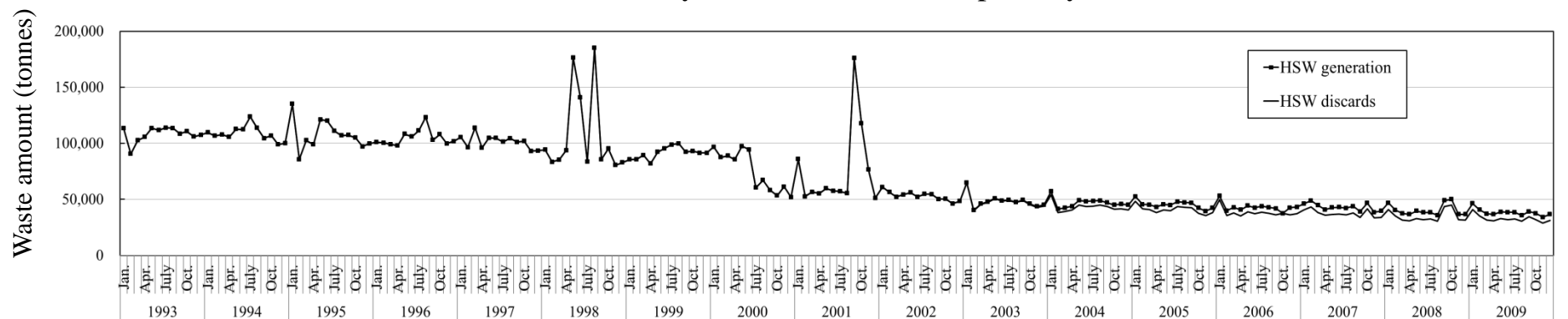


## B. An ITSA Modeling in Taipei City (II) - Monthly Time Series Data for the HSW amounts

Influences of Typhoons    The PAYT Policy  
Activation



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



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

## B. An ITSA Modeling in Taipei City (III)

- By examining the monthly data in Taipei City, three influential factors are considered: (1) the policy effects; (2) the climate episodes; (3) the lifestyle.
- The general formulation of the ITSA could be presented as the following equation:

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

where  $Z_t$  is a random series of interest;  $\theta_0$  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.



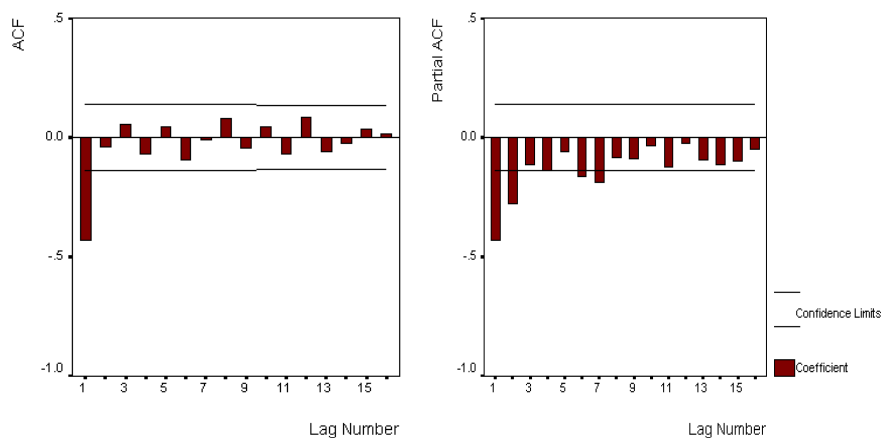
## B. An ITSA Modeling in Taipei City (IV)- Descriptions of the variables

Variable	Description
$HSW_{g,t}$	The quantity of <u>HSW generation</u> 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 <u>HSW discards</u> in the $t$ -th month (tonnes). (the amount of $HSW_{g,t}$ 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 the $t$ -th month, and 0, otherwise.
$Rain350_t$	The number of extremely torrential rain (>350 mm per day) event in the $t$ -th month.

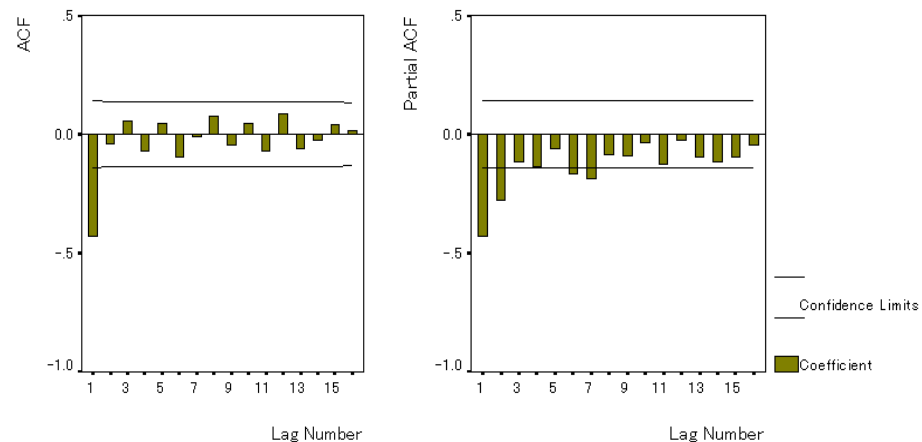
## B. An ITSA Modeling in Taipei City (VII)- ACF and PACF Analysis for the First-order Differenced HSW Series

- To deal with the heteroskedasticity for the error term in the previous ITSA model, the first-order difference is taken for the two series.

$d(HSW_{g,t})$



$d(HSW_{d,t})$



## B. An ITSA Modeling in Taipei City (VIII)- The OLS Results of the First-order Differentiated Series

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 <sup>**</sup> )	
$\Delta(HSW_{g,t-2})$	-0.271 (-4.75 <sup>**</sup> )	
$\Delta(HSW_{d,t-1})$		-0.546 (-9.58 <sup>**</sup> )
$\Delta(HSW_{d,t-2})$		-0.270 (-4.74 <sup>**</sup> )
$PAYT_t$	-2234.23 (-1.97 <sup>**</sup> )	-2283.04 (-2.03 <sup>**</sup> )
$CNY_t$	7379.12 (3.54 <sup>**</sup> )	7383.37 (2.15 <sup>**</sup> )
$Rain350_t$	13382.8 (9.09 <sup>**</sup> )	121753 (9.11 <sup>**</sup> )
LM heter.	1.38	1.38
Durbin-h statistic	-1.33	-1.32
$R^2$	0.477	0.477

**Note:** (1) Values in the parentheses denote the  $t$  statistics;  
 (2) \* and \*\* denote significance at the 10% and 5% levels, respectively.

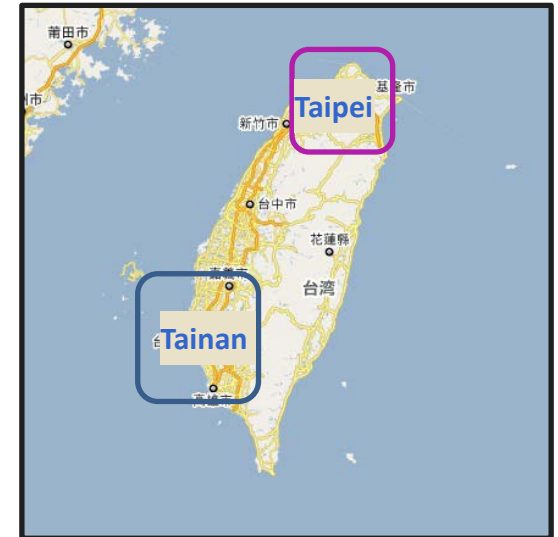
## B. The ITSA Model Implications

- Based on the **PPP**, the PAYT system is proved to be **effective** in HSW reduction in the case study of Taipei City.
- Intensive **3Rs activities** with particular emphases on “**reuse**” and “**recycling**” could be promoted during **the Chinese New Year**.
- Different impacts of the **rainfall scales** on **HSW generation/discards** are identified. **Flood disaster prevention** would be favor of **HSW reduction** in highly urbanized area (e.g., Taipei City) where **underground spaces** are intensively utilized.

## C. Analysis on the Stakeholders' Opinions

- **Data Collection**

- **Hearing Survey** with the local civil servants
- **Questionnaire** for the citizens for investigating their willingness to pay (WTP) in terms of the HSW management fee



Source: Google map, 2011.

- **Data Analysis**

- **Truncated Regression (Tobin) Analysis**  
**on the WTPs**

## C. CVM Questionnaire Survey

- The following CVM survey is to investigate the WTA for HSW service.
- 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 with regard to the population weight among administrative wards
- The respondent ratio is **10.4%** in Taipei City, and **7.2%** in Tainan City.
  - The mayor election
  - Doubt on mail fraud
  - Christmas season

# PAYT as a **Debate** in the Mayor Election of Taipei City

## 台北市／環保政策 郝蘇打起「垃圾」戰！

【聯合晚報／記者楊正海／台北報導】

2010.10.14 07:39 pm

郝批垃圾山 查：國民黨累積的 / 謝宏斌

台北市長候選人郝龍斌競選總部立委發言人團首度舉行記者會，猛攻蘇貞昌的環保政策，批蘇貞昌自稱在台北縣長任內清理了五座垃圾山，其實只把小垃圾山全部移至林口下福村腐植土堆置場掩埋，變成一座大垃圾山。

至於蘇貞昌考慮取消垃圾費隨袋徵收的構想，發言人團成員鄭麗文指出，蘇貞昌七年縣長任內，台北縣的垃圾減量只達到 22.74%，台北市因實施垃圾費隨袋徵收制度，迄今垃圾減量已達到 73%。

鄭麗文說，台北市今年將達到垃圾零掩埋，領先全世界 30 年，為何還要再走回頭路？希望「蘇貞昌不要在躲在粉紅色的休閒衫後面，派出打手，對重大建設進行潑糞式、找碴式的找麻煩」，請蘇親自出來面對。

立委蔡正元指出，郝龍斌擔任環保署長時，曾建議時任台北縣長的蘇貞昌，與台北市一同實施垃圾費隨袋徵收制度，卻遭蘇貞昌拒絕，結果造成台北縣林口現在有一座非常大的垃圾山。

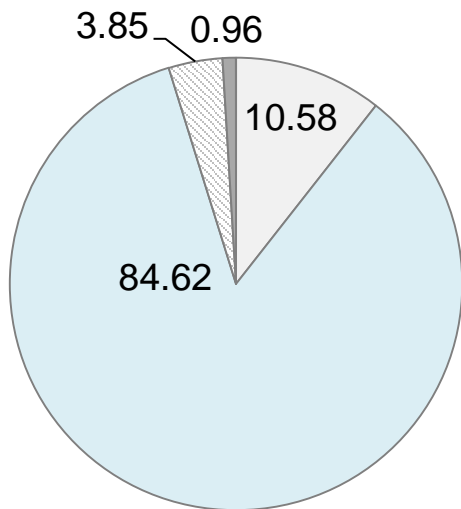
立委費鴻泰說，如果取消垃圾費隨袋徵收，台北市 10 年來的努力將毀於一旦。

立委李鴻鈞指出，台北縣在國民黨執政後，2009 年 7 月起開始實施垃圾費隨袋徵收制度，以土城和永和為例，到今年 2 月底為止，土城市的垃圾清運量下降 42%，永和市下降 47%，就是實施垃圾費隨袋徵收所創造的環保效益。

- The candidates hold opposite opinions on the PAYT in the mayor election **last November**.
- In order not to be influenced by the Mayer election, the questionnaire survey was **postponed**.

## C. Results of the Questionnaire Survey (I) - The public opinion on the charging basis

a. Taipei City (n=104)



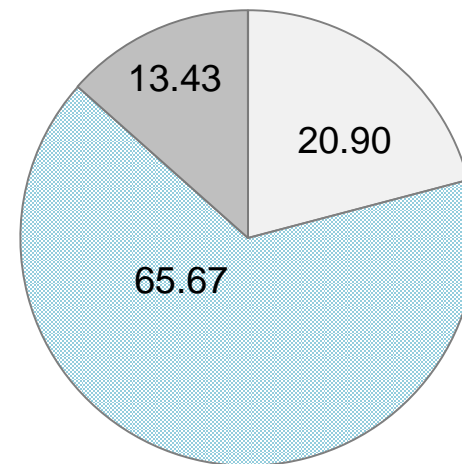
□ by water consumption

■ by waste volumn

▨ by the household size

■ charge with the producers

b. Tainan City (n=67)



□ by water consumption

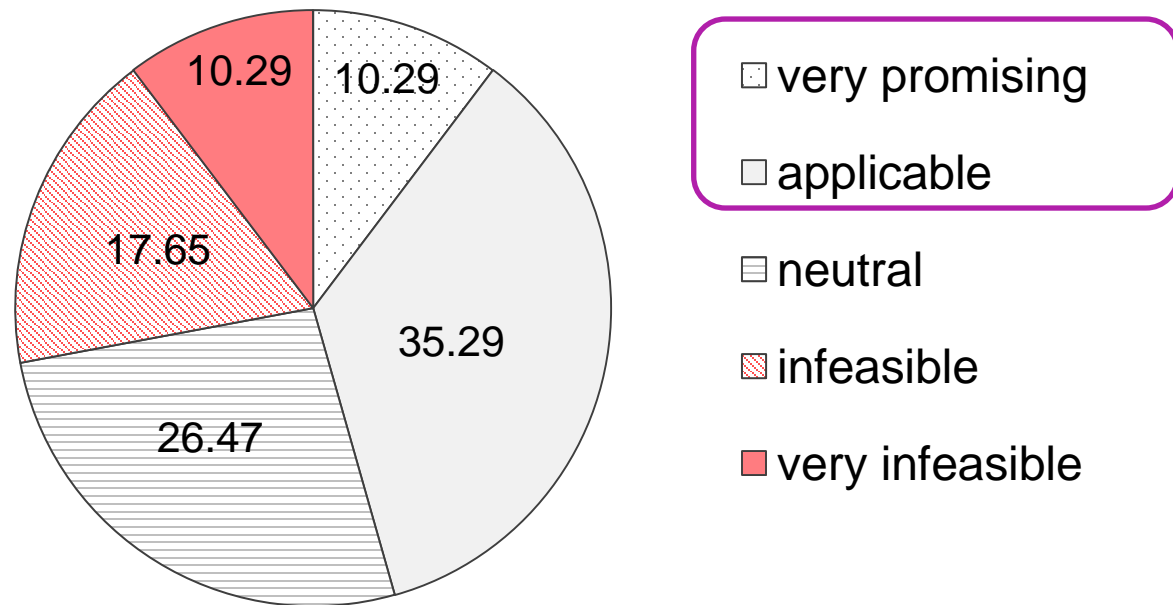
■ by waste volumn

■ by the household size



## C. Results of the Questionnaire Survey (II)-

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

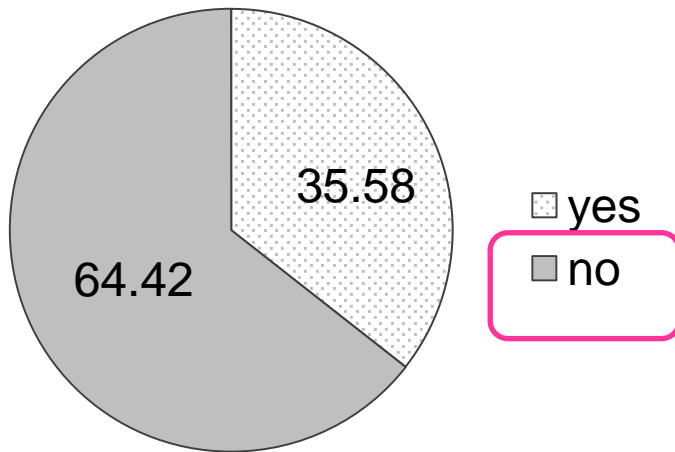


## C. Results of the Questionnaire Survey (III)-

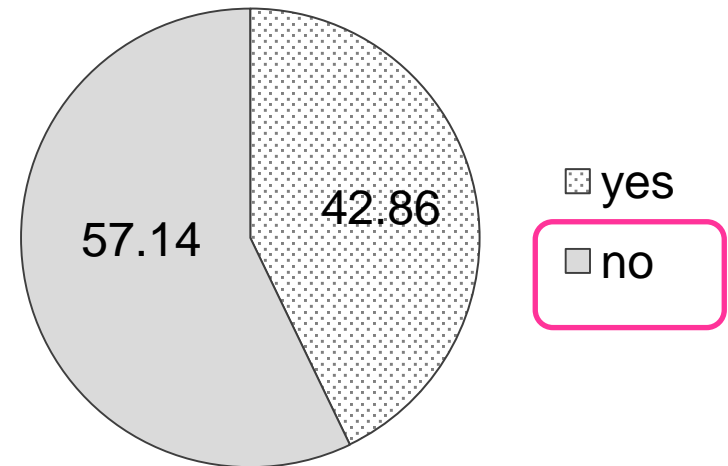
The public awareness on the current fee level :

**Do they know how much they pay?**

a. Taipei City (n=104)



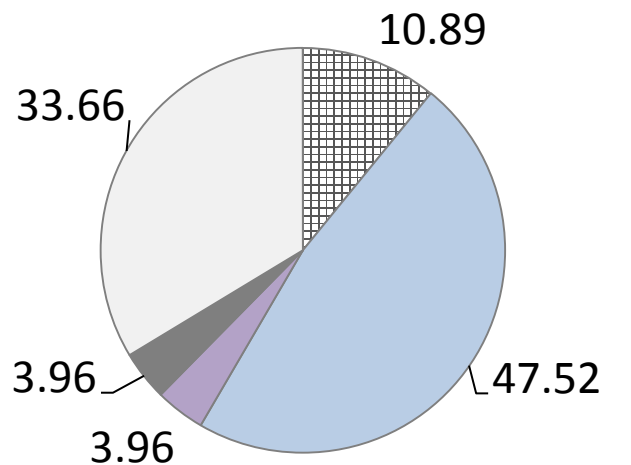
b. Tainan City (n=70)



- 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.

## C. Results of the Questionnaire Survey (IV) - Opinions on the fee level

a. Taipei City (n=101)



Too high

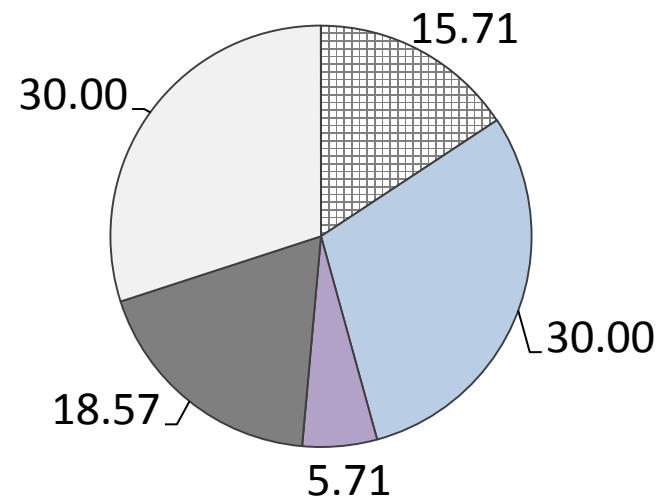
Adequate

Too low

It should not be levied

Neutral

b. Tainan City (n=70)



Too high

Adequate

Too low

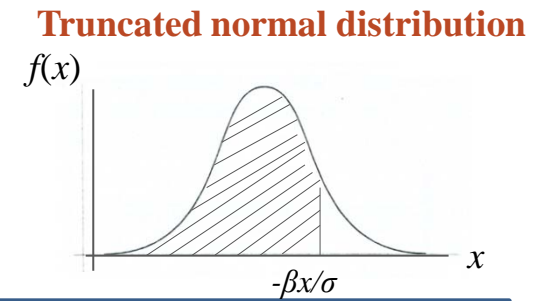
It should not be levied

Neutral

## C. Preliminary Truncated Regression (Tobin) Analysis of the WTPs

- In this study, only the **rational** WTP bidding samples, consistent with the respondent's **attitude**, would be considered in the model development, implying that the range of the WTP variable is **restricted**.

$$WTP_i = \alpha + \beta_j \times x_{j,i} + \mu_i^* \quad \forall WTP_i \geq WTP_0$$
$$\mu_i^* = \sigma \times \mu_i$$



where  $WTP_i$  is the vector of the  $i$  respondent's WTP;

$WTP_0$  is a **threshold value**;

$x_{j,i}$  represents the variables representing the **respondent's personal attributes**;

$\mu_i^*$  is a truncated normal distribution error term **with a non-zero mean**;

$\alpha$ ,  $\beta_{j,i}$  and  $\sigma$  are the parameters.

- In such a case, the ordinary least-squares method **could not** be used.
- The parameters of the equations were solved by using the **maximum likelihood method** with the **R** statistical software (version 2.13).

## C. Preliminary Truncated Regression Analysis of the WTPs (II) -Descriptions of the variables

Variable	Description
$WTP_{Taipei,i}$	The <b>WTP value</b> for the respondent $i$ in <u>Taipei City</u> (New Taiwan Dollar (NT\$) at 2010 prices <u>per liter HSW</u> );
$WTP_{Tainan,i}$	The <b>WTP value</b> for the respondent $i$ in <u>Tainan City</u> (NT\$ at 2010 prices <u>per 1m<sup>3</sup> water consumption</u> );
$EXCCon_i$	<b>The degree</b> that the respondent $i$ agree with the <b>payment for the potential external (environmental) cost</b> associated with HSW management (1: favor / very favor; 0: neutral / disfavor);
$Income_i$	The respondent $i$ 's household monthly <b>income level</b> (0: 0~20,000 NT\$ at 2010 prices; 1: 20,000~30,000 NT\$ at 2010 prices; 2: 30,000~50,000 NT\$ at 2010 prices; 3: 50,000~100,000 NT\$ at 2010 prices; 4: > 100,000 NT\$ at 2010 prices);
$Educ_i$	The respondent $i$ 's <b>education level</b> (0: lower than high-school level; 1: high-school level; 2: undergraduate level; 3: graduate level);

## C. Preliminary Truncated Regression Analysis of the WTPs (III)- The Maximum Likelihood Estimation Results

### Taipei city:

$$\widehat{WTP}_{Taipei,i} = 0.159 \times EXCCon_i + 0.246 \times \mu$$

(20.52\*\*)
(9.24\*\*)

Log-Likelihood: -0.264 ; N= 47

### Tainan city:

$$\widehat{WTP}_{Tainan,i} = 0.865 \times EXCCon_i + 0.515 \times Income_{Tainan,i} + 1.14 \times \mu$$

(4.90\*\*)
(1.38)
(6.76\*\*)

Log-Likelihood: -36.65 ; N= 23

**Note:** (1) Values in the parentheses denote the  $t$  statistics;

(2) \* and \*\* denote significance at the 10% and 5% levels, respectively.

# Environmental Impact from the PAYT Policy in Taipei City

- The ITSA model suggests that the MSW reduction effect of the PAYT policy is around **27,936.48** tonnes per year.
- The environmental impact concerns the Greenhouse (GHG) gas emission in this study.
- The reduced MSW discards is assumed to eliminate the GHG emission from waste incineration process.
- The IPCC 2006 Manual is applied for the GHG estimation from waste incineration.
- Some **domestic parameters** are set up according to Weng et al. (2009).
- The impact of the electricity generation from waste incineration on GHG emission is not considered yet.

Incineration	CO <sub>2</sub>					CH <sub>4</sub>	N <sub>2</sub> O
total (Gg CO <sub>2</sub> - eq./yr)	total (Gg/yr)	Paper (Gg/yr)	Plastics (Gg/yr)	Leather (Gg/yr)	Textile (Gg/yr)	(Gg CO <sub>2</sub> -eq./yr)	(Gg CO <sub>2</sub> -eq./yr)
<b>8.85</b>	<b>8.47</b>	<b>0.064</b>	<b>8.39</b>	<b>0.005</b>	<b>0.01</b>	<b>0.0001</b>	<b>0.38</b>

# The SWOT analysis of the PAYT in Taiwan

- In 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.

## Strengthens

- 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.

## Opportunity

- Enhanced recycling activities with the PAYT would promote the **recycling/reuse industry**.

## Weakness

- 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.

## Threats

- **Fake collection bags** might appear in the market.
- The PPP is not well accepted by a part of citizen. (The clarification of responsibility)



# Conclusion

- Both the citizens regard that the **PAYT** is a rational HSW charging system in Taiwan. However, it seems **difficult** to alter the fee level of PAYT systems while the some citizens are not happy with new changes.
- The CVM is difficult to be implemented unless the public is **well informed by the required in-depth knowledge**, but it could serve as **an education tool** as well.
- The degree that the citizens accept the concept of **external costs** of HSW is an influencing factor on the WTP bidding process.
- The detailed internal and external cost/benefit items should be further studied.

# Future Remarks

- It seems **difficult** to alter the fee level of PAYT systems while the some citizens are not happy with new changes.
- 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 addition, the detailed internal and external cost/benefit items should be further studied.
- Uncertainty analysis** might be included in support of the quantitative analysis.
- The implementation of the PAYT could be further promoted widely in major metropolitan areas in Taiwan as well as in the developing countries in Asia.