IDEC DP² Series Vol. 7 No. 4

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Measuring the Impact of Modern Waste Collection and Processing Service Attributes on Residents' Acceptance of Waste Separation Policy Using a Randomized Conjoint Field Experiment in Sleman Regency, Indonesia*

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February 24, 2018

Abstract

Indonesia is one of the countries that are facing serious solid waste problems. Though the issue is now addressed in its capital city of Jakarta, many secondary cities are left behind. This research attempts to analyze the effects of the waste management policy components impacting respondents' policy acceptance probabilities in Sleman Regency near Yogjakarta, Indonesia. Using a randomized conjoint field experiment based on the proposal of modern waste collection services the paper shows that a new waste management policy including waste separation with frequent organic waste collection will increase popular support. Indeed if the government introduces a waste collection and processing services that consist of the most preferred levels of these attributes, it is shown that majority of the residents supports this new waste management policy, which will reduce waste at its source.

Key Words: Waste management policy, Waste separation, Randomized conjoint experiment, Indonesia

*This work was partly supported by a Grant for Environmental Research Projects #153421 from The Sumitomo Foundation.

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1 Introduction

Reflecting its rapid economic growth, the waste volume in Indonesia is soaring, which made Indonesia one of the countries that are facing the most serious solid waste problems. Unlike the capital city of Jakarta that already started to address the issue, many secondary cities in Indonesia including Yogjakarta are still left behind. The government has already implemented regulations concerning waste management, which include modernization of waste handling and reduction measures to overcome the increasing waste volume. However, in practice, waste is still poorly managed in these areas, making it difficult to reduce the annually increasing waste volume. A proper waste management system that includes waste sorting at the source could be a solution of waste reduction, however, it may face public opposition for its increased waste handling and costs. To successfully and effectively introduce this new waste management policy that is not necessarily popular to the residents, policy maker must precisely understand people's preferences toward the waste separation as part of a waste management policy. This paper thus analyzes the causal effects of relevant waste management policy components impacting respondent's choice probabilities of policy acceptance, based on the randomized conjoint field experiment.

An increase in population and economic growth leads to an increase in waste generation, particularly in urban environments. The increased quantity and complexity of solid waste, especially in cities, is caused by economic development, urbanization, and improved living standards (Rathi, 2007). The imbalance between rapid economic growth and waste management causes waste issues and has become a serious problem faced by the government and public. Due to its large population, Indonesia is also facing the problem of a huge amount of waste discharge. The problem is more acute as considering its geography; Indonesia is the world's largest archipelago, comprising nearly 17,504 islands. On average, every Indonesian generates 0.76 kg/day of solid waste. Thus, with a total population more than 200 million, Indonesia generates some 187 thousand tons a day of municipal solid waste (MSW) over a total area of 1,890,000 km2, which is administratively distributed across its provinces (Chaerul, 2007).

Waste is not just a local issue but also a global one. Both developed and developing countries are facing this problem. Increases of population, urbanization, industrialization and economic development have brought increases of municipal solid waste volumes all over the world, especially in developing countries (Yuan and Yabe, 2015). Inappropriate waste management causes some environmental problems, such as water, soil and air pollution. Furthermore, in some cases, inappropriate waste management can cause serious health problems. Zhang et al. (2010) explained that a number of developing countries are now confronting the growing problem of MSW disposal. For example, the reported total amount of MSW generated in China increased by seven times 1980 to 2007. In India, the amount of discharged waste in Delhi has tripled in 2012 from 2012. The projection for Asia shows that MSW will more than double by 2025 (Pokhrel and Viraraghavan, 2005). Indonesia is a developing countries and has a large of population.

According to a study by Jambeck, et al. (2015), within the project "Plastic waste inputs from land into the ocean," Indonesia is the second biggest contributor of plastic waste to the seas after China. In 2010, Indonesians who lived along the beach produced more than 3 million metric tons of poorly managed plastic waste, with about a third being considered to be ocean waste. In addition to plastic waste, MSW disposed of in landfills can produce methane gas, which has been identified as a cause of increasing global warming. According to the US Environmental Agency's Global report, in 2010, Indonesia occupied seventh place of the global methane emissions sources. In other words, Indonesia considered to be one of the countries that

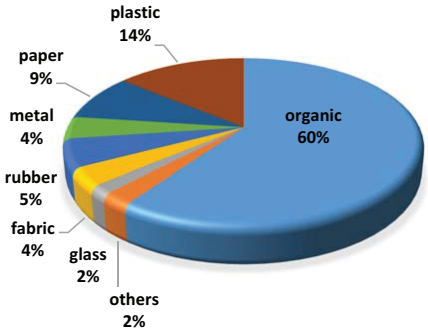
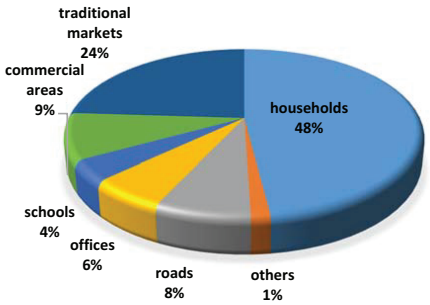


Figure 1: Compositions of waste in Indonesia



Source: Ministry of Economic Affairs, 2015

Figure 2: Waste sources in Indonesia

contributes to increases of global warming via its methane emissions.[1]

As the population and income in Indonesia increase, the MSW volume also increases, although there have been some efforts to reduce the waste volume (Ministry of Economic Affairs, 2015). The pie charts show the sources and compositions of waste in Indonesia, and explain that almost 60% of the waste in Indonesia is organic waste, with plastic being the second most common type of waste. Households contribute 48% of the waste and are the largest contributor of waste of the other waste sources in Indonesia. Waste management is aimed at the waste collection and transport from waste sources to the final landfill. In general, the waste management system in Indonesia follows a collect-transport-dispose method. In this system, there is no waste treatment before the final disposal to the landfill.

In 2008, the Indonesian government tried to change the old waste management system into the new system. The government enacted Law No. 18/2008 and Government Regulation No. 81/2012 concerning the waste management system in Indonesia. According to these regulations, the new waste management includes reducing and handling the waste at its source.[2] The reduction of waste can be accomplished via the reduction of the waste volume (reduce), the reuse of waste (reuse) and the recycling of waste (recycle), which is known as the 3R principles. Meanwhile, the handling of waste includes waste separation from its source,

[1]Source is from www. ina. or. id (2015).

[2]Law No. 18/2008 is Waste Management in 2008 and No. 81/2012 is Household Waste and A Kind of Household Waste Management in 2012 both stipulated by Ministry of Law and Human Rights in Jakarta.

an intermediate waste process before its final disposal and a final dispose with treatment to safely dispose of the waste in the environment.

After the enactment of waste management regulations, the Indonesian government set a target of managing 80% of the urban waste in the National Mid Term Development Plan 2010-2014. Furthermore, the government also expected a 100% target of sanitation access, including waste management, so that an Indonesia that is free of waste can be achieved in 2020 (Ministry of Economic Affairs, 2015). However, in 2013, the Statistics of Indonesia recorded that the waste is still poorly managed. This includes slight majority of waste being burned, 25% of waste being dumped into a landfill, 10% of waste being disposed of into river bodies, another 10% of the waste not being treated, about 4% of the waste being buried in the ground and only less than 1% of the waste being processed into compost. A study conducted by the Ministry of Economic Affairs in 2013 discovered that great majority of the landfills in Indonesia still operate as open dumps. Another problem of waste management in Indonesia is the low participation in reducing waste volume at the source. The data states that the percentage of households that do not separate their waste increased from 76% to 81% (Statistics of Indonesia, 2017), meaning that the households are reluctant to separate their waste at their house.

These arguments show that waste is still poorly managed in Indonesia. Due to this poor waste management, the waste volume in Indonesia will continue to increase year by year, if without any reduction. A proper waste management system that includes waste sorting at the source can be a solution for waste reduction. Some developed countries, such as Germany, the United Stated and Japan, have succeeded in implementing waste separation as part of the waste management system. In Japan, 69% of the total MSW can be reduced by implementing a waste separation system (Ministry of Environment of Japan, 2014). Zhuang, et al. (2008) stated that waste sorting at a source that is a part of waste management system is a cost-effective method. In Indonesia, the largest amount of MSW comes from household waste, as households contribute approximately 48% of the total MSW. It is therefore essential to introduce waste separation for the success of waste management policies, and to do that, identifying households' preference and behavior for various waste management services becomes the main consideration when designing a effective waste management policies. Oosterveer, et al. (2010) stated that understanding household attitude and behavior for handling waste at its source is important when designing a waste management system.

To understand the households' choices of and attitude towards a waste management system, especially with waste separation, field experiments are needed. Therefore, this research designs a conjoint field experiment for gathering stated household preferences of hypothetical waste collection services focusing on waste separation at the source to determine household preferences and behaviors interacting with the waste management system. Some research had been conducted to examine personal preferences of waste management in different areas. Caplan, et al. (2002) conducted research on the waste management preferences in Ogden, Utah, which faced waste generation problems due to the closing of its landfill and rapid population growth. Unlike the current paper that utilizes randomized conjoint field experiment, they used the contingent ranking (CR) method to determine personal preferences for waste management in this research.[3] Caplan et al. (2002) used the difference levels of waste service costs and waste separations. For the waste separation, they gave options to respondents in order to choose to separate their waste with no separation, green waste and recyclable waste. They also gave options for different levels of service costs, which included current and higher

[3]This method asks people to choose the most and least appealing hypothetical choice set. To simplify answering the questions, respondents should be asked to assess hypothetical sets with the inclusion of a few familiar options, including the status quo.

service costs. They found that people in Ogden city supported the new waste management and stated that more than half of the respondents were willing to separate their waste as garbage and green waste.

Yuan and Yabe (2014) conducted another research on the household preferences of kitchen waste source separation in Beijing, China. A a contingent valuation method (CVM) is used to infer people's behavior towards kitchen waste separation and to improve household waste separation services. They used five attributes; frequency of waste collection, time of waste collection, the need of instruction, the type of container and compensation for waste separation. The research showed that a low compensation is not a major factor in residents accepting the proposed separation services. In addition, the most important service that people want is frequent waste collection in the evening using plastic bag containers and no instruction.

Hazra et al. (2015) used six attributes in their using random parameter logit models: the method of waste collection, the walking time to the waste shelters, the type of waste containers, waste separation, clearance frequency and the annual municipal tax for waste collection services. Their research explained that education and income have positive relationships with willingness to pay for waste collection services, meaning that highly educated and high income people tend to have higher WTPs than less educated people with lower incomes. To understand household preferences for waste management, some researchers such as Sakata (2007), Nakatani, et al. (2008), and Sheau-Ting, et al. (2016) used conjoint analysis in which respondents had the freedom to determine what kind of waste management they want. Nakatani, et al. (2008) discovered that people would like to support waste separation as part of the waste management policy in Kawasaki City. Sheau-Ting, et al. (2016) stated that to encourage people to apply waste separation, the distance to the nearest recycling bin should be considered.

These previous studies utilize methods such as conventional conjoint analysis or parametric approaches to capture personal preferences of waste management. Instead of using conventional conjoint analysis or parametric approaches that rely on more restrictive assumptions, this research uses a randomized conjoint experiment based on Hainmueller, et al. (2013) to understand causal effects of policy aspects on personal choices concerning waste collection and processing services.[4] Hainmueller, et al. (2013) revised the conventional conjoint analysis in the framework of a randomized experimental design that can estimate the causal effects of policy components on respondent's choice probabilities without bias arising from misspecification, beyond the findings from the conventional methodological literature. Using this new conjoint analysis, the level of attributes for each alternative are purely randomly assigned for constructing choice sets, which allows us to identify the causal effects of each attribute on the decision non-parametrically.

There are also some differences in the attributes used in this research compared to those used in previous research. In this research, we combine the waste separation and frequency of waste collection for both organic and inorganic waste. Given that we conducted the survey in developing countries where survey instruments are limited, we simplify the waste separation as organic and inorganic waste to prevent burdening the respondents. In contrast to other works, we also include intermediate processing facilities as one of the attributes. The intermediate processing facilities will support waste separation as part of the waste management policy.

Our results show that organic waste collection will increase popular support for the new waste management policy due to its significantly positive effect on both the internal and external choice probabilities. The

[4]Conventional conjoint analyses such as the random utility model require parametric assumptions on the preference distribution such that the preference for observable characteristics is additive separable and the preference for unobservable characteristics follows the type-I extreme value distribution. See, for example, Small and Rosen (1981) for further details.

other attributes that have positive effects on the internal choice probabilities are the intermediate processing facilities, final disposal facilities and monthly payments. If the government introduces a waste collection service that consists of the most preferred levels of these attributes, the choice probability of the respondents supporting the new waste management will increase by approximately 59%. In other words, the majority of people will support the new waste management policy in this case, which will reduce waste at its source.

The next section discusses in detail the survey design, including the random sampling, the design of the conjoint experiment, the household survey, the main survey and the descriptive statistics. Section 3 explains the result and findings of the research. Finally Section 4 provides the discussion and conclusions of this research.

2 Survey Design and Data Profiles

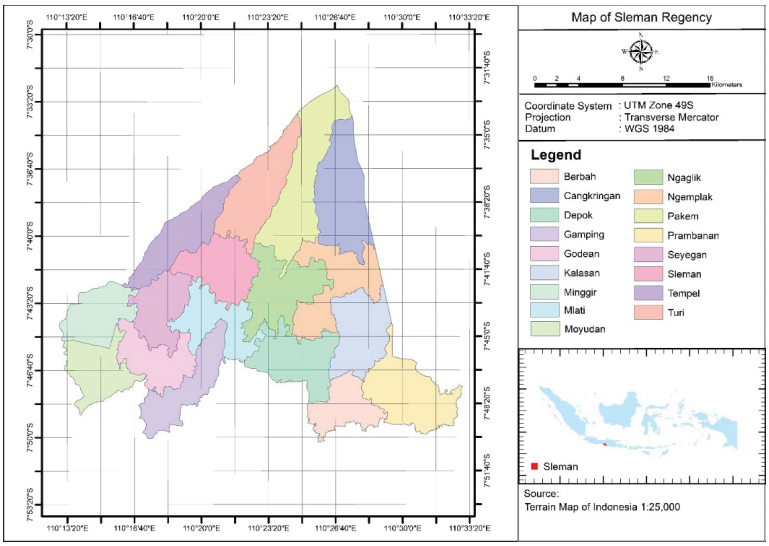
2.1 Overview of the Survey Area

Indonesia is the largest archipelagic country and Yogyakarta province is one of the second largest concentration of population and economic activities. Population in Yogyakarta Province is growing at a rate higher than that of Jakarta, the biggest and densest city in Indonesia; it is estimated to be approximately 1.19% between 2010 and 2015 (Statistics of Indonesia, 2017). An increase in population will certainly add more pressure on the environment, such as increasing the waste volume in urban areas. The waste volume in Yogyakarta is recorded as approximately 8,229 m^3 (Environmental Agency of Yogyakarta Province, 2015).[5] In terms of waste management, Yogyakarta is still behind Jakarta; the Jakarta government has spent 2,457 billion rupiahs to centralize the waste management in their area. The result is that almost 90% of the total waste in Jakarta Province is managed by the government and end up in designated landfill sites. In addition, Jakarta is the province that has the lowest percentage of burned waste, at only 5.3%, whereas the average percentage of burned waste in Indonesia is 50.1% (Ministry of Economic Affairs, 2015).

In contrast, Yogyakarta Province spends 14.2 billion rupiahs to manage the waste in their area (Local Government of Yogyakarta Province, 2015). This is a very small amount when compared to the Jakarta waste management fund. Therefore, the waste management in Yogyakarta still lags behind that of Jakarta and only 17% of the total waste in Yogyakarta is recorded as managed by the government, while most of the waste is still mismanaged by the community, being burned, buried in the ground, dumped in the yard or discarded in the river. Statistically, the percentage of waste burning in Yogyakarta is 53%, making it ten times higher than that in Jakarta (Ministry of Economic Affairs, 2015).

Sleman Regency is one of the districts in Yogyakarta Province where the survey is conducted. Geographically, Sleman Regency is located in the northern part of Yogyakarta, which borders the Bantul and Yogyakarta districts to the south, the Klaten district to the east, the Boyolali district to the north and the Kulonprogo district to the west. Specifically, the Sleman Regency is located between the 7°34' and 7°47' southern latitudes and the 110°13' and 110°33' eastern longitudes. The total area of the Sleman Regency is 57,482 ha or approximately 18% of Yogyakarta Province. The linear distance of between Sleman Regency and Yogyakarta Province capital is 9 km (Regional Planning and Development Agency of Sleman Regency, 2016).

[5] This volume is small compared to that of Jakarta, which has a total waste volume of approximately 34,609 m^3 however, it is expected to grow faster.



Source: Regional Planning and Development Agency of Sleman Regency, 2016

Figure 3: Map of Sleman Regency, Indonesia

In 2015, the total population of Sleman Regency was 1,167,481 people, with a population growth rate of 1.41% in the past five years. The population density in this area is 2,031 people per km^2, which increased 4.74% from the previous year. In 2014, the number of households is recorded as 369,534 households, which increased 21.84% from 2010-2014. In 2015, the economic growth rate in Sleman Regency was 5.31%, which was the highest among the other districts in Yogyakarta Province. However, the GDP per capita in this regency is still second after Yogyakarta city, which had a population of 28.91 million in 2014 (Regional Planning and Development Agency of Sleman Regency, 2016).

The Sleman Regency is the part of Yogyakarta Province that has the highest economic growth rate. Therefore, Sleman Regency experienced positive economic growth. This positive economic growth is accompanied by an increase in the population in this region, making Sleman Regency the region with the largest population in Yogyakarta Province. Consequently, the increase in the population will lead to an increase in the waste volume in this area. In 2015, the waste volume in the Sleman Regency was recorded as 2.879 m^3, 57% of which comes from urban areas. Waste management in this area is centralized or managed by a local government and still uses the collect-transport-dispose method ending in the Piyungan landfill in Bantul Regency. Although there is waste management in this area, this waste collection service covers only 5.92% of the total waste volume in Sleman Regency (Regional Planning and Development Agency of Sleman Regency, 2015). Therefore, most of the existing waste is still managed independently by communities through burning, burying in the ground or dumping into yards or rivers, meaning that waste is still poorly managed in this area.

The main survey of this research was conducted from February 27th to March 12th 2017 in Pringwulung, Condongcatur Village, Depok Sub-district, Sleman Regency, Yogyakarta Province. Pringwulung was randomly selected from 1,212 small villages in Sleman Regency. In this area, the total population is 1,564 people, and there are 485 households. Among 485 households, we selected 300 households as our survey respondents. Due to the absence of household lists, we visited each household to become familiar with our

Table 1: Number of households surveyed in project-affected villages

Respondent Characteristics		Freq.	Percent
Gender	Male	156	52.00
	Female	144	48.00
Age	Young (< 35 years old)	70	23.33
	Middle (35-60 years old)	211	70.33
	Elderly (< 60 years)	19	6.33
Education level	Elementary school	24	8.00
	Junior High School	20	6.67
	Senior High School	156	52.00
	Bachelor Degree	94	31.33
	Master/Phd	5	1.67
	No answer	1	0.33
Occupation	Civil servant	17	5.67
	Private sector	64	21.33
	Own small bussiness	112	37.33
	Retired	6	2.00
	Others	100	33.33
	No answer	1	0.33
Monthly Income	< 1 million rupiahs	52	17.33
	1 - 2.5 million rupiahs	124	41.33
	2.5 - 5 million rupiahs	88	29.33
	5 - 7.5 million rupiahs	7	2.33
	> 7.5 million rupiahs	4	1.33
	No answer	25	8.33
Household size	1-4 people	248	82.67
	5-6 people	43	14.33
	7-10 people	9	3.00
Status of the House	Self-Owned	165	55.00
	Rent	119	39.67
	Others	16	5.33
Length of stay	< 5 years	96	32.00
	5-10 years	92	30.67
	11-20 years	29	9.67
	> 20 years	83	27.67

respondents. After we fulfilled our sample number, we then dropped the rest of the households that had not yet been visited.

2.2 Descriptive Statistics

A household questionnaire was used to capture the characteristics and behavior of the waste management of the households. The questionnaire includes (1) basic information such as age, gender, education, occupation, family size, and monthly income; and (2) household waste management behavior, such as waste separation behavior and the satisfaction with the current waste management.

The characteristics of the households can be seen in Table 1. The table above shows the characteristic of the households captured by the questionnaire. It explains that 52% of the respondents are males and most of them (73.3%) are middle aged or between 35-60 years old, while 85% of the household heads finished

Table 2: Respondents behavior on waste management

Respondents behaviour on current waste management		Freq.	Percent
Waste separation	Yes	78	26.00
	No	222	74.00
Participation on waste separation	Yes	175	58.33
	No	69	23.00
	No Answer	56	18.67
Current waste management satisfaction	Yes	240	80.00
	No	60	20.00
Regular waste disposal schedule	Yes	114	38.00
	No	186	62.00

the compulsory education, which is six years in elementary school and three years in junior high school. In addition, 52% of the respondents graduated high school, and 33% are college/universities graduates. Approximately 37.3% of the respondents own small businesses, 21.3% work in the private sector, 5.7% are civil servants and 2% of the respondents are already retired. However, 33.7% of the respondents did not state their job in the questionnaire. In total, 17.3% of the households have monthly incomes below 1 million rupiahs and are considered as low-income households. Most of the households (70.7%) have monthly income ranges between 1 million to 5 million rupiahs, and 3.7% of them have monthly incomes above 5 million rupiahs, while 8.3% of the respondents did not state their monthly incomes.

Family sizes in the households range from 1 to 10 people, with 82.7% of the households have for 1-4 people, while 17.3% of the households have more than 4 people. Additionally, 55% of the respondents are the house owner, 39.7% of the respondents rent their house, and the rest are neither homeowners nor tenants. Furthermore, 32% of the respondents have lived in their house for less than 5 years, 30.7% have lived in their house for approximately 5-10 years and 37.3% of them have lived in their house for more than 10 years.

In addition to household characteristics, there is some information about household behaviors with the current waste management. Table 2 describes household attitudes and behaviors towards the current waste management system.

In the questionnaire, respondents were asked about their behaviors that handle waste at its source. The results show that most of the respondents do not separate the waste from their house. Nearly 74% of the respondents do not sort their waste, while just 26% of them separate their waste into organic and inorganic waste. In terms of the current waste management in the respondent neighborhood, 80% of the respondents stated that they are satisfied with the current waste management. In addition, 38% of the households regularly dispose of the household waste, while 62% of them do not have regular schedules to dispose of the waste.

The current waste management is managed by the community. They hire someone to collect households waste from their house to temporary waste shelters. There is no waste separation of the household waste, so the organic and inorganic waste is still mixed. In this scheme, the government responsibility is to collect and transport the garbage from the temporary waste shelter to the final disposal or landfill. Further questions on waste separation were asked to understand respondent understandings of the importance of waste separation.

We describe the hearing results in Tables 3 and 4.

According to the table, slightly more than 40% of respondents stated that mixed transport and disposal

Table 3: Reason for not sorting the waste

Reason for not sorting the waste	**Freq.**	**Percent**
Negative nearest neighbor effect	0	0.00
Complicated MSW classifications	10	3.61
Do not have time	72	25.99
Mixed transport and disposal after separating at source	111	40.07
Lack of awareness of MSW source separation	7	2.53
Delay in bag delivery or poor collection service	1	0.36
Insufficient MSW source separation facilities	52	18.77
Inadequate public education	14	5.05
Others	10	3.61

Table 4: The importance of MSW

The Importance of MSW source separation	**Freq.**	**Percent**
Reduce the amount of waste disposed and reduce waste treatment fees	42	10.55
Reduce environmental pollution and negative health impacts	208	52.26
Sell recyclables for money	135	33.92
Not concerned	13	3.27

facilities discourage their willingness to separate the waste, as these facilities do not yet support waste separation. In this area, organic and inorganic waste are still mixed in the temporary waste shelter. Furthermore, there is no intermediate processing facility to process both organic and inorganic waste.

Another potential reason for the respondents to not separate the waste is a lack of time. Nearly 26% of the respondents stated they do not have time for waste separation, perhaps because waste separation has not become a habit for the respondents, meaning that they think waste separation is time consuming. In addition, there are no plastic bags for sorting waste, which might make waste separation more difficult.

The respondents were also asked about the importance of waste separation. More than half of the respondents agree that waste separation will reduce environmental pollution and negative health effects, and nearly 34% consider that recyclable waste from waste separation can be sold to earn money.

2.3 Experimental Design

In this research, we use a new conjoint analysis based on Hainmueller, et al. (2013) to understand personal choices of waste management policies. Hainmueller, et al. (2013) revised the conventional conjoint analysis in the framework of a randomized experimental design that enables to estimate the causal effects of each policy component on respondent's choice preferences without biases beyond the findings from the conventional methodological literature. There are several versions of this new conjoint experiment design in terms of choice set and choice making. According to the rating-based conjoint analysis, respondents are asked to rank each alternative based on their preference.

In this research, we generated hypothetical waste collection services that aim to improve waste management services especially in the research area. In a choice set, we provide three alternatives including the status quo, which the respondents have to rank these three alternatives. This means that the respondent is given the freedom to not choose between the first two proposed alternatives as they can choose the status quo.[6] In this research, we explain the status quo must be chosen when the current waste management is fine and it is not necessary to implement new waste management system.

Before we conduct a conjoint experiment, we first show the *scenario* to each respondent so that they understand the research aim and design and their role in it. The following is the scenario used to explain our experiment to the respondents:

> "We will ask your preferences on hypothetical household waste collection and disposal service methods. You will be requested to rank three choice sets: option A, option B, and option C as current status. Among the three options, the rankings are 1) the most preferable choice, 2) the second preferable choice and 3) the least preferable choice. The common assumptions of household waste collection and disposal methods are 1) each household has the responsibility to perform waste separation at home, 2) each household has to bring the separated waste to the nearest collection station, 3) payment per month per household is the only fee that the you will pay. You will be asked to make rankings four times with different combinations of household waste collection and disposal methods with different conditions."

Then, we give the respondent the questionnaire, including the choice sets that the respondents had to rank. A choice set consists of three alternatives, including the status quo. Each of the first two alternatives has six

[6] Another version of the rating-based conjoint analysis provides a choice set that has only two alternatives without status quo, from which the respondents have to choose one.

attributes that are randomly assigned. Each alternative is a proposed policy program and is characterized by six attributes. The attributes are prepared based on the current waste management system and new waste management systems that might be implemented to improve waste management services in the research area. These attributes are: organic waste collection frequency, inorganic waste collection frequency, walking time to the nearest waste station, intermediate processing facility, final processing facility, and monthly payment amount.

The detailed attributes and their respective levels can be seen in Table 5. The first attribute is the frequency of the organic waste collection services (Organic Collection) at three levels. This attribute explains the frequency of organic waste collection and transportation services within a week, which is provided by the government. The first level provides a once-a-week organic waste collection service. The second level gives a three-times-a-week organic waste collection service. The third level offers the most frequent organic waste collection services, which is five times a week.

The second attribute is the frequency of the inorganic waste collection services (Inorganic Collection), which is provided at three levels. In this attribute, we provide inorganic waste collection services to complete the organic waste collection services. The first level provides a once a week inorganic waste collection service. The second level gives a three times a week inorganic waste collection service. Finally, the third level offers the most frequent inorganic waste collection services, which is five times a week.

The third attribute is the walking time to the nearest temporary waste shelter in the respondent's area (Walking Time) and is given at three levels. This attribute describes the approximate time required to bring the waste from the respondent's house to the nearest temporary waste collection service. The first level is the longest walking time, which is 30 minutes. The second level and the first level, respectively, are 15 and 5 minutes.

The fourth attribute is the intermediate processing facilities (Intermediate), which are given at four levels. This attribute offers intermediate processing facilities that are used to process both organic and inorganic waste. The implementations of these facilities are intended to support the waste separation system. The first level is none, which means there is no intermediate processing facility provided by the government. The second level is composting. This level offers composting facilities as an intermediate processing facility to process organic waste into compost. The third level is recycling. This level offers to build recycling facilities to process inorganic wastes, especially recyclable waste. The last level is incineration, which offers incineration facilities to handle both organic and inorganic waste by burning.

The fifth attribute is the final disposal facilities (Final), with two levels. This level offers final disposal facilities that should be provided to accommodate the waste after being processed by the intermediate processing facilities. The first level is open dumping, which is a common final disposal facility in Indonesia. In the open dumping method, waste is dumped on an open land and there is no treatment to minimize the environmental pollution from the waste. The second level is a sanitary landfill, which is a method of waste disposal where the waste is buried either underground or in large piles. This method of waste disposal is controlled and monitored very closely.

The last attribute is the monthly payment for the waste collection services (Payment), which is set at four levels. These levels include free, 24,000 rupiahs, 48,000 rupiahs and 96,000 rupiahs.[7] Free payment is provided to the areas that have no waste collection services, while 24,000 rupiahs is a standard monthly

[7]These levels are approximately, 2, 4, and 8 US dollars respectively.

Table 5: Detailed attributes and their levels

No.	Attributes	Level 1	Level 2	Level 3	Level 4
1.	Organic Waste Collection (Frequency of organic waste collection and transportation services in a week which is provided by the government)	Once a week	3 times a week	5 times a week	
2.	Inorganic Waste Collection (Frequency of inorganic waste collection and transportation services in a week which is provided by the government)	Once a week	3 times a week	5 times a week	
3.	Walking Time to the Nearest Waste Shelters (The time required to bring the waste from respondent house to the nearest temporary waste collection services)	30 minutes	15 minutes	5 minutes	
4.	Intermediate Disposal Facilities (The facilities are constructed by the government and are used to process both organic and inorganic waste before final disposal)	None (there is no intermediate disposal facilities)	Composting	Recycling	Incineration
5.	Final Disposal Facilities	Open dumping	Sanitary landfill		
6.	Monthly Payment for Waste Collection Services	96,000 rupiahs	48,000 rupiahs	24,000 rupiahs (standard monthly payment in the research location)	Free (represent the area which has no waste collection services)

Table 6: Example of a choice set

		Choice A	Choice B	Choice C
Attribute 1	Intermediate processing facility	None	None	Current system is fine and do not need new system (Status quo)
Attribute 2	Collection frequency for Non-organic wastes	5 times a week	3 times a week	
Attribute 3	Walking time to the nearest waste collection station	5 minutes	30 minutes	
Attribute 4	Final disposal facility	Sanitary landfill	Sanitary landfill	
Attribute 5	Collection frequency for organic wastes	Once a week	3 times a week	
Attribute 6	Payment per month per household	Free	Rp. 24,000	
	Your Ranking➔			

payment for the waste collection services in the research area.

These six attributes and their respective levels give 864 policy alternatives in total, two of which are randomly paired to construct 432 choice sets, including the status quo (an example of choice set is given in Table 6). Each respondent is required to make a ranking decision four times for four different choice sets. Of these, 108 households responded to 432 choice sets when the different choice sets were offered. In this research, we repeatedly used 108 groups of four choice sets for the 300 respondents at the survey site. Each of the two alternatives in each choice set consists a unit of analysis, and the data set includes 2,400 observations with two alternatives each for four rounds of questions for 300 respondents.

2.4 Estimation Strategies

In this research, we used a new conjoint analysis based on Hainmueller, et al. (2013) to understand personal preferences for waste management policies. Hainmueller, et al. (2013) revised the conventional conjoint analysis in the framework of randomized experimental designs that could estimate the effects of causal components on respondent's stated preferences without biases beyond the findings from the old methodological literature.

Using new conjoint analysis, we estimate the causal effects of policy attributes on two types of choice probabilities. The first type of choice probability is the internal choice probability, in which we observe whether a policy is preferred over another policy. That is, the internal choice probability compares two proposed policy programs without reference to the current situation as status quo. The second type of choice probability is the external choice probability, in which we estimate whether a policy is preferable to the status quo. In estimating the internal choice probability, a choice indicator takes the value of 1 as an outcome variable for a policy that is chosen as a higher ranking, while 0 is assigned to a lower ranking, irrespective of the ranking of the status quo. The external choice probability is used to compare two proposed

policies to the status quo. Here, 1 is assigned to any policy alternative that has a higher ranking than the status quo, and 0 is used otherwise. This means that if the ranking of the status quo is the highest (or the lowest), both alternative policies are both assigned 0 (or 1).

To estimate both the internal and external choice probabilities, Hainmueller, et al. (2013) proposed the following model:

$$y_{itj} \quad = \quad \beta_0 + \sum_{l=1}^{L} \sum_{d=2}^{D_l} \beta_{ld} a_{itjld} + u_{itj}$$

where a_{itjld} is a dummy variable for the l-th level of an attribute l of a policy j in task t of a respondent i, L is the number of attributes, Dl is the number of levels of an attribute l, β_{ld} is its coefficient, and u_{itj} denotes the error term. Then, $y_{itj} \in \{0, 1\}$ is a choice indicator variable for the estimation of the internal choice probability. $y_{itj} = 1$ if the preference rank of policy j is higher than its alternative policy. In the estimation of the external probability, $y_{itj} = 1$ if the preference rank of a policy j is higher than the status quo.

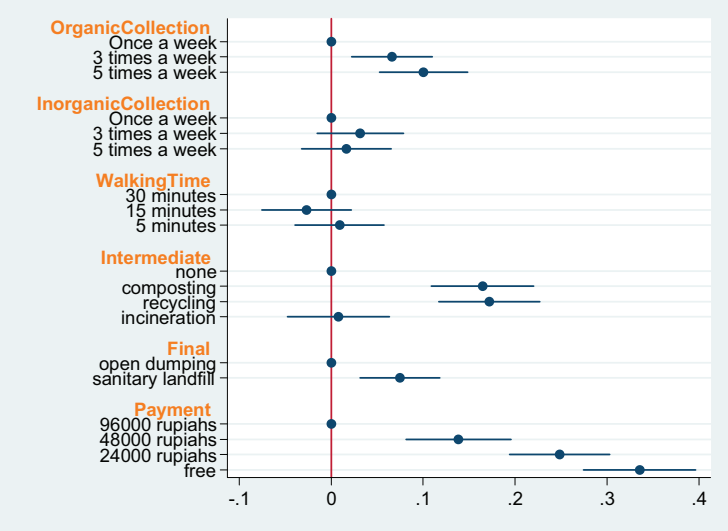
Even though the respondents are randomly chosen from the population, there is a possibility that there is a correlation of the observed choice outcomes because the unit of analysis in this regression is not the respondent but each alternative in each task of each respondent. To avoid the bias from such correlations in error terms, as suggested by Hainmueller, et al. (2013), clustered-robust standard errors at the respondent level are used in all regressions.

3 Results and Findings

Following the estimation strategy as above, we estimate the average marginal component effect (AMCE) of each of the policy attributes and observe the influence on the respondents' acceptance probability. Hainmueller, et al. (2013) state that the ordinary least square (OLS) method can be used to estimate the coefficients from the linear regression of the choice indicator on the set of dummy variables for the levels of the attributes. This estimation provides unbiased and consistent AMCEs because we use independent randomized attribute levels in each choice set. In this research, we estimate both the internal and external choice probabilities of hypothetical waste collection services. As stated above, the external choice probability shows the estimation of choosing a proposed policy compared to the status quo i.e. the current waste management system in the survey area. This differs from the internal choice probability, which only estimates the probability of choosing between two proposed policies without considering the status quo. Following sections discuss these results in turn.

3.1 Internal Choice Probability

The internal choice probability explains the probabilities of choosing a proposed policy among the two proposed policy, excluding the status quo. The estimated component effect of the hypothetical waste collection service attributes on the internal choice probability is shown in Figure 4. The result of the internal choice probability shows that the Organic Collection, Intermediate and Final attributes have statistically significant positive effects on the hypothetical waste collection services, while there are no significant effects from the Inorganic Collection and Walking Time attributes. In addition, the Payment attribute also gives a significant



Notes: The figure describes the estimated AMCEs for each policy attribute with specific levels using the clustered-robust 95% confidence interval (horizontal bars) in which the robustness levels are the respondent clustering. In the figure, the six attributes are located on the left side, including their respective levels, with the worst level as the baseline, which is illustrated by the solid circle on the zero line without showing the interval estimates. The baseline reference levels are as follows: "once a week" for the Organic Collection attribute, "once a week" for the Inorganic Collection attribute, "30 minutes" for the Walking Time attribute, "none" for the Intermediate attribute, "open dumping" for the Final attribute, and the highest payment of "96,000 rupiahs" for the Payment attribute.

Figure 4: Average marginal component effects on the internal choice probability

effect in that the lowest payment has a positive effect on the internal choice probability.

For the frequency of the organic waste collection services attribute (Organic Collection), two levels provide positive effects on the respondent's choice probabilities relative to the baseline, showing that level 2, which is a three times a week organic waste collection service, increases the respondent's choice probability to support a new waste management policy, especially with a waste separation system, by approximately 7% compared over the first level, i.e., once a week organic waste collection service. A more significant effect is shown by the third level, which is a five times a week organic waste collection service, that will increase respondent's choice probabilities by more than 10% over the benchmark of once a week collection. For the inorganic waste collection frequency attribute (Inorganic Collection), frequency does not seem to matter. Both superior levels namely three times and five times a week collection do not give significant estimates compared to the baseline.

Another insignificant estimation can also be seen in the walking time to the nearest temporary waste shelter attribute (Walking Time). The two levels namely 5-minute or 15-minute walking time do not provide any significant effects on the respondent's choice probability over the benchmark of 30 minutes. For the intermediate processing facilities attribute (Intermediate), the third level, which is recycling facilities, unexpectedly provides the highest effect on increasing respondent's choice probabilities to support new waste collection services, showing an increase of approximately 17% relative to the baseline (there are no intermediate processing facilities). The implementation of composting facilities (the second level) will increase respondent's probability to support the new waste management by approximately 16% compared to the baseline. However, the fourth level, incineration facilities, does not provide a clear estimation of the respondent's choice probability. For the final disposal facilities attribute (Final), the second level (sanitary landfill) provides a

positive effect on the respondent's choice probability. The sanitary landfill will increase the probability by approximately 7% relative to the baseline (open dumping).

For the Payment attribute, the natural effects are shown from the choice probabilities, in which the free monthly payment will have the biggest impact of the payment levels in terms of increasing the respondent's choice probability for the new waste collection services. A free monthly payment will increase the choice probability by approximately 34%, followed by 24,000 rupiahs with approximately 25% and 48,000 rupiahs with approximately 14%, all of which are compared to the baseline, which is 96,000 rupiahs or the highest monthly payment for the waste collection services.

According to the internal choice probability result, the intermediate processing facilities have the greatest influence on respondent decisions to support the new waste collection services compared to the other attributes. The implementation of intermediate processing facilities such as recycling and composting facilities will increase public support of a waste separation system. The implementations of recycling and composting facilities will have higher impacts than reducing monthly payments from 96,000 rupiahs to 48,000 rupiahs (approximately, eight to four US dollars). In addition, respondents seem like consideration of organic waste collection more than that of inorganic waste collection, which is proved by the significant effect of the organic waste collection on their support of the new waste management policy. In addition, the respondents prefer to have more frequent organic waste collection services, which may correlated to the smell of organic waste. It seems that the respondents are also aware of the final disposal facilities that are less harmful for the environment because they prefer sanitary landfills as the final disposal facility over open dumping.

3.2 External Choice Probability

The external choice probability estimates the probability of supporting a proposed policy rather than the status quo. The results of the external choice probability have similar trends to those of internal choice probability, although many attributes exhibit insignificant coefficient unlike in the internal choice probability. The estimated external choice probability is summarized in Figure 5. As can be seen in Figure 5, except for the payment attribute, only the organic waste collection frequency of five times a week has a significant impact on the peoples' acceptance of the proposed policy. This implies that respondents prioritize the frequency of the organic waste collection services over the other attributes. More precisely, for the Organic Collection attribute, while the second level (three times a week) does not clearly increase respondent choice probability to support the new waste management policy, the third level (five times a week organic waste collection services) shows a positive effect compared to the baseline (once a week). The result indicates that if the frequency of organic waste collection service is increased to five times a week from the benchmark of once a week, the respondent choice probability of supporting the new waste management policy will increase by approximately 5.5%. For the Inorganic Collection attribute however, the both levels superior to the benchmark –three times and five times a week– do not give any clear estimated changes relative to the baseline of once a week. These results imply that residents are more concerned about the collection frequency of organic waste, not about that of inorganic waste.

For the Walking Time, Intermediate, and Final attributes on one hand, all levels that are better than the benchmark (30 minute walking time, no intermediate processing facilities, and open dumping respectively) do not have statistically significant effects, meaning that they do not have any effect on the respondents' policy acceptance probability for supporting the new waste collection services. On the other hand, for the

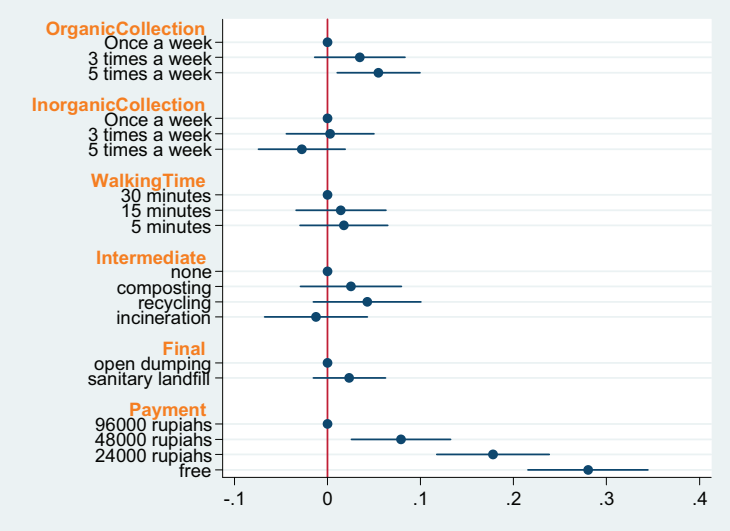
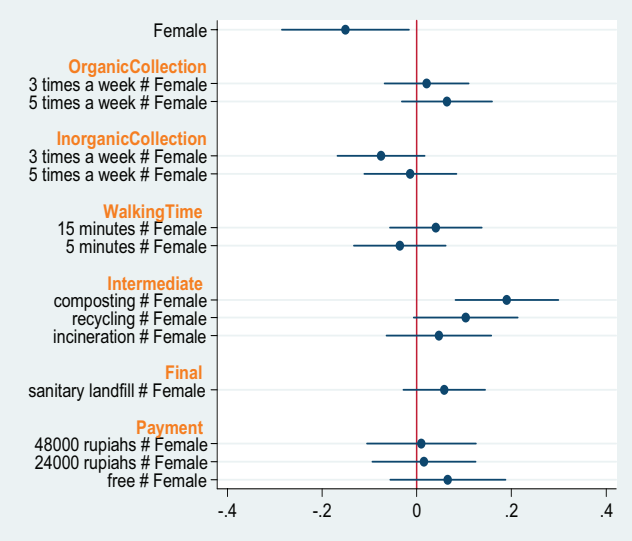


Figure 5: Average marginal component effects on the external choice probability

Payment attribute, the external choice probability shows the same trend as the internal choice probability. The lowest payment, which is a free monthly payment, provides the biggest impact in terms of increasing the respondents' choice probability to support a new waste management policy relative to the other monthly payments. Free monthly payments will increase the respondent choice probability by 28%, followed by that of 24,000 rupiahs (about two US dollars) with approximately 18%, and 48,000 rupiahs (about four US dollars) with approximately 8%, all of which are relative to the baseline of 96,000 rupiahs (the highest monthly payment of about eight US dollars).

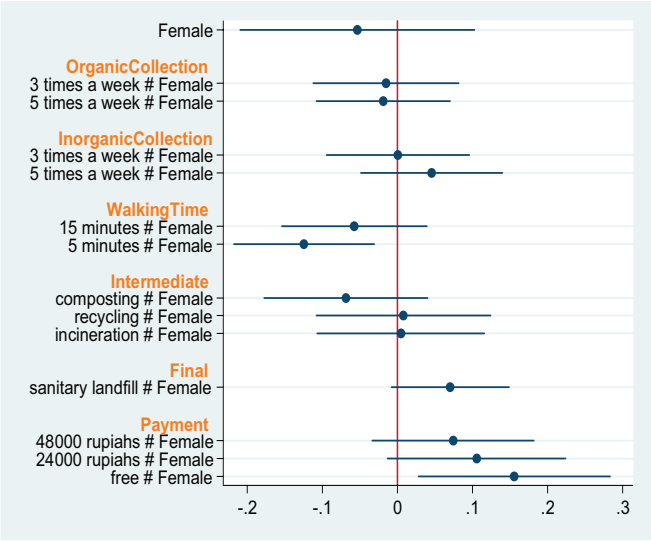
According to the external choice probability result, the constant term of the estimation is considerably low, reaching only 17%. This means that the percentage of people who will support the new waste collection service at the benchmark (the worst set of attributes) is just 17%. However, the implementation of the most preferred waste management policy will gain majority support of waste separation. If the government introduces the waste collection service which consists of the a 5 times a week organic waste collection service, recycling as the intermediate processing facility, sanitary landfill as the final disposal facility and free monthly payment, then the policy acceptance rate will increase to approximately 59%.

Interaction Effects To understand personal preferences of waste collection services based on their characteristics, we estimated the interaction of AMCEs with these characteristics, and combined these with the internal and external choice probabilities. Among those respondent characteristics such as gender, age, years of education and monthly income, a note must be made on the results of gender characteristics (see Figures 6 and 7). Results of the internal choice probability shows that the implementation of composting as an intermediate disposal facility will increase the probability to support the new policy of the female respondents by as high as 19%. More interestingly, the external choice probability results show that male does not like to walk too long to waste station, while female respondents care more about the cost of the services. When the monthly payment of the waste collection is free, the policy acceptance probability of the female respondents will increase by approximately 15% relative to male.



Notes: Male is the benchmark and consists 52% of the entire sample, while Female is the rest of 48%.

Figure 6: Interaction of causal effects on the internal choice probability with gender



Notes: Male is the benchmark and consists 52% of the entire sample, while Female is the rest of 48%.

Figure 7: Interaction of causal effects on the external choice probability with gender

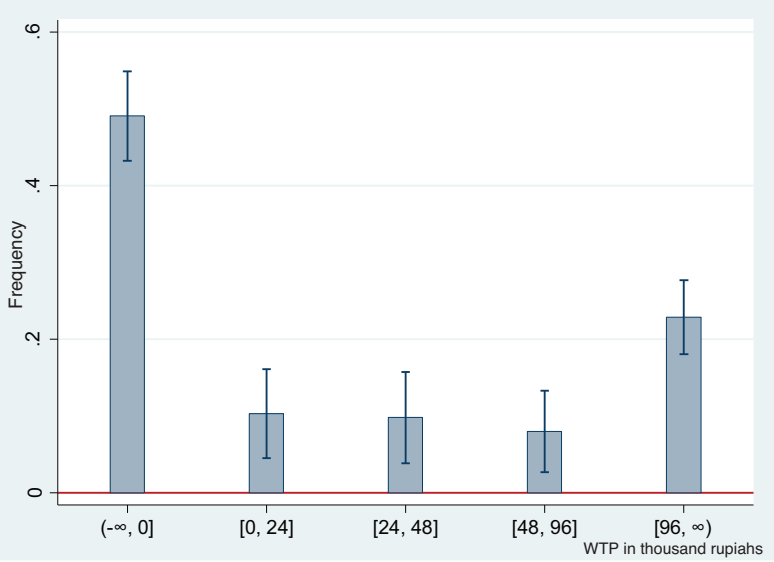


Figure 8: Density of willingness to pay distribution for the acceptance of proposed waste management policy.

Welfare Analysis Randomized conjoint experiment designed by Hainmueller et al. (2013) allows us to partially identify the distribution of the willingness to pay (WTP), and to compute the lower bound of the average WTP for accepting the proposed policy.[8] Willingness to pay is a measure often used in policy evaluation and policy-making decisions (see for example Arrow et, al., 1993 and Alberini and Cooper 2000). Figure 8 shows the distribution of willingness to pay to accept the proposed waste management policy. As can be seen in the figure, slight majority of the people have the positive willingness to pay, supporting our basic findings that the policy will gain majority support with free monthly payment. Figure 9 shows the relationship between the average WTP of those against the policy (i.e., those with negative willingness to pay to accept the policy) in the horizontal axis and the lower bound of the average WTP over the entire respondents in the vertical axis. It shows that as long as the average willingness to pay among the negative-WTP people is greater than $-57,000$ rupiahs, the lower bound of the average WTP is positive, or in other words, society gains positive welfare by introducing the modern waste management policy.

4 Conclusion

Secondary cities in Indonesia are now left behind in modernizing the waste management policy, unlike its capital city of Jakarta. This research examined the people's preference toward a modern waste collection and processing services including waste separation in Sleman Regency based on a randomized conjoint field experiment. Internal choice probability estimation results indicate that recycling and compositing as intermediate processing facilities are preferred by the respondents once the policy is introduced. In addition to the intermediate processing facilities, respondents are also aware that sanitary landfill as the final disposal facilities is less harmful to the environment over open dumping. According to the external choice probability

[8]The idea derives from that of Bhattacharya (2015) who provided a point estimate of willingness to pay. The method allows us to compute the willingness to pay non-parametrically, without relying on restrictive assumptions. See Appendix for technical details of computation of the willingness to pay and its lower bound.

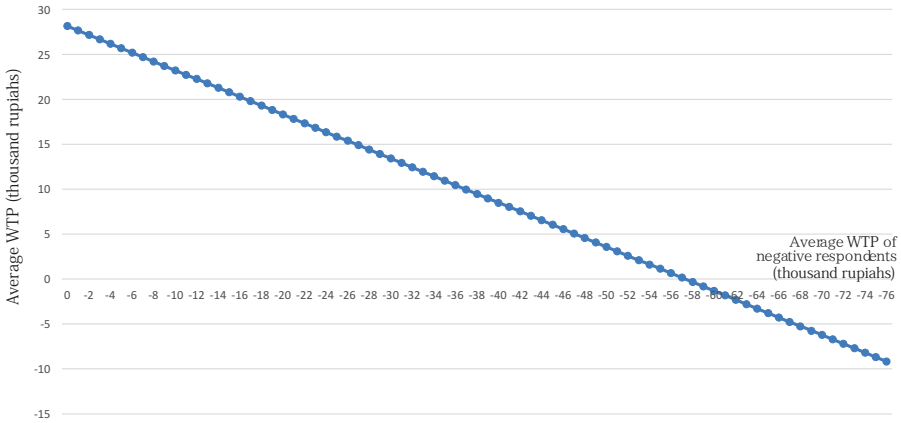


Figure 9: Average willingness to pay (vertical axis) with respect to the average willingness to pay of those against the policy (horizontal axis).

estimation results, the waste collection services which have five times a week organic waste collection will gain people's support of new waste management policies including waste separation. If the government introduces the waste collection service which consists of the most preferred levels and attributes, which includes a free, 5 times a week organic waste collection service, then the majority of the people will support the new waste management policy, which is considered to reduce waste at the source.

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Appendix: Derivation of Average Willingness to Pay

Here we provide the derivation of the average willingness to pay for accepting a policy, as well as its lower bound.[9] Let $f(X|\boldsymbol{a})$ be the density of people whose willingness to pay to accept the policy of which all attributes' values (except the Payment attribute) are given by a vector $\boldsymbol{a}$ is equal to X, and let $F(X|\boldsymbol{a})$ be its cumulative density such that

$$F(X|\boldsymbol{a}) = \int_{-\infty}^{X} f(x|\boldsymbol{a})\,dx.$$

Note here that if we denote by $q(X,\boldsymbol{a})$ the external choice probability of a policy with Payment X and other attributes $\boldsymbol{a}$ against the status quo (i.e., no policy), then we immediately have

$$F(X|\boldsymbol{a}) = 1 - q(X,\boldsymbol{a}).$$

Marginal distribution of the willingness to pay is then obtained simply by summing the above over the attribute space:

$$F(X) = \sum_{\boldsymbol{a}} F(X|\boldsymbol{a})\,p(\boldsymbol{a})$$

where $p(\boldsymbol{a})$ is the relative frequency of attribute combination $\boldsymbol{a}$ given X. Finally, let $F^{-1}(F)$ be the inverse of $F(X)$. Then the average willingness to pay is simply obtained as $\int_0^1 F^{-1}(\phi)\,d\phi$.[10]

We know from the obtained results the estimates of external choice probability for each policy $q(X,\boldsymbol{a})$ at $X = 0$, 24,000 rupiahs, 48,000 rupiahs, and 96,000 rupiahs respectively. This identifies the distribution of cumulative marginal willingness to pay distribution $F(X)$ piecewise at these values of X as well as $X = -\infty$ and $X = +\infty$, namely, $F(-\infty) = 0$ and $F(\infty) = 1$. The average willingness to pay can be decomposed at these X as

$$\sum_{i=0}^{4} \int_{F(X_i)}^{F(X_{i+1})} F^{-1}(\phi)\,d\phi$$

where $X_0 = -\infty$, $X_1 = 0$, $X_2 = 24{,}000$ rupiahs, $X_3 = 48{,}000$ rupiahs, $X_4 = 96{,}000$ rupiahs, and $X_5 = \infty$. Since the cumulative distribution F is monotonically increasing in X, it must be that

$$\sum_{i=0}^{4} \int_{F(X_i)}^{F(X_{i+1})} F^{-1}(\phi)\,d\phi \geq \sum_{i=0}^{4} X_i\left[F(X_{i+1}) - F(X_i)\right]$$

where the right hand side provides the lower bound of the average willingness to pay for the policy acceptance.

[9] The method is first derived and applied to the case of water quality improvement policy of Inlay lake in Myanmar by Hninn et al. (2017).

[10] Applying the integration by parts and also by substitution to the definition of the average willingness to pay $\int_{-\infty}^{\infty} X f(X)\,dX$ yields the result.