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A Nonparametric Welfare Analysis on Water Quality Improvement of the Floating People on Inlay Lake via a Randomized Conjoint Field Experiment

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Abstract

This study evaluates the potential surplus gain of a water improvement policy and the causal effects of its components on choice probabilities for the floating people on Inlay Lake, Myanmar, based on a randomized conjoint field experiment. In our experimental design, respondents rank three options: two alternative policies and one status quo. We then present a method that enables us to estimate the minimum willingness-to-pay for a policy in the form of compensating variations under a set of weak assumptions using this conjoint data. Results show inter alia that the provision of toilet facilities and a collective wastewater treatment, and joint implementation of the policy by the government and local NGOs have a positive effects on the choice probabilities. Results also show that the surplus gain from a water-quality improvement policy is at least as large as 22.9% of the average annual per-capita income of those on the lake.

JEL Codes: Q53, Q56, Q58

Keywords: eutrophication, randomized conjoint experiment, nonparametric welfare analysis, envirodevonomics

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1 Introduction

Envirodevonomics argues underscore of field measurements of the marginal willingness-to-pay for improvements in environmental quality in developing countries, mainly due to market failure (Greenstone and Jack 2015). Well-informed respondents, with their higher availability of credit and clear property rights, would likely enhance their investment for a better environment. There are also potential challenges with regard to measurement errors and biases in field experiments on stated preferences in developing countries (Whittington 1998, Durand-Rorat *et al.* 2015). Nevertheless, considering their significance in terms of future global environmental sustainability and sustainable development, additional empirical evidence is needed from developing countries to improve our understanding of these difficulties. Therefore, this study provides new empirical findings in the emerging field of Envirodevonomics. Here, we conduct a non-parametric analysis of welfare gains, using primary data from a conjoint field experiment on hypothetical water quality improvement programs for Inlay Lake, Myanmar. The objective of the study is to show that the willingness-to-pay and the welfare gain are significantly high if a water quality improvement program is implemented, where both pollution control and conservation of natural resources of the lake are considered (Perrings, 2014). Note that this study does not directly quantify the willingness-to-pay for improvements in water quality, but rather the willingness-to-pay for policy programs that aim to improve water quality.

In our experimental design, respondents rank three options in terms of their personal preference: two water quality improvement programs and one that maintains the status quo. Each program is characterized by multiple attributes. These include the financial burden, program period, type of implementer, and additional services, such as the provision of a toilet system, collective water treatment of manufacturing wastewater, garbage collection, and an agriculture assistant that provides standardized optimal inputs of organic fertilizer and/or pesticide. This study provides two types of estimators. The first type is the causal effects of policy attributes on the probability that individuals choose a policy program. This probability can be interpreted as the extent of the public support for the policy program. Our results show that among additional services, toilet provision has the largest positive impact on public support. Additionally, we find that people prefer programs implemented jointly by the government and local NGOs, rather than by the government on its own. The second type of estimator is the willingness-to-pay for a water quality improvement program. We show that the lower bounds of the willingness-to-pay can be estimated non-parametrically from our experiment data, and that the lower bound of the surplus gain is considerably large (22.9% of per-capita income in the study area). Then, we compute the conditional average welfare gains, which allows us to examine the welfare impacts of each policy attribute. Our analysis shows that, even for the lower bound of the surplus gain, the toilet provision service and the joint implementation between the government and local NGOs have positive impacts.

This study makes four contributions to the existing literature. First, we examine the floating villages in the northern part of Inlay Lake, Myanmar, because they are some of the most nature-dependent economies in the world. Both the quantity and quality of the water have been deteriorating in the lake, which has increased the awareness and concern of those living on the lake. Individual sources of income vary within the economy, including traditional fishing, tomato production on the floating gardens, and tourism (*e.g.*, restaurants and hotels, boat drivers, handcrafting, and dying and silver manufacturing). However, most depend on, or are affected by the condition of the lake water *via* changes in ecological services and natural resources. Moreover, compared with the income sources, the livelihoods of the villagers depend more homogeneously on the lake water. Boats, with and without engines, are the only means of transportation, even when visiting a neighboring house. The villagers still use the lake water for bathing and for washing their clothes and dishes. However, the recent pollution of the lake water has meant that drinking water and water for cooking have to be secured by a pipe from spring water reservoirs or groundwater wells from the surrounding land, or from delivery tanks or rainwater. The source of water depends on people's location and wealth. As a result, 11.62% of the villagers in our sample area still drink lake water. The lake is also a sink for human waste and garbage, although some villagers take their garbage to surrounding land areas for burning. However, to the best of our knowledge, few studies quantify the welfare gain from water quality improvement programs for the floating people of Inlay Lake, or for any other lakes around the world.

Second, in collaboration with the local government and a local NGO, we successfully collect an up-to-date list of villages and all names of the household heads of Nyaung Shwe Township. Then, based on our definition of a floating village as one where all villagers reside on the lake, we identify 17 floating villages comprising 2,284 households and 13,794 people. From these, we randomly select 327 households.[1] Since there is relatively large disparity in population size among villages, we apply stratified random sampling by village, with sampling rates between 13.5% and 15.0% over the 17 villages. Note that one of authors visited and met all selected households and conducted the survey within one month. No respondents were missing from the original list of selected households. The other co-authors participated either in the preliminary survey or the pilot survey.[2] Considering the various implementation challenges in developing countries, this ideal random sampling at the household level and the consistent survey should minimize any sampling bias.

Third, our conjoint field experiment for collecting stated preferences over hypothetical policy alternatives follows a new approach proposed by Hainmueller, Hopkins, and Yamamoto (2014). Conventional conjoint analyses were introduced in the early 1970s by Green and Rao (1971), and are now widely used in various fields, including environmental evaluation.[3] However, these techniques are not based on the potential outcomes framework of causal inference (Neyman 1923, Rubin 1974). The new method by Hainmueller, Hopkins, and Yamamoto (2014) revised the conventional conjoint analysis in the framework of randomized experimental design in order to estimate the causal effects of a policy and its components. Using their approach, 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

[1] Khin (2011) noted that there are 35 floating villages with 20,000 people. However, half of these villages include residents who are not floating on the lake. We target only those villages where all residents reside on the lake at the time of our survey.

[2] The preliminary survey was conducted for six days from October 8–13, 2014, to collect 30 samples, mainly by means of interviews. The pilot survey was conducted for 10 days from October 7–16, 2015, collecting 50 samples for the conjoint field experiment. The main survey was conducted between December 29, 2016, and January 25, 2017.

[3] See Holmes and Adamowicz (2003) for the history of the conventional conjoint analysis.

the choice decision non-parametrically. A criticism of conjoint survey experiments is their external validity, because respondents face hypothetical choices and do not have a monetary incentive to provide their true preference. However, Hainmueller, Hangartner, and Yamamoto (2015) provided evidence that the results of the new conjoint analyses are closely consistent with the results based on a natural experiment, which supports the external validity of the conjoint analysis. Thus, the number of studies that use a similar approach to examine people's preferences for public policies is increasing. These include studies on international environmental agreements (Bechtel and Scheve 2013, Gampfer, Bernauer, and Kachi 2014, Bernauer and Gampfer 2015) and migration policies (Hainmueller and Hopkins 2015). However, no studies apply this approach to domestic or regional environmental policies. Moreover, all existing studies target people in developed countries or urban area of developing countries, while we focus on the policy preferences of people in rural area of a developing country.

Lastly, and most importantly, we propose a new method of a bounded estimation of the welfare gains expected from implementing different proposed policy programs by expanding on the work of Bhattacharya (2015). The new proposed conjoint analysis has been applied in the field of politics, but has yet to be applied to environmental or development economics. Thus, our extension of the method to economic analyses, including welfare analyses, broadens the areas within which the method can be applied. Using the conjoint experiment data, we identify the lower bound of the impacts of a policy implementation on the welfare of village people non-parametrically.

The remainder of the paper is organized as follows. The next section provides a brief overview of the water quality of Inlay Lake. Section 3 explains our survey design, including the random sampling, the design of the conjoint experiment and household survey, and the pilot and the main survey. Then, Section 4 provides the theoretical grounds and modeling framework, followed by a discussion of the empirical methodologies in Section 5. Finally, Section 6 summarizes our main findings, and Section 7 concludes the paper.

2 Water Quality of Inlay Lake

Inlay Lake is the second largest wetland in the country (Su and Jassby 2000) and is located in Nyaung Shwe Township, Taunggyi District of Southern Shan State in Myanmar. The lake is well known by domestic and international tourists for its rich cultural heritage and biological diversity. The Inlay Lake Wildlife Sanctuary, established in 1985, became an ASEAN Heritage Park in 2003 and part of the World Network of Biosphere Reserves of UNESCO in 2015.

Long-term steady demographic pressure and intensifying economic activities have resulted in water quality degradation (*i.e.*, eutrophication), as well as associated environmental problems of the lake. The population of Nyaung Shwe Township increased steadily from 77,000 to 189,000 between 1973 and 2014, with an average annual growth rate of around 2.2% (Su and Jassby 2000, Ministry of Immigration and Population 2015).

As one of the main economic activities, tomato farming on the floating gardens now generates two-thirds of the regional agricultural production (Butkus and Myint 2001).[4] Consequently, 32.4% of open surface water area, or 46.7 km^2, was lost between 1935 and 2000, mainly because of the development of the floating gardens (Sidle *et al.* 2007). The use of chemical fertilizers and pesticides to improve the productivity of tomato farming has increased, with Butkus and Myint (2001) reporting that these were already being overused 15 years ago. Therefore, one of the causes of eutrophication is considered to be the excessive use of fertilizers and pesticides for tomato production, yet another is human waste disposal. Although scientific evidence through regular monitoring and/or ad-hoc research is minimal, Akaishi *et al.* (2006) found that the concentrations of PO4-P, NO2-N, and NO3-N are relatively high in the Inlay Lake water. They also found *E.coli* or coliform bacteria in the surface water of the lake, which can cause diarrhea if the water is not treated before drinking. Nevertheless, some village people still use lake water as drinking water, while most houses dispose of excretions directly into the lake. It is clear that an appropriate public policy program for the lake is urgently needed.

In order to improve the water quality and the environment of the lake, various stakeholders including state government departments, the local government, international organizations (*e.g.*, donor agencies and the United Nations), and international NGOs have been striving for conservation through programs and projects. At the same time, local NGOs known as community-based organizations (CBOs) have been established. There are currently approximately 20 local CBOs working on community development activities, including environmental conservation in the Inlay Lake area. However, there has been little improvement so far in the quality of the lake water (UNDP 2014), because most activities are small and independent public awareness and training activities. Therefore, large-scale and comprehensive countermeasures are required, including improvements in sanitary and environmental infrastructures and regulations.

3 Survey Design and Implementation

3.1 Scenario

Water flowing into Inlay Lake through several river channels varies in terms of volume and quality, where the lake water flows slowly downstream. When there is heavy rain in the upstream watershed, some rivers supply fresh water, while others supply high-sediment water, which have different impacts on the quality of the lake water. At the same time, the spatial maldistribution of floating houses and gardens, as sources of pollutants, contributes to the large variation in the quality of the water. Despite such hydrological complexity, there is insufficient information on the changes and variations in water quality to be able to generalize the water quality in time and space. Therefore, the scenario of the experimental survey employs a narrative of water quality improvements, which is free from scientific information of the respondents. The following is the scenario given to the respondents before conducting the conjoint experiments.

[4] Floating gardens are large blocks of organic-rich soil brought from the wetlands around the lake (Sidle et al. 2007). These must cope with decayed grasses, reeds, marsh plants, and aquatic plants excavated from the lake bottom.

"We would like to propose several different public policy programs for improving water quality of Inlay Lake. We assume all of the proposed programs will equality bring same achievement in the water quality improvement, that is, the improved water quality is ensured to be good for cooking anywhere and anytime in the lake but may not be good for drinking. It should be also noted that the collected money is fully and properly used for attaining aforementioned goal in the water quality improvement. The project is primarily implemented by local government with the collected money"

Since the status quo of the water quality varies among respondents, the concept of improvement also varies. However, these heterogeneous variations across respondents are captured by individual preference parameters.

3.2 Conjoint Experimental Design

There are several versions of conjoint experiment design in terms of choice set and choice making. In a version, a choice set has two alternatives, from which a respondent must choose one. In another version, a choice set includes a third alternative, namely maintaining the status quo, or not choosing one of the first two alternatives. Here, there are at least two variations; one is choosing the best option and another is ranking the alternatives. From the first dichotomous choice to the ranking, the burden on respondents is increased to allow richer information to be collected. We confirmed from our pilot survey that respondents clearly understand the scenario and the choices. Thus, we selected the version in which they rank three alternatives including the status quo.

Each alternative is a proposed policy program and is characterized by seven attributes. The first attribute is a toilet system ($TOILET$), with three levels. The first level offers that the local government provides a toilet and a collection tank for each house. The second level adds a collection service by the government to the first level. The third level assumes no toilet system is provided. The second attribute is a garbage collection service ($GARBAGE$), with two levels: once-a-week collection and no service. Although different frequencies of collection service were tested in the pilot survey, there was not much difference in preferences across the frequencies owing to a lack of familiarity with the service. At the same time, villagers are eager to have such services. Thus, the first level is once a week, as the most preferred option in the pilot survey, and the second level is no garbage collection service. The third attribute is a collective public wastewater treatment facility for dying and silver gilt ($WASTEWATER$), introduced and operated by the government, with two levels: with and without the service. The original scenario in the pilot survey had three levels, differentiating between a mandatory connection and a voluntary connection. However, there was no significant difference between the two connections in the pilot survey. Thus, the first level offers the facility provided by the government and the second level is that no facility is provided. The fourth attribute is government regulation and guidance on optimal fertilizer and pesticide inputs for tomato production ($FERTILIZER$). This assumes a new government service for tomato farmers, from research activities on optimal inputs of fertilizer and pesticide to regulatory guidance for farmers, based on the results of the study. The first level assumes government services are provided only for fertilizer input, while the second level assumes they are only provided for pesticide inputs. The third level provides for both. Although there is no clear difference in the preferences across the three levels in this attribute, we suspect there are heterogeneous preferences among tomato farmers and others in the pilot survey. Thus, we decide to keep the three levels in the main survey.

In addition to the first four attributes defining different services offered by the local government, three more attributes are added to specify the characteristics of the proposed policy programs. The first is the project period (*PERIOD*), with three levels that specify the duration wherein the predetermined common narrative target is achieved. This attribute captures respondents' preferences on how intensively and immediately the project should be implemented to attain the goal. The first, second, and third levels are set to 5 years, 10 years, and 20 years, respectively. The next attribute is the implementing organizations (*ORGANIZATION*), with two levels: the government alone, and jointly with local NGOs. As mentioned earlier, it is widely accepted that third parties such as NGOs or CBOs play a role in the public policy programs with the governments and villagers in the area. Because it is evident that government services are not leading to sufficiently higher expectations by the third parties, we received a strong preference toward joint implementations between the government and local NGOs in the pilot survey. Thus, the first level overs only government implementation, and the second level is a joint implementation. The last attribute is payment (*PAYMENT*), with three levels. The selection of payment vehicles and the range of levels were examined carefully in the pilot survey. Initially, the pilot survey used three levels of monthly payments during the given project period, from 3,000 Kyats 15,000 Kyats, where 3,000 Kyats is the hourly wage for unskilled labor work in the area. The result of the pilot survey revealed that even 15,000 Kyats would not strongly discourage the willingness to support the policy programs. As a result, we modified the range to 5,000 Kyats to 20,000 Kyats, with four levels. It is worth mentioning that a cash donation to Buddhist temples is common practice in the study communities. Thus, we suppose that credit liquidity is sufficient to employ cash payments in this study. Moreover, our sample shows that the average household donation per month is slightly more than 20,000 Kyats, which accounts for 6.7% of household income.

The seven 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 a choice set is given in Appendix I).[5] Each respondent is required to make a ranking decision three times for three different choice sets. Hence, 144 households consume 432 choice sets, if each choice set is different.[6] In our survey, we repeatedly use 144 groups of three choice sets, where each group is used either 2 or 3 times, given that we have 327 respondents.[7]

[5]That is, of the 372,816 potential pairs, 432 are selected randomly.

[6]The order of attributes given in the choice set is fixed, despite the literature suggesting that the order be changed randomly. However, because this causes confusion and difficulty for respondents, we give priority to reducing the burden for repeated choice decisions.

[7]In the main survey, we use printed copies of choice sets. In the pilot survey, we used a computer. The reason for the change is that computer screens occasionally make it difficult to communicate with respondents in their houses.

3.3 Collected Data and Sample Profile

The types of data collected from the main survey, conducted from December 27, 2016, to January 25, 2017, after the final confirmation of the revised scenario from December 24–26, 2016, can be divided into two categories. The first category is the choice preferences for the proposed policy programs. Here, we can further derive two types of data from the ranking information, namely internal choices and external choices of preferences, with appropriate coding. The internal choice of preference compares the ranking between two proposed policy programs, wherein 1 is assigned to alternative with the higher ranking, and 0 otherwise, irrespective of the ranking of the status quo.

The external choice of preference compares the ranking between the status quo and other two alternatives. Here, 1 is assigned to any policy alternative with a higher ranking than that of the status quo, and is 0 otherwise. Note that if the ranking of the status quo is the highest or the lowest, both two alternative policy programs assign 0 or 1. One can argue that both internal and external choices of preferences have pros and cons. Obviously, the internal choice cannot guarantee that the proposed policy alternatives are preferred over the status quo, while the preference information between the two policy alternatives is lost in the above-mentioned cases of external choice.

The second category is household survey data, which consists of six subcategories: (1) a household roster, whereby basic information (ethnicity, religion, age, gender, education, and job) and the mutual relations of all family members are identified; (2) income generation, whereby the sources of household income for the last 12 months are quantified, with possible calculations including wage and working hours, quantities of production, selling prices, necessary costs, and so on; (3) living conditions, including water supply, toilet, garbage disposal, and health conditions; (4) durable goods, including the possession and purchasing history of major durable goods; (5) financial conditions, such as debt, savings, and donations for the previous 12 months; and (6) environmental awareness, which includes perceptions on recent changes in the quality of the lake water, as well as three major causes from a given list and respondents' level of understanding of the scenario for conjoint experiment.

The characteristics of our sample data from the 327 households are as follows. Slightly more than half of all respondents are female (51.38%) and the average age is 44.7 years. Nearly 60% of the household heads completed up to a primary level of education (59.33%), 21.10% completed up to middle school, and 3.98% and 1.83% are high school and collage/university graduates, respectively, whereas 13.76% are illiterate. Family size ranges from 1 to 11, with an average size of 4.7. The total annual household income ranges from 360,000 Kyats (300 USD) to 21.6 million Kyats (18,000 USD), with an average of 3.6 million Kyats (3,000 USD). Moreover, the average per capita income is 840,000 Kyats (700 USD), with a range of between 158,000 Kyats (131 USD) and 5.4 million Kyats (4,500 USD).

[Table 1 around here]

In all, 43.43% of household heads are engaged in farming, and typically tomato production (see Table 1). In Inlay areas, farmers cultivate tomatoes for six months, starting from March or April, and do other jobs for the rest of the year, such as fishing, carpentry, and seasonal jobs. Although tomatoes can be harvested after 40 days from shedding seeds, farmers divide their floating gardens into blocks, and seeding and harvesting are scheduled to be repeated every 6 weeks to 14 weeks. Thus, farmers are usually engaged in tomato farming for six months. It is specially noted that in 2015, tomato production in the delta region in the south of the country, which is a competitor of Inlay tomatoes, was severely damaged by flooding. As a result, tomatoes from Inlay enjoyed higher prices, approximately double the usual price, which inflates our income statistics. On the other hand, fishing is more common as a secondary job (77 household heads) than as a primary job (44 household heads). Fishing used to be a high-income source in the past, but fishery resources have decreased, particularly the Inlay carp (Cyprinus Carpio Intha), known locally as nga-phein, which have diminished owing to sedimentation and eutrophication (Su and Jassby 2000).

[Table 2 around here]

In addition to the job structure of household heads, Table 2 summarizes the total household income by source. Because household heads and other household members usually have multiple jobs, it is important to know the economic implications of these jobs. From our survey sample, we aggregate all income sources from all sample households. The economic significance of farming is the largest, with 36.13% of the total, which is lower than the share of farming in the primary jobs of household heads (43.4%). This gap implies a diversification of income sources. Although fishing was replaced by tomato farming, approximately 15% of income is still generated by fishing. Relatively few villagers engage in small businesses, but these generate relatively large profits (around 10%). In contrast, 85 households (26%) generate income from local cheroot cigarette businesses as a main supplementary income source. However, this contributes only 5% of income, even though it is a prevailing activity.

[Table 3 around here]

The respondents are asked to give their perception of recent (the last five years) changes in the water quality of Inlay Lake. The results show that 48% of respondents perceive that the water quality of the lake is significantly worse, while 4.9% perceive no change, or that it has improved.

[Table 4 around here]

Table 4 summarizes the major suspected causes of water quality deterioration of Inlay Lake. During the preliminary survey and the pilot survey, we collected possible causes of water quality deterioration from the villagers, the local government, and local NGOs. Ten major water pollution causes were presented to the respondents, of which they needed to select at most three. The respondents provided multiple causes, with an average number of 2.48. Thus, they believe there are more than two possible causes jointly affecting the water quality. Two of the major causes, identified in more than half the cases, are the direct discharge of wastewater and night soil, and the use of fertilizer and pesticide for tomato production. Thus, respondents understand that they are causing the pollution. At the same time, respondents are also concerned about water scarcity and sedimentation from various indirect causes, such as forest degradation and climate change. As a source of pollution, few respondents believe that people living upstream are causing the pollution.

4 Conceptual Framework

We show a simple model to illustrate the welfare implications from the choice data. The structural choice probability is first defined based on a simple, but therefore robust choice model, which is a key concept in examining the welfare implications. We then show that the welfare gain from a policy implementation can be recovered from the structural choice probability.

4.1 Choice model

Let us consider a policy consisted by n attributes. The utility of an individual i without policies, refereed as the status quo utility, is denoted by $U_0(\eta_i)$ where η_i is a preference parameter. The utility of an individual i under a water improving policy is denoted by

$$U(C, \boldsymbol{A}, \eta_i),$$

where C is the individual burden to implement the policy, and $\boldsymbol{A} = [A_1, A_2, ..., A_n]$ is a vector of attributes that are discrete. We naturally assume following properties of the utility function;

Assumption 1: For any $\boldsymbol{A}$ and η_i,$U(C, \boldsymbol{A}, \eta_i)$ is a continuous and decreasing function of C.

Assumption 2: For any $\boldsymbol{A}$ and η_i,$U(C, \boldsymbol{A}, \eta_i) \to -\infty$ if $C \to \infty$, and $U(0, \boldsymbol{A}, \eta_i) \geq U_0(\eta_i)$.

Assumption 1 implies that no individual prefer higher burden, and the continuity is needed to ensure the existence of the willingness-to-pay. Assumption 2 requires that individuals do not prefer to implement a policy with infinitely high burden and must prefer[8] to implement a policy with zero burden. This assumption is also needed to ensure the existence of the willingness-to-pay.

A policy is preferred than status quo if and only if

$$U(C, \boldsymbol{A}, \eta_i) \geq U_0(\eta_i),$$

The choice probability of a policy rather than status quo can be then defined as

$$q(c, \boldsymbol{a}) = \Pr[U(c, \boldsymbol{A}, \eta_i) \geq U_0(\eta_i) | \boldsymbol{A} = \boldsymbol{a}],$$

where c and $\boldsymbol{a}$ are realized values of C and $\boldsymbol{A}$. Note that $q(c, \boldsymbol{a})$ is referred as the structural choice probability in Bhattacharya (2015).

We can additionally define the marginal structural choice probability as

$$Q(c) = \sum_{\boldsymbol{a}} \Pr[U(c, \boldsymbol{A}, \eta_i) \geq U_0(\eta_i) | \boldsymbol{A} = \boldsymbol{a}] \times p(\boldsymbol{A} = \boldsymbol{a}). \tag{1}$$

[8] We abbreviate the term "weakly" here and after.

where $p(\boldsymbol{A} = \boldsymbol{a})$ is the joint distribution of the profile attributes. In the choice experiment of the current paper, the joint distribution is specified as the joint uniform distribution.

The conditional structural choice probabilities are also defined as

$$Q(c|A_l = a_l) = \sum_{\boldsymbol{a}_{-l}} \Pr[U(c, \boldsymbol{A}, \eta_i) \geq U_0(\eta_i)|\boldsymbol{A}_{-\boldsymbol{l}} = \boldsymbol{a}_{-\boldsymbol{l}}] \times p(\boldsymbol{A}_{-\boldsymbol{l}} = \boldsymbol{a}_{-\boldsymbol{l}}). \tag{2}$$

Note that because levels of attributes are independently determined in our choice experiment, $p(\boldsymbol{A}_{-\boldsymbol{l}} = \boldsymbol{a}_{-\boldsymbol{l}}|A_l = a_l) = p(\boldsymbol{A}_{-\boldsymbol{l}} = \boldsymbol{a}_{-\boldsymbol{l}})$.

Note that $Q(c)$ and $Q(c|A_l = a_l)$ can be estimated easily from the choice experiment data. Therefore, equations (1) and (2) provide interpretations of the estimated structural probabilities which are the share of individuals who prefer to implement a policy than to maintain the status quo.

4.2 Welfare gain

We now define the willingness-to-pay (WP), $C^{WP}(\boldsymbol{A}, \eta_i)$, under which an individual i is indifferent between a policy implementation and status quo. Formally, $C^{WP}(\boldsymbol{A}, \eta_i)$ can be defined as

$$U(C^{WP}(\boldsymbol{A}, \eta_i), \boldsymbol{A}, \eta_i) = U_0(\eta_i).$$

Note that Assumption 1 and 2 ensure the existence of $C^{WP}(\boldsymbol{A}, \eta_i)$. Moreover, Assumption 2 implies that for any $\boldsymbol{A}$, $C^{WP}(\boldsymbol{A}, \eta_i) \geq 0$.

It is difficult to estimate the admissible burden of each individual, while focusing on estimating the distribution and summary statistics. The cumulative distribution function of the willingness-to-pay can be defined as

$$F^{WP}(C|\boldsymbol{A} = \boldsymbol{a}) = \Pr[C^{WP}(\boldsymbol{A}, \eta_i) \leq C|\boldsymbol{A} = \boldsymbol{a}].$$

Assumption 1 implies that$U_0(\eta_i) = U(C^{WP}(\boldsymbol{A}, \eta_i), \boldsymbol{A}, \eta_i) \geq U(C, \boldsymbol{A}, \eta_i)$ if and only if $C \geq C^{WP}(\boldsymbol{A}, \eta_i)$. Thus, the above distribution can be rewritten as

$$F^{WP}(C|\boldsymbol{A} = \boldsymbol{a}) = \Pr[U_0(\eta_i) \geq U(C, \boldsymbol{a}, \eta_i)|\boldsymbol{A} = a],$$

and the marginal distribution function can be defined as

$$F^{WP}(C)) = \sum_{\boldsymbol{a}} \Pr[U_0(\eta_i) \geq U(C, \boldsymbol{a}, \eta_i)|\boldsymbol{A} = a] \times p(\boldsymbol{A} = \boldsymbol{a})$$

Combining this with the structural choice probabilities, equations (1) and (2), yields

$$F^{WP}(C) = 1 - Q(c), \tag{3}$$

and

$$F^{WP}(C|A_l = a_l) = 1 - Q(c|A_l = a_l). \tag{4}$$

Equations (3) and (4) imply that the structural choice probabilities are sufficient statistics to recover the distribution of the willingness-to-pay.

Summarized statistics of the willingness-to-pay distribution can be also recovered by the structural choice probability. The marginal average willingness-to-pay is obtained as

$$E[C] = \int_0^\infty C dF^{WP}(C) = \int_0^\infty C d[1 - Q(c)]. \tag{5}$$

and the conditional average willingness-to-pay is obtained as

$$E[C|\boldsymbol{A}_l = \boldsymbol{a}_l] = \int_0^\infty C dF^{WP}(C|A_l = a_l) = \int_0^\infty C d[1 - Q(c|A_l = a_l)], \tag{6}$$

where

$$Q(c) = \sum_{\boldsymbol{a}} \Pr[U(c, \boldsymbol{A}, \eta_i) \geq U_0(\eta_i)|A_l = a_l, \boldsymbol{A}_{-l} = \boldsymbol{a}_{-l}] \times p(\boldsymbol{A}_{-l} = \boldsymbol{a}_{-l})$$

and similarly is for $Q(c|A_l = a_l)$. Note that the average willingness-to-pay can be interpreted as a monetary measurement of the welfare gain from a policy implementation.

The above discussion implies that we can identify the monetary welfare gain from the choice experiment data. In particular, if we can identify $Q(c)$ and $Q(c|A_l = a_l)$ for any c, the monetary welfare gain is point-identified. However, our experiment data only provide estimators of the structural choice probabilities at 5,000, 10,000, 15,000, and 20,000 Kyats. This makes it difficult to obtain non-parametric point-estimators of the monetary welfare gain. Alternatively, the next section shows that we can identify the lower bound of the welfare gain in a straightforward manner.

4.3 Partial identification

The marginal and conditional average willingness-to-pay (equation 5) can be rewritten as

$$E[C] = \sum_{i=0}^{k} \int_{c_i}^{c_{i+1}} C d[1 - Q(c)]$$

where c_i is the ith threshold value for c, k is the number of threshold values, and $c_0 = 0$ and $c_{k+1} = \infty$. In our case $k = 4$, and $c_1 = 5,000$, $c_2 = 10,000$, $c_3 = 15,000$, and $c_4 = 20,000$. Note that $U_i(0, \boldsymbol{A}, \eta_i) \geq U_i(\eta_i)$ in Assumption 2 ensures that the minimum willingness-to-pay must be positive.

By using the mean-value theorem, above equation can be further modified as

$$E[C] = \sum_{i=0}^{k} \tilde{c}_i \left[Q\left(c_i\right) - Q\left(c_{i+1}\right) \right]$$

for some $\tilde{c}_i \in [c_i, c_{i+1}]$ for any $i = 0, \ldots, k$.[9] Since Q is monotonically decreasing in c, terms in the square brackets are together positive, and therefore letting $\tilde{c}_i$ simply be c_i yields the lower bound of the marginal average welfare gain say $\underline{C}$ as

$$\underline{C} = \sum_{i=0}^{k} c_i \left[Q\left(c_i\right) - Q\left(c_{i+1}\right) \right]. \tag{7}$$

Similarly, from equation (6), the lower bound of the conditional average welfare gain, say $\underline{C}|_{A_l = a_l}$ is also obtained as

$$\underline{C}|_{A_l = a_l} = \sum_{i=0}^{k} c_i \left[Q\left(c_i | \, A_l = a_l \right) - Q\left(c_{i+1} | \, A_l = a_l \right) \right]. \tag{8}$$

Equations (7) and (8) imply that lower bounds of both marginal and conditional welfare gain can be identified by using estimators of choice probabilities because these equations include no other unknown parameters[10].

5 Estimation Strategies

This section shows two types of estimation strategies. The first strategy is to estimate the causal effects of each attribute on the choice probabilities. The second is to estimate the welfare gain from a policy implementation.

5.1 Estimation of causal effects on choice probabilities

The choice experiment data allow us to estimate the causal effects on two types of choice probability. The first type of probability is that a policy is preferred to the other policy. The second is the probability that a policy is preferred to the status quo. We refer to the first as the internal probability, and to the second as the external probability.

To implement the estimations on the internal and external probabilities, a la Hainmueller, Hopkins, and Yamamoto (2014), we estimate the following population model;

$$y_{itj} = \beta_0 + \sum_{l=1}^{7} \sum_{d=2}^{D_l} \beta_{ld} \times a_{itjld} + u_{itj}, \tag{9}$$

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, D_l is

[9]Note that $Q\left(c_0\right) = Q\left(0\right) = 1$ and $Q\left(c_{k+1}\right) = Q\left(\infty\right) = 0$.

[10]Unfortunately, an upper bound derived in this manner involves a parameter c_{k+1} is infinity. Therefore, in the following analysis, we focus on estimating the lower bound of the welfare gain.

the number of levels of an attributes l, β_{ld} is its coefficient, and u_{itj} denote the error terms. Then $y_{itj} \in \{0, 1\}$ is a choice indicator variable: for the estimation of the internal probability, $y_{itj} = 1$ if the preference rank of policy j is higher than it's alternative policy. In the estimation on the external probability, $y_{itj} = 1$ if the preference rank of a policy j is higher than status quo.

Note that the unit of analysis in the regression is each alternative in each task of each respondent. Therefore, even though respondents are sampled randomly from the population, the observed choice outcomes within a respondent may be correlated, which may mislead the statistical inference results. For example, respondents have unobservable characteristics that affect their answer in every task, which generates a correlation of choice outcome within a respondent. To avoid the bias from such correlation in the error terms, we use the cluster robust standard error at the respondent level in all regressions, as suggested by Hainmueller, Hopkins, and Yamamoto (2014).

The approach of Hainmueller, Hopkins, and Yamamoto (2014) has two advantages. The first is that the assumption of conditional independency, $E[u_{itj}|a_{itj1}, ..., a_{itj7}] = 0$, must hold, because attributes are purely randomly ordered for each respondent. The second advantage is that we can estimate the causal effects non-parametrically, because all explanation variables (a_{itjld}) are dummy variables. Therefore, the estimated coefficients, $\hat{\beta}_i$, are consistent estimators of the causal effects. This allows us to compare the relative sizes of the estimated coefficients to examine the relative effectiveness of each attribute.

5.2 Estimation of welfare gains

To estimate the lower bound of the marginal average welfare gain, equation (7) implies that we need to estimate the structural choice probabilities of a policy. The estimated marginal choice probabilities can be obtained by the regression on

$$y_{itj} = \gamma_0 + \gamma_{15000} \times a_{itj15000} + \gamma_{10000} \times a_{itj10000} + \gamma_{5000} \times a_{itj5000} + v_{itj},$$

where $a_{itj15000}$, $a_{itj10000}$, and $a_{itj5000}$ are dummy variables for the policy burdens as 15,000 Kyats, 10,000 Kyats, and 5,000 Kyats, respectively; γ_{10000}, γ_{15000}, and γ_{5000} are their coefficients; v_{itj} are the error terms; and y_{itj} is an indicator variable. Here, $y_{itj} = 1$ implies that the preference rank of policy j is higher than that of the status quo option. Using estimated coefficients, the estimators of the marginal structural choice probabilities are obtained as $\hat{Q}(5000) = \hat{\gamma}_0 + \hat{\gamma}_{5000}$, $\hat{Q}(10000) = \hat{\gamma}_0 + \hat{\gamma}_{10000}$, $\hat{Q}(15000) = \hat{\gamma}_0 + \hat{\gamma}_{15000}$, and $\hat{Q}(20000) = \hat{\gamma}_0$, where a hat ($\hat{}$) implies an estimated coefficient.

Equation (7) then yields the estimator of the lower bound as follows:

$$\underline{\hat{C}} = 5000 \times [\hat{Q}(5000) - \hat{Q}(10000)] + 10000 \times [\hat{Q}(10000) - \hat{Q}(15000)]$$

$$+15000 \times [\hat{Q}(15000) - \hat{Q}(20000)] + 20000 \times \hat{Q}(20000)$$

$$= 5000 \times (\hat{\gamma}_{5000} + \hat{\gamma}_{10000} + \hat{\gamma}_{15000}) + 20000 \times \hat{\gamma}_0. \tag{10}$$

Similarly, the conditional choice probabilities can be estimated by the regression on

$$y_{itj} = \gamma_0^{d_l} + \gamma_{15000}^{d_l} \times a^{d_l}{}_{itj15000} + \gamma_{10000}^{d_l} \times a_{itj10000} + \gamma_{5000}^{d_l} \times a_{itj5000} + v_{itj}^{d_l},$$

using the sub samples consisting of alternatives with $A_l = a_l$. Equation (8) yields the estimator of the lower bound of the conditional average welfare gain, as follows:

$$\left.\underline{\hat{C}}\right|_{A_l=a_l} = 5000 \times (\hat{\gamma}_{5000}^{d_l} + \hat{\gamma}_{10000}^{d_l} + \hat{\gamma}_{15000}^{d_l}) + 20000 \times \hat{\gamma}_0^{d_l}. \tag{11}$$

The above equations imply that the estimated average welfare gain is naturally an increasing function of a constant term and the coefficients.

6 Estimation Results

This section first presents the estimation results of the causal effects of each componet of the policy on its choice probabilites, and then shows the estimated welfare gain. The choice probabilities are furher divided into those that are internal and external, as discussed above, and separately discussed in the following sections.

6.1 Results of choice probabilities

Figures 1 and 2 report the estimated coefficients and the 95% confidence intervals in population model (9) of the internal and external choice probabilities, respectively. Each solid circle in the figure represents a point estimator, while the horizontal bar is the 95% confidence interval. Note that the full results table can be found in Appendix II.[11]

Internal choice probability

[Figure 1 around here]

With regard to the internal probability, Figure 1 shows that *TOILET, GARBAGE,* and *WASTEWATER* have positive and statistically significant effects, while no significant effects of *FERTILIZER* are observed. *PERIOD* and *PAYMENT* also have natural estimated effects: a lower burden and a shorter targeting period have positive causal effects on the internal choice probabilities.

An important advantage of a randomized conjoint design is that it allows us to conduct causal interpretations for all estimated coefficients, which implies that we can compare the economic significance of the attributes. Among

[11] Note that for both internal and external choice probabilities, we estimate the interaction effects between pairs of attributes. However, we find no clear evidence of the existence of interaction effects.

the additional services, the causal effect of *TOILET* is especially high, with a size roughly the same as the effect of reducing the financial burden from 20,000 Kyats to 5,000 Kyats, or reducing the target period from 20 years to 5 years. Thus, Figure 1 shows the high demand for a toilet service, which implies that a water improvement project, including toilet service, would have more support from the local communities. Additionally, a collective wastewater treatment facility and garbage collection services are an effective way to get people's support, but there is no statistical evidence for the effectiveness of an agricultural service, as indicated by the estimate on *FERTILIZER*.

Our results show the relevance of the operators. The results for *ORGANIZATION* show that a joint implementation by the government and local NGOs significantly improves the internal choice probability. Moreover, its economic significance is high because the estimated effect of a joint implementation with local NGOs is roughly the same as the effect of cutting the burden or the target period to half, namely, from 20,000 Kyats to 10,000 Kyats, or from 20 years to 10 years. Therefore, our estimation results imply that local NGOs can play an important role in providing local community support for water improvement projects.

External choice probability

[Figure 2 around here]

From Figure 2, we can observe that the causal effects on the external choice probability have similar trends to those on the internal choice probability, although the sizes of the effects tend to be smaller than in the case of the internal choice probability. A potential reason for this is that, irrespective of its characteristics, the respondents wish to have the proposed policy program (see the coefficient of the constant term in Table A2 in Appendix). Hence, the estimated coefficients of the attributes become smaller because the variation in the outcome variables is smaller than in the case of the estimation of the external choice probability.

Even on the external choice probability, *TOILET* and *WASTEWATER* still have significant effects, and the toilet service again has a larger effects than the other services do. Furthermore, a policy implementation with local NGOs still has positive effects at the 10% significance level (see Table A2 in Appendix).

The burden and targeting periods show similar trends. A smaller burden and a shorter period can increase the choice probabilities. Note that the point estimators of individual burdens are not monotonically increasing because the estimated coefficient of 10,000 Kyats is lower than the coefficient of 15,000 Kyats. However, the results do not imply that the external choice probability decreases if the individual burden decreases from 15,000 Kyats to 10,000 Kyats because the difference between these coefficients is not statistically significant.

6.2 Results of the welfare

Table 5 reports the estimated lower bound of the welfare gain from a policy implementation as in equation (7). The first low shows the estimated lower bound of the marginal average welfare gain as 16,090 Kyats in each month, or 193,082 Kyats annually. Because the average annual per-capita income in the area is 840,000 Kyats, the estimated average willingness-to-pay is at least 22.9% of the average annual per-capita income.

The other rows show the estimated lower bound of the conditional average welfare gain. Among the additional services, the average surplus gain from water improvement projects with toilet service (*Toilet* and *Toilet and Collection*) is the highest. The difference in the surplus gains with and without the toilet service (*Toilet*) is more than 2,000 Kyats per month, which implies that the lower bound can be improved by about 14% by introducing toilets.

Table 5 consistently shows that including local NGOs has a significant welfare impact. The difference in the lower bound with and without local NGOs is about 760 Kyats per month, which is about a 5% improvement in the welfare gain.

7 Conclusion

This study examined the preference for a water improvement policy for Inlay Lake, Myanmar, based on a randomized conjoint experiment. We have shown that the additional service of providing toilet facilities has a strong positive effects on both the internal and external choice probabilities for a policy. Furthermore, a collective wastewater treatment for dying and silver manufacturing and the collection of household garbage are also estimated to increase the choice probabilities. In contrast to the consistent results showing respondents' perceptions of toilets being the cause of the pollution, the government intervention to regulate and optimize excess fertilizer and pesticide inputs for tomato production does not have agreement among the respondents. Here, we might need to examine the complex heterogeneous structure of respondents' preferences to better understand this result. The varying preferences may simply stem from the differences between being engaged in tomato farming or not, or the degree of dependency of a family's income on tomato farming. Our interaction with tomato farmers during our field visits showed that some clearly understand that if fertilizer and pesticide inputs can be optimized, they can save on production costs and improve their long-term productivity. However, others do not understand and/or do not like the idea of government intervention. This implies that knowledge and skill in terms of fertilizer and pesticide inputs will be needed by all farmers if the related public policy program is to be supported widely.

Another contribution of this study is methodological. We have shown that conjoint data can be used to draw out welfare implications non-parametrically. Using only weak assumptions, the method enables us to estimate the minimum willingness-to-pay for a policy change in the form of compensating variations. This method can be applied to environment improvement project evaluations that are otherwise difficult to estimate. Adopting this method to Inlay Lake, we conclude that the water quality improvement policy has a marginal average surplus gain of at least 193,082 Kyats per annul, which is 22.9% of the average annual per-capita income in the area. Additionally, the analysis of the conditional average surplus gain shows that including the toilet service increases the lower bound of the surplus gain by 14%. The analyses of the choice probabilities and the surplus gain show the importance of providing a toilet service when implementing a water quality improvement policy.

Our analysis also shows the importance of the role played by local NGOs. A joint policy implementation by the government and local NGOs has positive impacts on the internal and external choice probabilities, which are similar in size to the monthly burden reduction from 20,000 Kyats to 10,000 Kyats. Then, we estimated the welfare impacts of local NGOs, showing that the lower bound of the conditional average surplus gain increases by 5%.

We believe that our findings have important implications for future policy plans to improve the water quality of Inlay Lake. However, our study has an important limitation in terms of the external validity of the randomized conjoint analysis. Even though Hainmueller, Hangartner, and Yamamoto (2015) provide evidence for this validity in developed countries, no studies focus on developing countries. Therefore, additional studies are needed to test the external validity of the conjoint experiments in developing countries.

References

[1] Akaishi, F., Satake, M., Otaki, M., & Tominaga, N. (2006). Surface water quality and information about the environment surrounding Inle Lake in Myanmar. Limnology, 7(1), 57-62.

[2] Durand-Morat, A., Wailes, E. J., & Nayga, R. M. (2015). Challenges of Conducting Contingent Valuation Studies in Developing Countries. American Journal of Agricultural Economics, aav068.

[3] Bechtel, M. M., & Scheve, K. F. (2013). Mass support for global climate agreements depends on institutional design. Proceedings of the National Academy of Sciences, 110(34), 13763-13768.

[4] Bernauer, T., & Gampfer, R. (2015). How robust is public support for unilateral climate policy?. Environmental Science & Policy, 54, 316-330.

[5] Butkus, S., & Myint, S. (2001). Pesticide use limits for protection of human health in Inle Lake (Myanmar) Watershed. Living Earth Institute, Olympia, Washington, USA). www. living-earth. org/inle. html.

[6] Bhattacharya, D. (2015). Nonparametric welfare analysis for discrete choice. Econometrica, 83(2), 617-649.

[7] Gampfer, R., Bernauer, T., & Kachi, A. (2014). Obtaining public support for North-South climate funding: Evidence from conjoint experiments in donor countries. Global Environmental Change, 29, 118-126.

[8] Green, P. E., & Rao, V. R. (1971). Conjoint measurement for quantifying judgmental data. Journal of Marketing research, 355-363.

[9] Greenstone, M., & Jack, B. K. (2015). Envirodevonomics: A Research Agenda for an Emerging Field. Journal of Economic Literature, 53(1), 5-42.

[10] Hainmueller, J., Hangartner, D., & Yamamoto, T. (2015). Validating vignette and conjoint survey experiments against real-world behavior. Proceedings of the National Academy of Sciences, 112(8), 2395-2400.

[11] Hainmueller, J., & Hopkins, D. J. (2015). The hidden American immigration consensus: A conjoint analysis of attitudes toward immigrants. American Journal of Political Science, 59(3), 529-548.

[12] Hainmueller, J., Hopkins, D. J., & Yamamoto, T. (2014). Causal Inference in Conjoint Analysis: Understanding Multidimensional Choices via Stated Preference Experiments. Political Analysis, 22(1), 1-30.

[13] Holmes, T. P., & Adamowicz, W. L. (2003). Attribute-based methods. In A primer on nonmarket valuation (pp. 171-219). Springer Netherlands.rrings, C. (2014). Environment and development economics 20 years on. Environment and Development Economics, 19(03), 333-366.

[14] Khin, L. S. (2011) Development of clean water and sanitation in Inle Lake, Myanmar. EE2 Seminar: Water and Environment in Asia's Developing Communities Singapore International Water Week 2011 Co-located Event, Suntec Singapore International Convention and Exhibition Centre, 6 July 2011, Singapore.

[15] Ministry of Immigration and Population (2015) 2014 Myanmar Population and Housing Census, Union Report: Census Report Volume (2), Ministry of Immigration and Population, The Republic of the Union of Myanmar.

[16] Neyman, J (1923). On the application of probability theory to agricultural experiments: Essay on principles, section 9. (translated in 1990). Statistical Science 5, 465–80.

[17] Perrings, C. (2014). Environment and development economics 20 years on. Environment and Development Economics, 19(03), 333-366.

[18] Rubin, D. B. (1974). Estimating causal effects of treatments in randomized and nonrandomized studies. Journal of educational Psychology, 66(5), 688.

[19] Sidle, R. C., Ziegler, A. D., & Vogler, J. B. (2007). Contemporary changes in open water surface area of Lake Inle, Myanmar. Sustainability Science, 2(1), 55-65.

[20] Su, M., & Jassby, A. D. (2000). Inle: A large Myanmar lake in transition. Lakes & Reservoirs: Research & Management, 5(1), 49-54.

[21] Whittington, D. (1998). Administering contingent valuation surveys in developing countries. World development, 26(1), 21-30.

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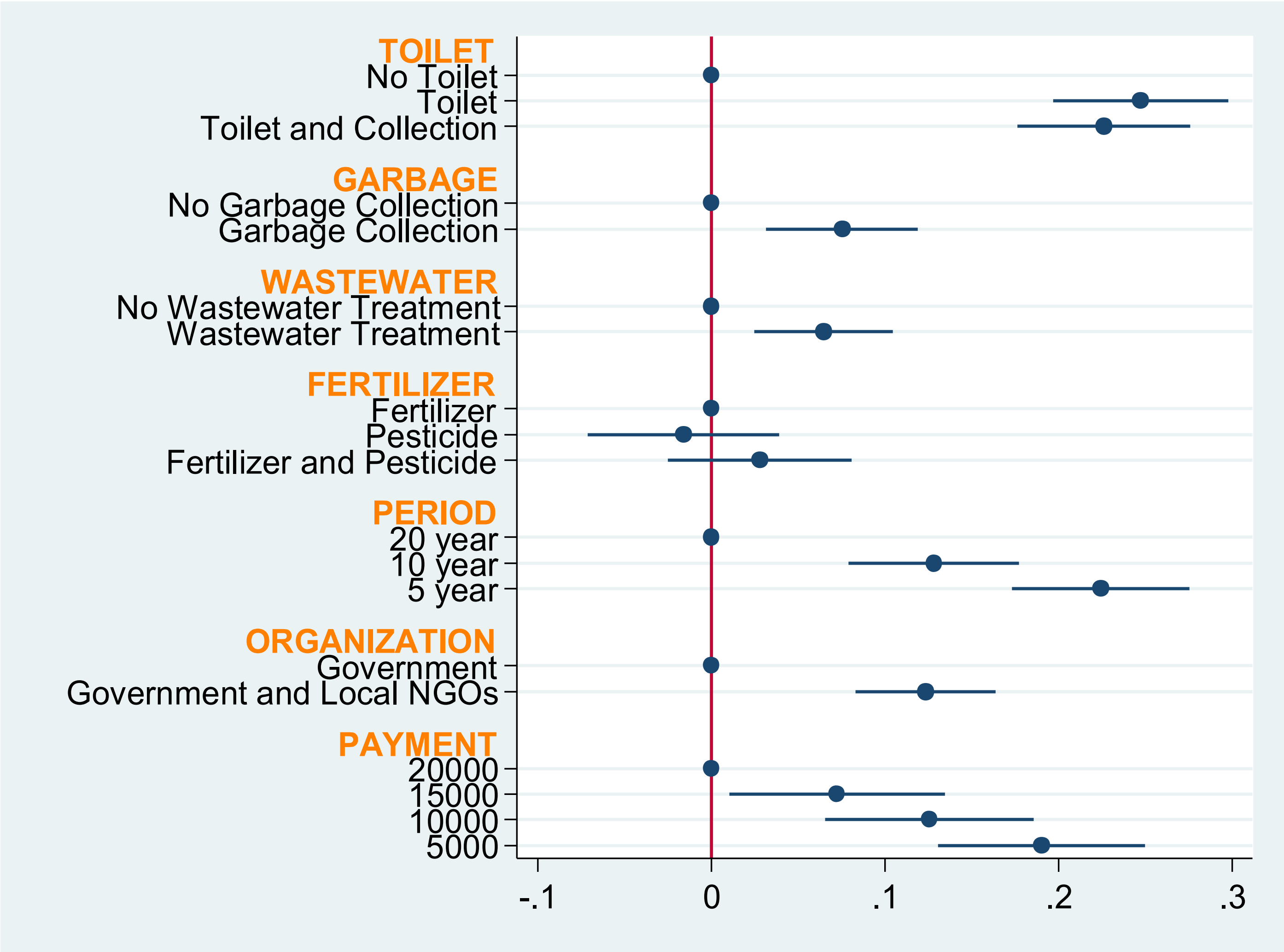

Figure 1: Average causal effects on the internal choice probability

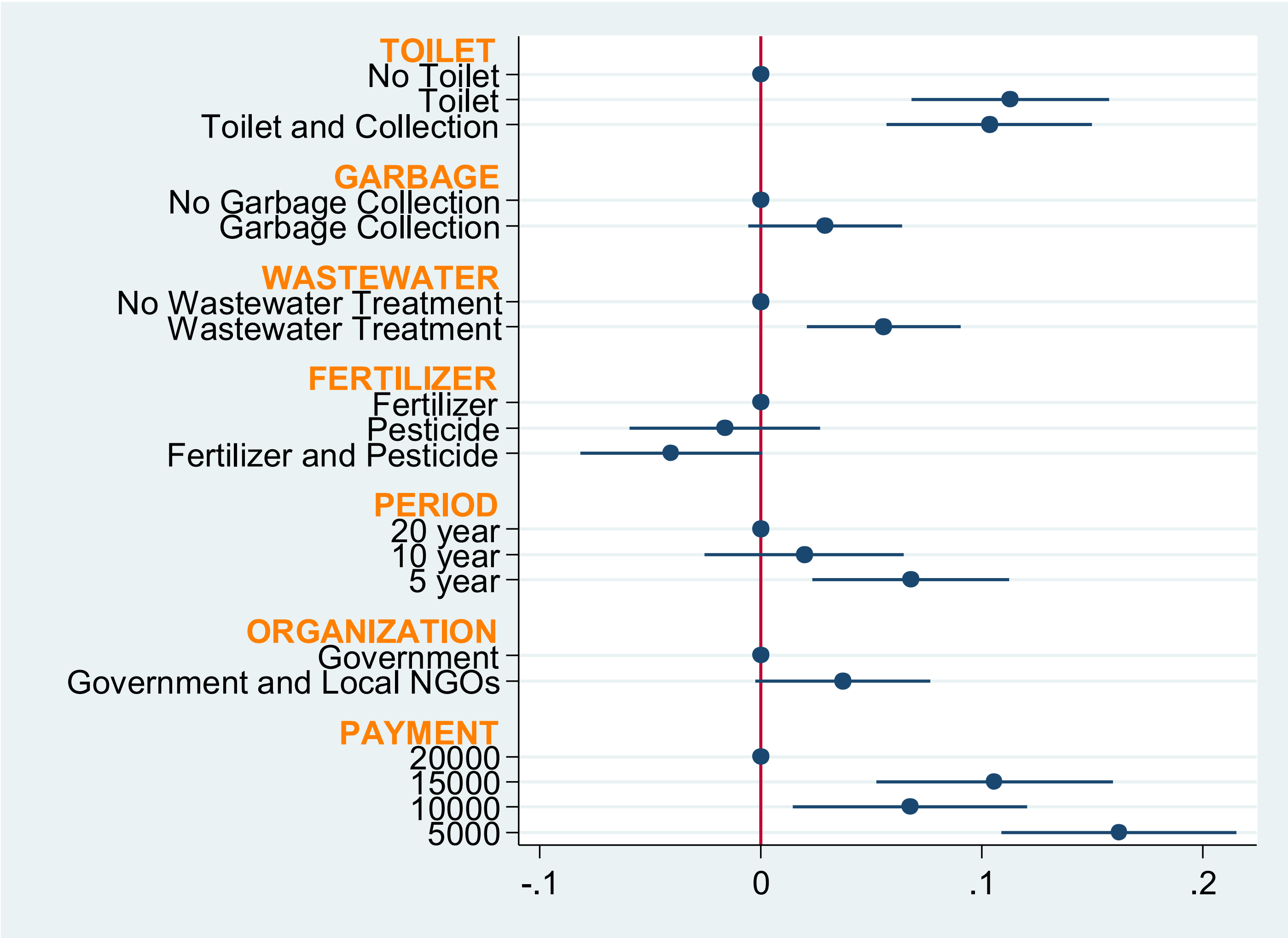

Figure 2: Average causal effects on the external choice probability

Primary	Number of household heads	Composition (%)	Secondary	Number of household heads	Composition (%)
Farmer	142	43.4%	Fisher	77	23.5%
Fisher	44	13.5%	Wage worker for farming	22	6.7%
Wage worker for farming	27	8.3%	Shopkeeper	18	5.5%
Carpenter	26	8.0%	Farmer	7	2.1%
Local cheroot	10	3.1%	Boat driver	5	1.5%
Small business	8	2.4%	Wage work for tailoring	5	1.5%
Shopkeeper	7	2.1%	Small business	3	0.9%
Trader/Broker	6	1.8%			
Various others	26	8.0%	Various others	44	13.5%
No primary jobs	31	9.5%	No secondary jobs	146	44.6%
Total	**327**	**100.0%**		**327**	**100.0%**

Table 1: Distribution of Major Primary and Secondary Jobs for Household Heads.

Source	**Composition (%)**
Farming	36.13
Fishing	15.30
Small business	10.01
Carpenter	6.09
Wage work for farming	6.39
Local cheroot	5.22
Trader/Broker	4.08
Wage work for tailoring	4.05
Boat driver	2.00
Various others	10.73
Total	**100.00**

Table 2: Distribution of total household income by source.

Perception	Numbers of respondents	Composition (%)
Seriously worsening	157	48.01
Worsening	153	46.79
Not changing	14	4.28
Improving	2	0.61
Don’t know	1	0.31
Total (%)	**327**	**100.00**

Table 3: Perception of recent changes in the water quality

Perception	Numbers of suspected causes	Composition (%)	Rate of selection (%)
Waste water and night soil (on the lake)	198	24.4%	60.6%
Fertilizer and pesticide (on the lake)	166	20.4%	50.8%
Forest degradation and sedimentation	145	17.9%	44.3%
Climate change	83	10.2%	25.4%
Tourism	66	8.1%	20.2%
Dam construction and operation	42	5.2%	12.8%
Fertilizer and pesticide (in the watershed)	22	2.7%	6.7%
Waste water and night soil (in the watershed)	18	2.2%	5.5%
Demolished floating garden	9	1.1%	2.8%
Others	63	7.8%	19.3%
Number of suspected causes	**812**	100.0%	
Number of suspected causes per respondent	**2.48**		

Table 4: Reasons for the water quality change

Average walfare gain	Attribute	Level	Point estimator	S.D	p-value	95% Confidence Interval		Annual gain
Baseline			16,090	315	0.00	15,471	16,709	193,082
Conditional	***TOILET***	**No Toilet**	14,667	481	0.00	13,720	15,615	176,007
		Toilet	16,908	349	0.00	16,220	17,595	202,893
		Toilet and Collection	16,715	369	0.00	15,989	17,441	200,583
	GARBAGE	**No Garbage Collection**	15,802	357	0.00	15,099	16,505	189,627
		Garbage Collection	16,375	368	0.00	15,650	17,100	196,498
	WASTEWATER	**No Wastewater Treatment**	15,537	395	0.00	14,759	16,315	186,438
		Wastewater Treatment	16,623	325	0.00	15,983	17,264	199,482
	FERTILIZER	**Fertilizer**	16,477	383	0.00	15,724	17,231	197,726
		Pesticide	16,149	399	0.00	15,364	16,934	193,786
		Fertilizer and Pesticide	15,653	426	0.00	14,814	16,493	187,841
	PERIOD	**20 year**	15,483	439	0.00	14,619	16,348	185,802
		10 year	15,908	404	0.00	15,112	16,703	190,892
		5 year	16,861	380	0.00	16,114	17,609	202,337
	ORGANIZATION	**Government**	15,708	397	0.00	14,926	16,489	188,491
		Government and local NGOs	16,468	353	0.00	15,774	17,162	197,618

Table 5: Average surplus gains from policy implmentation

Respondent No.
1

The 1st trial

		Choice Code 264	**Choice Code 476**	
		Choice A	**Choice B**	**Choice C**
Attribute 1	Toilet system (Toilet, septic tank, collection services are all provided by the government)	Toilet + Tank (but not collection service)	Toilet + Tank + Collection Service	Do not choose A and B
Attribute 2	Garbage collection services (Garbage collection services are provided by the government)	not available	not available	
Attribute 3	Public water treatment facility for the dying industry (the facility is constructed by the government and operational and maintenance costs are paid by the industry)	not available	Introduced	
Attribute 4	Mondatory optimal inputs of fertilizer and pesticide for tomato plantation (to achieve this, costs for governement research and guidance activities are required)	Mondatory optimal inputs of fertilizer and necessary guidance	Mondatory optimal inputs of fertilizer and necessary guidance	
Attribute 5	Period for the target of water quality improvements to be attained (The water qualtiy in front of individual house will be improved to the current level of northan part of the Inle lake)	20 years	20 years	
Attribute 6	Implementation organization	Local government with supports of local NGOs	Local government	
Attribute 7	Montly payment for the period until the water quality target is achieved	20000 Kyats	20000 Kyats	

Table A1: Example of Choice Set Screen

Attribute	VARIABLES	Internal	External
TOILET	**Providing Toilet with Tank**	0.113***	0.247***
		-0.0226	-0.0256
	Providing Toilet with Tank and Collection service	0.103***	0.226***
		-0.0235	-0.0253
GARBAGE	**Garbage Collection service**	0.0292	0.0755***
		-0.0177	-0.0222
WASTEWATER	**Wastewater Treatment Facility**	0.0556***	0.0646***
		-0.0177	-0.0203
FERTILIZER	**Fertilizer**	-0.0162	-0.0159
		-0.022	-0.0281
	Fertilizer and Pesticide	-0.0405*	0.0278
		-0.021	-0.027
PERIOD	**10 year**	0.0197	0.128***
		-0.0229	-0.025
	5 year	0.0678***	0.224***
		-0.0226	-0.026
ORGANIZATION	**Government and local NGOs**	0.0371*	0.123***
		-0.0201	-0.0205
PAYMENT	**15,000 Kyats**	0.106***	0.0725**
		-0.0272	-0.0316
	10,000 Kyats	0.0676**	0.126***
		-0.0269	-0.0305
	5,000 Kyats	0.162***	0.190***
		-0.0269	-0.0303
	Constant	0.577***	-0.00749
		-0.0418	-0.0343
	Observations	1,962	1,962
	R-squared	0.054	0.131

Table A2: Estimated effects on internal and external probabilities

Note. Outcome variable: the internal choice probability in the first column, and the external choice probability in the second column. Robust standard errors in parentheses are clustered on respondent. *** p<0.01, ** p<0.05, * p<0.1.