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Solid waste management program in developing countries: contingent valuation methodology versus choice experiment
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Abstract: The willingness-to-pay by households in Vietnam to improve collection and processing services linked to source-separated municipal solid waste (MSW) is investigated in this research. This study contributes to current literature by comparing welfare benefits derived from contingent valuation methodology (CVM) and choice experiment (CE) for changes to waste service provision. The respondents were also stratified, for the first time, by households with and without previously sorted waste and by urbanization grade. Our results return broadly consistent willingness-to-pay estimates across the two approaches, and offer evidence that MSW sustainable management—a priority need in developing countries—may be addressed by positively enticing residents into a new fee-for-service program, but where social benefits from such engagement are made clear. Interestingly, residents in lower urbanization grades and those who have not practiced sorted waste reveal higher WTP values. Our results suggest that respondents are most interested in a wider selection of separated material options (i.e., recycled, organic and residual) as well as the potential for CO_2 emission reductions associated with new waste management programs. We argue that an application of both stated preference techniques widens the set of policy input factors available to government officials and useful evidence for structuring future engagement programs to address those who retain a preference for the status quo.

Response to Reviewers:	Response Letter - Ms. Ref. No.: ENVI-D-21-02878 Title: Solid waste management program in developing countries: contingent valuation methodology versus choice experiment Editor's comments: Based on the advice received, I feel that your manuscript could be reconsidered for publication should you be prepared to incorporate major revisions. When preparing

your revised manuscript, you are asked to carefully consider the reviewer comments which are attached, and submit a list of responses to the comments. You are also requested to highlight the changes made in the revised manuscript.

Response: We wish to thank the Editor and five anonymous reviewers for very helpful comments and valuable suggestions to improve our paper. We have carefully noted the Editor's and Reviewer's recommendations and responded to them in detail below.

Reviewers' comments:

Reviewer #3:

In general, the manuscript is well written, but typos and grammatical errors are still found in different parts of the paper. Several sentences seem to be incomplete and/or confusing/convoluted. Authors are highly advised to have a thorough language proofreading.

Response: We appreciate and thank the Reviewer for pointing that out. We have corrected any typos and grammatical errors and double-checked the sentence structures.

The authors need to acknowledge the rich body of literature on waste sorting and management subject beyond the developing country including recent studies applying stated preference methods to elicit household preferences for waste sorting (e.g. Consumers in a circular economy: Economic analysis of household waste sorting behavior. Ecological Economics, 166, p.106402. https://doi.org/10.1016/j.ecolecon.2019.106402. Even though the authors focus on a developing country context, still the authors need to justify and demonstrate the novelty of the design of their stated preference (e.g. choice attributes) in comparison to the designs in previous studies that have been carried out elsewhere. In the Literature Review section, the authors do include references, but they are rather limited and the section lacks critical overview of evidence from existing literature to highlight for example on drivers/determinants of household waste sorting behaviour/preferences which would be critical to inform the design of their present study.

Response: We appreciate and thank the Reviewer for pointing that out. We agree that the original review was limited for brevity reasons, and are very happy to include more references to clarify our contribution with reference to more recent and expanded sets of household preferences for waste solutions and their drivers of support.

Lines 104 - 117: Lacking references. Are these authors' own assumptions? Clarify.

Response: We have included a citation for this from World Bank 2018.

Lines 188 - 189: Provide justification as to why the authors chose this particular approach (compared to others) for eliciting the respondents' response on payment/bid in the CVM.

Response: We have included justification for this from lines 190-192. This should be a closed-end question, not an open-end.

Lines 205 - 210: Provide a discussion on how these selected attributes compare with previous CE studies on waste sorting preferences.

Response: We have included a discussion for this to make clear with previous CE studies in the literature review section and highlighted,

Line 211-213: Clarify what the authors mean by survey packages and survey versions. How are the two related?

Response: We have updated the text on this paragraph to make it clear by using the same words as in the survey versions.

Lines 211 - 217: Clarify the number of choice sets that each household was presented with during the CE survey.

Response: We have updated the text on this paragraph to make it clear.

Lines 220 - 221: Were the respondents presented with CVM and CE on the same day, one after the other? This must be quite demanding/exhausting to the respondents. Critical reflection from the authors in the paper regarding this matter is needed.

Response: We thank the Reviewer for pointing this out to us, and we have rewritten that section to make it more clear.

Lines 225 - 233: In the paper, provide characteristics that define each of the three urban grades.

Response: We have updated the text on this paragraph to make it clear in the data collection section.

Line 244: "Accordingly, when undertaking the of" Something missing here?

Response: This has now been revised.

Line 246: What does tk in equation (2) signify? Clarify this in the paper.

Response: We have updated the text on this paragraph to make it clear.

Line 262 - 263: The sentence is incomplete and convoluted. Rewrite.
Response: This has now been revised.
Lines 309 - 311: Many CE studies have found that this IID assumption did not hold. The authors need to examine and demonstrate in the paper whether in their case the IID assumption holds. Otherwise, the authors should present alternative models that better capture preference heterogeneity (RPL, LCM).
Response: We thank the Reviewer for making this important point. We agree, and have employed the Hausman and McFadden (1984) test to check whether the IIA property is violated. We provide more discussion about this from Eq. 13 to Eq. 16 and add Table 5 as the MNL model result and Table 6 IIA test result.
Lines 356 - 478: These are mostly results. Discussion of the findings in relation to existing literature appears to be very limited. Major improvement in this section is inevitable.
Response: We have rewritten and expanded our discussion of the existing literature to ensure that this is now clearer in the Discussion section.
Lines 357 - 367: The authors only present the characteristics of their sample respondents but do not provide evaluation on how representative the sample is in relation to the target population. This is important to acknowledge and has important implications on the generalisability of the findings especially the fact that authors emphasize practical applications to local policy.
Response: We agree with the Reviewer, and have added the text to explain the representation of the sample by comparing it to the Vietnam Households Living standard survey by General Statistic Office.
Line 376 - 377: Provide the number (proportion).
Response: This has now been added.
Lines 513 - 518: Provide more concrete examples/proposals.
Response: This has now been added.

Reviewer #4:
In the paragraph from lines 117 to 122, on page 5, the author(s) mention the factors driving behavioral change in waste separation by private households. There is already statistical evidence on the factors that influence such behaviors in relation to the separation of solid waste by households at the urban level. I would particularly recommend reading and referencing the document:
Padilla, A. J., & Trujillo, J. C. (2018). Waste disposal and households' heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia. Waste Management, 74, 16-33.
Response: This has now been added.
It would be convenient for the author(s) to specify which software they used for their experimental design. In addition, it would also be convenient for the authors to specify at the end which of the two methodologies is the optimal one in terms of policy design, considering the "high" percentage of opt-outs.
Response: This is a good point, and that detail has now been added.
The author(s) should justify why they choose a logit instead of a probit, and check the estimates without the opt-outs in a second estimation through a tobit model to corroborate the robustness of the design. In both methodologies, the author(s) also do not take into account the illegal disposal of waste, which is a key factor within MSW in developing countries.
Response: Again, we agree. We have rewritten and expanded our discussion of the econometric approaches to ensure that this is now clearer in the relevant section.

Reviewer #5:
The author(s) attempt to investigate the willingness-to-pay for solid waste in Vietnam using the CVM and CE valuation methods. In as much as I commend the authors for the effort, I have some concerns. I have outlined my comments for the necessary action before the paper can be considered.

In line 32. Your first statement of claim is not supported with facts and figures or even a reference. What is the evidence that Vietnam in developing countries in general are grappling with solid waste management? Kindly do the needful.
Response: A reference in support of this view has now been added.
Line 38: You are assuming that the problem is revenue so willingness-to-pay from the public sector may enable investments. On what premise is this based? Why is the problem not attitudinal? I think this has to be motivated a little bit.

Response: We agree with the Reviewer, and have included more discussion in the relevant section.

Again, why should the public pay for a private problem? Your argument for public investment does not present a paradigm shift in the narratives hence the problem will persist if the government cannot pay.

Response: The frame in this case is one of private payments to support the existing public investment that is insufficient to cover current and expected future funding requirements. Hence, our exploration of the level to which private payments may be elicited, set and ideally recovered. As this may not be as clear as we had hoped, we have rewritten where appropriate in an effort to address that.

In your Introduction, you have not been able to convince the reader regarding the reason why both approaches are important for solid waste management. Again, you have not been able to convince the reader why WTP is even important whiles public investment is being considered. You could have re-written your introduction using the study site to motivate the work better. Nonetheless, the current approach is not bad provided the study is well motivated.

Response: We agree with the Reviewer, and have included more citations from related previous research in literature in the introduction.

Line 104: It is unclear the fraction of the solid waste generated in Vietnam that is recycled.

Response: This sentence has now been revised.

Literature: Kindly show some related solid waste studies that compared methods and yielded similar results. You may want to add some few CVM or CE and other studies that yielded related estimates and why.

Response: We agree with the Reviewer, and have included more citations from related previous research in literature in the introduction.

The CVM hypothetical market must be clearly stated. I'm unsure how this was explicitly stated. Kindly quote the description.

Response: This has now been added.

Also, how the bidding format was applied is unclear. Yes, the stating bids have been given, how did it result in open-ended responses. How were the starting bids obtained from the managers and public officials with aboutVND30,000 difference? Why didn't you use actual market estimates for the various communities or areas?

Response: We have rewritten and expanded our discussion of the approaches to type of questions and bases for bid formulation to ensure that this is now clearer in the material section.

Why is the monthly fee for MSW management service for the CVM different from the CE. What informed this difference. Example $0.86/month (CE) and $0.87/month (CVM)

Response: We have rewritten and expanded our discussion of the approaches to ensure that this is now clearer in the material section.

Line 219: In the abstract, I see you used stratified sampling technique, however, in the method, I see just random sample. Which type of random sampling and how was this achieved?

Response: We appreciate and thank the Reviewer for pointing that out. We have corrected this as suggested.

In Table 1, is Option C the status quo? If yes, indicate it.

Response: This has now been added.

Line 282: Why is income controlled for as a dummy while the raw data obtained was not dummy? A Table of descriptive statistics even in appendix will do.

Response: That is a useful idea and has now been added. To follow up quickly here, the dummy income value is based on the amount of US$385 issued by law in the National Assembly, and from which different levels of income were then stratified.

Line 357: The socio-economic characteristics are not compared with national data or estimates. Pls do!

Response: This has now been added and compared to the national survey.

Line 409: In Table 3, you present only the estimates without the margins or marginal effects. Pls do!

Response: We agree that the estimation of marginal effects in the Logit model is necessary in other cases. However, in the case of MWTP estimation, we only need the sign of coefficients to explain the relationship between the determinants and the probability of agreeing to pay for the SW management program. In addition, the coefficients generated from the Logit model must be used to estimate the MWTP instead of marginal effects. Therefore, we present only the coefficients in this case.

In Table 4, what is in parenthesis?

Response: This has now been added to the note for these numbers.
I expect the authors to support their findings with existing literature.
Response: This has been raised by some of the other reviewers, and addressed as recommended.
The observations in Table 3 and 5 and different. Kindly justify in the paper.
Response: This has now been added in the material and methodology section related to the different approaches between CE and WTP.
Line 480: Why should a study with observations in Vietnam be interesting to all in developing countries
Response: We have expanded our discussion of this to ensure that this is now clearer in the material section.
Check how in-text citations with et al are presented. (XXXX et al., 2010) or XXXX et al. (2010)
Proofread the work thoroughly to correct minor typos
Response: Revised. Again, we are grateful to the Reviewer for their attention to detail.

Reviewer #6:
1- The English should be revised by a native English speaker.
Response: We thank the Reviewer for pointing that out. One of the authors is a native English speaker and we have used that person to carefully once more correct any typos and grammatical errors, and to double-check the sentence structures.
2- How to select the overall study sample as well as the number of samples in each city should be fully described.
Response: We have updated the text in this paragraph.
3- In the results section, the respondents' attitudes toward the MSW status are mentioned, while in this study, the respondents' attitudes were not evaluated. Based on the content, the respondents' experience in dealing with the issue seems to have been examined.
Response: We have updated the text in this in the material section.
4- The reason for the importance of the study and its implications, especially for global readers, has not been clearly and attractively stated.
Response: We have rewritten and expanded our discussion of the approaches to ensure that this is now clearer in the material section.
In total, I congratulate authors because it is an interesting paper. I suggest accept with minor revisions.
Response: We appreciate this positive feedback and thank the Reviewer for these opening comments about the value of the paper and its findings.

Reviewer #7:
The manuscript is to valuate the solid waste management programme in Vietnam using CVM and CE. Although the manuscript is well organised, there are some serious problems which need substantial revised to make it suitable for publication. The following are the detail comments:

1. Literature review: The results of similar studies should be reviewed and included in the literature review section. Currently the literature review focuses on methodologically review.
Response: We thank the Reviewer for suggesting this as it is a good idea and in line with other review comments. We totally agree, and this text has been added accordingly.
2. Methodology section: The questionnaire design has not been well described. I only see how the CVM and CE test are designed. None of the other data collected in this questionnaire survey has been included. As i aware in the results and discussion section, there are some other parameters used for statistical analysis. However, there are no information provided in the questionnaire design.
Response: The relevant sections of text have been revised in line with the Reviewer's suggestions.
3. The objective of this research is not clear. after reading the first part of the manuscript, it seems to me that this is a study in comparing two valuation methods and using solid waste management as an example for the evaluation of the two valuation method. However, i am aware that in the results and discussion section, this is not what I thought. It is a paper to evaluate the soild waster management programme in Vietnam. If so, there is a question needed to be answered, why use two valuation methods?

Response: We have rewritten and expanded our discussion of the approaches to ensure that this is now clearer in the material section.

4. if this manuscript is a study of the two valuation methods, there are nothing in the discussion sections about the good or bad of these methods.

Response: We do not view the work as a critique either way, as sufficient material is already in print on that subject. However, to address this for others, we have rewritten the paper where appropriate.

5. There is very limited in-depth discussion on the results with previous studies. Whether your results are similar and difference with previous studies? and why?

Response: We thank the Reviewer for pointing this out to us, and we have rewritten it where appropriate in line with other suggested changes.

1 **Solid waste management program in developing countries: contingent valuation**

2 **methodology versus choice experiment**

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Declarations

13

14 **Conflicts of interest/Competing interests:**
15 - The authors have no conflicts of interest to declare that are relevant to the content of this
16 article.
17 - The authors have no relevant financial or non-financial interests to disclose.
18 - All authors certify that they have no affiliations with or involvement in any organization
19 or entity with any financial interest or non-financial interest in the subject matter or
20 materials discussed in this manuscript.
21 - The authors have no financial or proprietary interests in any material discussed in this
22 article.

23

24 **Availability of data and material:** Data is available from the corresponding author upon request.

25

26 **Authors' contributions:** All authors contributed to the study conception and design. Material
27 preparation, data collection and analysis were performed by Xuan Thi Dan Huynh and Tien Dung
28 Khong. The first draft of the manuscript was written by Xuan Thi Dan Huynh and Tien Dung
29 Khong and all authors commented on previous versions of the manuscript. All authors read and
30 approved the final manuscript.

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4 **Highlights**

5

6 • Waste is a key issue for developing nations like Vietnam, with limited resources to cope.

7 • Social concern for environmental issues may lift households' WTP and increase resources.

8 • Identifying key attributes of preferred policy will strengthen MSW management and WTP.

9 • Identifying homogenous benefits may encourage those with status quo preferences to

10 engage.

11

12 **Abstract**

13 The willingness-to-pay by households in Vietnam to improve collection and processing services

14 linked to source-separated municipal solid waste (MSW) is investigated in this research. This study

15 contributes to current literature by comparing welfare benefits derived from contingent valuation

16 methodology (CVM) and choice experiment (CE) for changes to waste service provision. The

17 respondents were also stratified, for the first time, into households with/without previously sorted

18 waste and across urbanization grades. Our results return broadly consistent willingness-to-pay

19 estimates across the two methodologies, and offer evidence that MSW sustainable management—

20 a priority need in developing countries—may be addressed by positively enticing residents into a

21 new fee-for-service program, but only where social benefits from such engagement are made clear.

22 Interestingly, residents in lower urbanization grades, and those who have not previously sorted

23 waste, reveal higher WTP values. Our results suggest that respondents are most interested in a

24 wider selection of separated material options (i.e., recycled, organic and residual) as well as the

25 potential for CO_2 emission reductions associated with new waste management programs. We argue

26 that an application of both stated preference techniques widens the set of policy input factors

27 available to government officials and useful evidence for structuring future engagement programs

28 to address those who retain a preference for the status quo.

29 **Keywords**: Disposal, Mekong River Delta, source-separation, strategic actions, willing to pay

30

31 **1. Introduction**

32 Governments worldwide are grappling with solid waste management, particularly in rapidly

33 developing countries like Vietnam. Unsuccessful waste management is associated with negative

34 environmental impacts including greenhouse gas emissions, land and water contamination, odour,

35 landscape deterioration and noise, and human health concerns such as fire hazard and disease

36 (Ghanbari et al. 2012). Effective waste management could reduce these negative impacts, but it

37 would most likely come at a high cost to society for improved infrastructure, modern

38 collection/sorting systems, and increased public awareness campaigns. Developing countries may

39 struggle to afford these increased costs, limiting their range of policy alternatives. However, if the

40 public is willing/able to pay for improved municipal solid waste (MSW) management the revenue

41 may enable investments to avoid amenity losses, human health risks, etc. (Pearce and Howarth

42 2000).

43 Reconciling the needs of waste producers with those of the waste managers is critical for

44 achieving policy objectives. To that end, stated preference techniques play an important role in

45 estimating both the willingness to pay (WTP) for a change to an environmental state and key

46 attributes for successful waste management policies (Ko et al. 2020). Waste management services

47 are frequently under- or non-priced, making it challenging to obtain economic benefit estimates

48 from market prices (Anaman and Jair 2000). Further, social preferences for waste services are not

49 homogenous across individuals and therefore policy-makers need to adopt targeted instruments

50 with appropriate incentives based on evidence (Massarutto et al. 2019). These characteristics also

51 support the selection and application of stated preference techniques—making them quite

52 common, as detailed below. Stated preference techniques also enable the benefit transfer of WTP

53 estimates beyond original study sites (Hanley et al. 1998a). This can be important for developing

54 countries if budget/time constraints make repeated valuation surveys at sites of interest impractical

55 (Damigos et al. 2016), and where a high level of precision is not required (Rosenberger and Loomis

56 2001).

57 Household preferences for waste scheme management have been researched widely via

58 elicitation approaches such as choice experiments (Lee et. al, 2017) and CVM (Kipperberg and

59 Larson, 2012). Yet studies of stated preferences for waste management in developing countries

60 remain limited (Ko et al. 2020). This is despite a recognition of the need for this work nearly two

61 decades ago, especially via preference choice sets to identify the attributes of effective waste

62 management systems (Jin et al. 2006), and applications of discrete choice experiments aimed at

63 identifying the value provided by waste sorting services (Nainggolan et. al., 2019). This motivates

64 our study of waste management preferences using both contingent valuation methods (CVM) and

65 choice experiment (CE) techniques to examine individual (private) drivers of willingness to pay

66 for a specific change to the environmental state, as well as the key (public) policy attributes that

67 might incentivize wider adoption by less-supportive individuals in the Mekong River Delta region

68 of Vietnam as a case study.

69 **2. Study site background**

70 The Mekong River Delta (MRD) has experienced a significant economic expansion in recent years

71 which has increased solid waste output. Migratory movement from rural to urban regions between

72 2009 and 2018 was caused by low and unstable regional earnings. Climate change has impacted

73 rice and other production in rural areas of the MRD, while the rapid development of industry and

74 services in urban areas of the six major MRD provinces/cities has created an imbalance in regional

75 income distribution. Rapid population expansion has depleted natural resources such as water,

76 electricity, and raw materials to fulfill production and consumption demands; negatively impacting

77 the environment. As a result, the amount of MSW created in metropolitan areas is rapidly

78 increasing.

79   MSW from urban areas accounts for more than half of all waste generated in Vietnam,

80 growing from 32,000 tons per day in 2014 to 37,000 tons per day in 2019 (Ministry of Natural

81 Resources and Environment of Vietnam, 2016; 2020). In 2020, the total daily volume of solid

82 waste created in MRD regions was around 14,000 tons. By contrast, the volume of solid waste

83 collected by government services each day is 9,800 tons or roughly 70% of the volume created

84 (Ministry of Natural Resources and Environment of Vietnam, 2020). Therefore, waste service

85 infrastructure, financial investment and human resources in the MRD region have not kept pace

86 with output growth. Further, in many MRD districts waste collection, transportation and treatment

87 operations are disconnected from one another, particularly at the municipal level where

88 public/private interaction is highest. Poor implementation of waste services is also driving

89 environmental and public health issues. In recent years environmental deterioration, particularly

90 in landfills, has been a significant source of concern. A program to improve municipal solid waste

91 (MSW) collection and treatment is therefore critical.

92   An issue is the public cost of such change, and limited privately provided revenues. The

93 present monthly rate for current MSW collection and treatment services of around US$0.86 per

94 household is substantially lower than the service operating costs (Ministry of Natural Resources

95 and Environment of Vietnam, 2020), limiting government investment unless private individuals

96 are willing to pay more for the service in future. Increased pressure on government policy-makers

97 to identify an appropriate MSW management solution has come from a recent *National strategy*

98 *on Integrated Solid Waste Management: 2025 to 2050* approved by the Vietnamese Prime Minister

99 in Decision No. 2149/QD-TTg. The strategy sets specific objectives: that, by 2025, 90% of all

100 urban solid waste will be collected and treated according to national standards with 85% of all

101 MSW to be recycled, reused, energy-recovered or converted to organic fertilizer. This objective

102   necessitates the implementation of a more sophisticated waste management system with different

103   integrated solutions in the MRD. A focus of that change is the source separation of waste materials.

104   Source separation is the segregation of different types of solid waste (organics, plastics,

105   paper, non-recyclables) at the location where they are generated (household or business). The

106   number and types of categories into which wastes are divided usually depend on the collection

107   system used and their final destination/use (Moh, 2017). Advantages of source separation include

108   (World Bank, 2018):

109   *(i)*   Economic: organic and recycled waste components in Vietnam account for about 60% - 65%

110   and 22% - 26% of solid waste, respectively. Organic components in residential solid waste

111   can be used to supply raw materials for fertilizer products in conjunction with the source-

112   separation of materials (e.g., composting bins or separate green waste collection). Recyclable

113   components such as plastic, glass, nylon, metal, and rubber can also be removed at source to

114   save money on incinerator operation costs while also increasing total landfill space for

115   residential solid waste.

116   *(ii)*   Environmental: lowering the volume of organic and harmful materials (e.g., oils, paints and

117   chemicals) through source-separation reduces negative environmental effects such as smells,

118   leachate, and soil, groundwater and surface water contamination.

119   *(iii)*   Social: Solid waste source separation also raises public awareness about environmental

120   conservation. Increased awareness, and the development of positive environmental habits,

121   can lead to increased social benefits.

122   In order to successfully accomplish a source separation initiative, private households must

123   be incentivized to change their behaviour (i.e., separate waste materials), and contribute to public

124   waste service funding so that the government can update their equipment, processes and employee

125   skills. As a result, we are interested in knowing what factors will encourage behavioural change

126   in the separation of waste, and if households would be willing to cover the additional costs of

127 upgraded services; where the fee paid in the future will obviously be higher than current, especially 128 in the case of developing country where this study will provide a useful base to compare with 129 other developing contexts (Padilla and Trujillo (2018).

130   Both the requirement for increased revenue in support of changes to MSW management in 131 the MRD and the complex set of treatment criteria established under the new national strategy link 132 well with our adoption of stated preference techniques. Further, it is highly likely that there will 133 be a diverse set of preferences spread across the population spanning high acceptance of the need 134 for environmental change to those who prefer the status quo. Identifying these different groups 135 and their potential drivers is a key advantage of stated preference techniques. Finally, recent 136 reductions in oil prices highlight volatility in waste recycling markets and a need for governments 137 to be prepared to invest locally to address future instability (Ko et al. 2020). Our study of MSW 138 using stated preference techniques is therefore timely given a narrow focus on these issues in 139 developing countries since 2006. In support of that view, we begin with a review of the relevant 140 literature in this field.

141 **3. Literature review**

142 As stated above, solid waste management preferences are hard to assess since they often have no 143 market value and must be estimated using non-market valuation approaches. A willingness to pay 144 (WTP) for additional services that may change an environmental state is the underlying premise 145 of these approaches (Bateman et al., 2002). Optimal waste management systems ensure that 146 society gains a net maximum benefit from proper disposal (Garrod and Willis, 1998), and stated 147 preference techniques are commonly used to elicit people's WTP to establish those economic 148 benefits (Jin et al. 2006). The two most commonly applied techniques in the MSW literature are 149 contingent valuation methods (CVM) and choice experiments (CE). These techniques share a 150 common random utility theory basis allowing for direct comparison (bid) and are based on an

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151 assumption that peoples' behaviour in a hypothetical market can indicate their genuine intentions

152 for environmental products (Hanley et al., 1998b), even with very little data (Diafas, 2016).

153   Both Damigos et al. (2016) and Ko et al. (2020) provide helpful summaries of applications

154 of CVM and CE techniques in the study of solid waste management. Both summaries indicate that

155 CVM techniques (see Aadland and Caplan 2006; Yusuf et al. 2007; Gillespie and Bennett 2013;

156 Ferreira and Maques 2015; Maimoun et al. 2016) are more commonly applied over CE—mainly

157 due to the complexities associated with CE design and implementation. However, despite these

158 issues, many studies employ CM to determine the MSW program characteristics for which people

159 are willing to pay (see Othman 2007; Adeoti and Obidi 2010; Czajkowski 2013; Yuan and Yabe

160 2015; Fukuda et al. 2018; Tarfasa and Brouwer 2018). In a seminal study, Adamowicz et al. (1998)

161 show that CE techniques may be beneficial over CVM in some contexts where they completely

162 explain the trade-offs between attribute qualities. CE techniques can also be used to eliminate bias

163 and other issues that might arise in surveys that include only "agree" or "disagree" questions

164 (Ready et al., 1996). Specific to MSW contexts, the capacity for CE to identify key attributes of

165 MSW programs that appeal to people is a necessary foundation for suggesting legislation or

166 program reforms to improve the efficacy of waste management services (Pearce et al., 2006).

167   By contrast, CVM surveys focus on recognizing the gains or losses from an environmental

168 change using a limited set of commodity features (Diamond and Hausman, 1994; Stevens et al.,

169 2000) where it may be appropriate to use an open-ended WTP question format. Where multiple

170 attributes are connected to an environmental change, applications of CVM may be inappropriate

171 (Jin et al. 2018). Further, in developing contexts where market distortions complicate shadow

172 pricing exercises (Arrow, 2001), and literacy rates are low, personal interviews using CVM

173 approaches may provide a more appropriate elicitation method (Johnston et al. 2017). Recognizing

174 the pros and cons of these techniques this study employs both CVM and CE approaches to i) assess

175 MRD household willingness to pay for improved solid waste management programs to reduce the

7

176 government's total financial burden in the Mekong Delta and ii) identify key policy attributes that

177 will inform future MSW policy design and implementation and increase engagement across a

178 wider sample of the MRD population. These are useful contributions in this growing literature,

179 where we will also compare estimated welfare differences—as suggested by Boxall et al. (1996)

180 —as important possible drivers of differences between the two modelled results.

181 There has been an increase in the number of studies using the CE method to evaluate various

182 attributes of sorted waste management programs (Das et al., 2008). Some studies, such as Othman

183 (2002), Jin et al (2006) and Karousakis and Birol (2008) have used CE methods to evaluate solid

184 waste management programs. However, it is necessary to clearly define the attributes of the waste

185 management program being studied. Past studies have often focused on the attributes associated

186 with the phases of a waste management system including: i) monetary attributes or the fee that

187 people pay for the improvement of the quality of services (Fukuda et al., 2018; Karousakis and

188 Birol, 2008; Othman, 2007; Sakata, 2007, Tarfasa and Brouwer, 2018); ii) the amount people may

189 receive for contributing to an improvement in the quality of solid waste management services

190 (Yuan and Yabe, 2015); iii) waste collection periods (Czajkowski et al., 2014; Fukuda et al., 2018;

191 Karousakis and Birol, 2008; Yuan and Yabe, 2015); iv) the availability of equipment to support

192 waste classification (Fukuda et al., 2018; Tarfasa and Brouwer, 2018; Yuan and Yabe, 2015) or

193 final waste treatment (Fukuda et al., 2018; Othman, 2007); and/or v) improved recycling methods

194 as an incentive to change behaviour (Sakata, 2007). However, in developing countries, the number

195 of solid waste classification types is often lower than that of studies conducted in developed

196 countries where solid waste might be classified into one of five (Czajkowski et al., 2014) or as

197 many as 11 categories (Sakata, 2007).

198 Therefore, when designing a CE survey the key attributes and levels must be carefully

199 identified and examined (Pearce et al., 2006), with the number of attributes proportional to the

200 number of observations in the study (Bateman et al., 2002); that is, the larger the number of

observations, the greater the number of attributes that can be included. However, to avoid complex choice sets for respondents, the number of attributes should be limited to no more than four or five attributes (Pearce et al., 2000; Hanley et al., 2002). Willis and Garrod (1999) argue that solid waste management strategies should address public concerns about sustainable use of resources as well as reduce the amount of solid waste that needs to be disposed of in landfills. This suggests four attributes related to a household's MSW reduction program: reducing the amount of solid waste that needs to be treated, reducing the amount of CO_2 emitted from solid waste treatment, the number of types of solid waste classified, and the monthly fee for MSW management.

Further, while contemplating environmental action, psychological considerations should also be taken into account. This broad term refers to an individual's personality and perceptual qualities as they relate to their behaviour. Intrinsic incentives to engage such as behavioural gratification (De Young, 1986) and threats to welfare from environmental problems (Baldassare and Katz, 1992) are examples. A study should also consider any contextual factors, personal capacities, attitudinal factors, and habitual factors (Soderholm, 2013) as key elements that influence environmental behaviour. Finally, drivers of individual attitudes and motives for change could stem from technical-organizational circumstances (external factors), socio-demographic factors (e.g., age, gender, income), and socio-psychological variables (Miafodzyeva & Brandt, 2013).

4 Research methodology

4.1 *Survey instrument design*

For both the CVM and CE survey instruments our design process began with a thorough scan of the available literature, and initial discussions/focus groups with both waste management experts and local resident groups. This information was then used to establish requisite framing information to be added into each survey, as well as final attribute and payment card details. In each case, the penultimate survey designs were pre-tested with 20 randomly selected households

9

226 to ==calibrate== the validity of the format, comprehension of the information included, and the

227 effectiveness of any bias management tools employed.

228   In the final iteration of the CVM survey, respondents were first introduced to the proposed

229 MSW program and told that it would aim to reduce landfill solid waste by supporting management

230 methods such as waste avoidance and reduction (e.g., recycling, reusing); where some further

231 detail about how this would work in practice via source separation was also offered. A cheap talk

232 script as an *ex-ante* bias correction was also shown to the respondents to remind them to consider

233 budget constraints and state an amount as if the payment was real. The respondent was then asked

234 if they would be willing to pay for the proposed program using ==closed==-ended questions comprising

235 five possible monthly payment bid values: VND20,000, VD50,000, VND80,000, VND110,000

236 and VND130,000 (which were equivalent to US\$[1]0.87/month, US\$2.18/month, US\$3.49/month,

237 US\$4.81/month, and US\$5.68/month). ==The closed-ended question format was chosen because of==

238 ==its significant benefits over other forms. In fact, this type of question is much easier for respondents==

239 ==to answer as they can focus on the question rather than the framing issues (Whitehead, 2006).==

240 These bid values were based on additional discussions with local waste managers and public

241 officials from urban joint-stock companies as the local authority managing waste in every province

242 in Vietnam, and reflect the range of expected low and high-cost changes. Finally, respondents

243 were asked to provide some social demographic characteristics and their perceptions and benefits

244 of MSW programs. ==The commonly used model to estimate utility functions in CVM method is the==

245 ==Logit model. This model is based on limited assumptions and is popular due to the simplicity of==

246 ==estimations.==

247   ==By contrast, the== CE survey instrument included more detail about the proposed program

248 attributes and how changes to the environment might alter under different levels of those attributes.

249 When designing a CE survey both the key attributes and their relevant levels must be carefully

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[1] US\$1 was equal to 22,890 Vietnamese Dong (VND) on June 30th, 2021

250 developed and tested (Pearce et al., 2006). The total number of attributes that can be taken into

251 account is proportional to the number of study observations (Bateman et al., 2002); the more data

252 gathered, the higher the number of attributes that can be included. However, to avoid complicated

253 choice sets for respondents the number of attributes should be limited (Hanley et al., 2002)—

254 typically to six attributes/levels at most inclusive of the payment option. Based on the discussions

255 and focus groups outlined above, we settled on four attributes for the study (with levels in

256 parentheses):

1. The percentage of solid waste recycled (0%, 5%, 10% and 15%) through the new program

2. The rate of CO_2 emission reductions (0%, 5%, 10% and 15%) achieved

3. The number of MSW separation classes on offer (unsorted, recycled + residual, or recycled + organic + residual) through provided bins, and

4. The monthly fee for MSW management service (US$0.86/month, US$2.14/month, US$3.43/month, US$4.71/month and US$5.57/month).

263 Consistent with the literature, when investigating households' preferences for waste separation

264 these four attributes may differ according to specific local conditions (e.g. payment fee and the

265 number of MSW sorting classes) (Czajkowski et al., 2014). These attributes have been widely,

266 and successfully, used in different contexts. Therefore, their application for waste sorting in this

267 study is deemed appropriate. Naturally though, the attribute levels employed by our study differ

268 from those of others to accommodate local MRD household preferences for emission rate

269 reductions, levels of waste recycled, and sorted-waste classifications based on our pilot program

270 data (i.e. consistent with the government-provided bin classes).

271 Following the pre-testing phase, an orthogonal combination approach was used to create 25

272 alternative survey versions using the four attributes/levels detailed above. These options were then

273 incorporated into five final different survey versions (see Table 1 for an example choice set), and

274 each household was provided with one of those five survey versions. Each package corresponded

275 to a set of choices, and each question had three options. Option A and option B were hypothetical

276 solid waste management service quality improvement plans defined by the four criteria above,

277 with varying levels the attributes. Option C was the status quo option, where an individual saw no

278 need to increase the current MSW management service quality.

4.2 Data collection

280 Once finalized, the two survey instruments were implemented among a stratified sample of the

281 population. Following Jin et al. (2018) and Contu and Mourato (2020) we administered both

282 surveys to each household. This was done so that we could compare welfare estimates and

283 contribute to the ongoing examination of comparability between the two approaches in the

284 literature (see for example Lehtonen et al. 2003), and highlight better how each can inform

285 program or policy decision-making processes in developing contexts (Boxall et al. 1996). In order

286 to avoid bias when presented to respondents with CVM and CE on the same day, each scenario

287 was carefully explained to the respondents (Boxall et al. 1996).

288   The final data (380 observations) for our study was gathered by conducting direct interviews

289 with local residents in three of the biggest MRD cities: Can Tho (urban grade 1 – 146 responses),

290 Long Xuyen (urban grade 2 – 120 responses), and Ca Mau (urban grade 3 – 114 responses).

291 According to the Ministry of Natural Resources and Environment of Vietnam (2016), urbanization

292 is a critical reason for sharp recent solid waste increases; but where differing levels of urbanization

293 will drive different sources of waste and separation requirements. Thus, in urban settings within

294 developing countries, the use of stratified samples is common (see for example Chaudhry et al.

295 2007) and, for our purposes, useful as the results of this study may in future be applied to the rest

296 of the Mekong River Delta region.

297

298 **Table 1. Description of different version options in the CE questionnaire**

Categories	Option A	Option B	Option C
Rate of MSW being recycled	Reduced 10%	Reduce 5%	**Do not choose both A and B** <mark>(Status quo)</mark>
The rate of CO_2 emissions is reduced	Reduced 15%	Reduce 15%	
Number of types of classified MSW	Recycling and remaining	Non-classified	
Fees for solid waste management service	US$0.87/month	US$2.18/month	
Please **tick only 1** of the 3 options	☐	☐	☐

299 *4.3 Data analysis*

300 The CVM survey instrument used in this study is based on random utility theory as detailed by

301 Luce (1959) and McFadden (1973), which states that the indirect utility function as a vector of a

302 households' use of a resource (V) follows the form:

303 $$V(p, q_i, M, \varepsilon) \tag{1}$$

304 where p is the price vector, q is the number of goods, M is income, and ε is a random error. For

305 simplicity, we can remove the price vector from the indirect utility function and assume that any

306 change in an environmental good will be at the expense of a households' capacity to perform MSW

307 source separation. Accordingly, when undertaking the classifying and separating their MSW, the

308 utility of a household will be:

13

$$V(q_0, M + t_k, \varepsilon) \geq V(q_0, M, \varepsilon) \tag{2}$$

309

310 In the CVM scenario, the bid or cost of the program arose from our earlier discussions with

311 experts and residents. The probability that a household chooses to answer "Yes" with the *bid* t_k

312 is:

$$Pr[Yes] = Pr[V(q_0, M + t_k, \varepsilon_1) \geq V(q_0, M, \varepsilon_0)] \tag{3}$$

313

314 If we assume that the utility function is linear: $v(q_i, M) + \varepsilon_i,$ $\tag{4}$

315 then it is possible to write the probability formula (3) for the option "Yes" as:

$$Pr[Yes] = Pr[v(q_0, M + t_k,) - v(q_0, M) + \varepsilon_1 - \varepsilon_0 \geq 0]. \tag{5}$$

316

317 The household will select "Yes" when the total usefulness changes, $\Delta U = v(q_0, M + t_k,) - v(q_0, M)$,

318 and the difference in error, $\eta = \varepsilon_1 - \varepsilon_0$, is greater than 0. The subsequent probability is:

$$Pr[Yes] = Pr[\eta \geq -\Delta U]. \tag{6}$$

319

320 Based on the theory of probability, we have:

$$Pr[Yes] = Pr[\eta \geq -\Delta U] = 1 - F_\eta (-\Delta U), \tag{7}$$

321

322 where F_η is the cumulative density function (CDF) of η. If $F(x)$ has a symmetrical distribution then

323 $F(x) = 1 - F(-x)$. If we assume that η has a symmetrical distribution we can write:

$$Pr[Yes] = F_\eta (\Delta U). \tag{8}$$

324

325 Based on probability theory, the <mark>maximum likelihood estimation approach was employed to</mark>

326 determine the cumulative density function (CDF) and <mark>then</mark> the values of the corresponding

327 coefficients. A parametric method is employed to estimate willingness-to-pay mean and median

328 based on the coefficient of bid and other variable coefficients related to attitude and other

329 households' socio-economic characteristics. This research used the Logit model, which is one of

330 the approaches commonly used to estimate the cumulative density function when the random error

331 has a normal distribution, to estimate the coefficients of these variables. The Logit model is

332 presented as follows:

$$P_i = F(x_i'\beta) = \frac{e^{x_i'\beta}}{1 + e^{x_i'\beta}}, \tag{9}$$

333

14

334   where $x_i'\beta = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 d_1 + \beta_4 x_3 + \beta_5 d_2 + \beta_6 d_3 + \beta_7 d_4 + \beta_8 d_5.$ (10)

335   The dependent variable (Y) is the probability of agreeing to pay for the increased MSW

336   management service fee. This variable holds two values: $Y = 1$ if the respondent agrees to pay,

337   and $Y = 0$ if the respondent does not agree to pay. The independent variables include the bid (X1),

338   which is the monthly fee per household for increased MSW management services. These rates are

339   suggested based on rates for unsubsidized MSW services from the government and local experts.

340   The variable age (X2) is the respondent's age (in years). The variable male (D_1) is a dummy

341   variable that holds two values: $D_1 = 1$ if the respondent's gender is male, and $D_1 = 0$ if the

342   respondent's gender is female. Edu (X3) is the respondent's years in school (in years). It is expected

343   that respondents with higher educational attainment tend to understand the benefits of increased

344   MSW management services and the environmental harm from solid waste. Therefore, they tend to

345   pay higher for any program changes. Income D_2 (dummy variable) holds two values: $D_2 = 1$, if the

346   respondent's monthly income is US\$385.44 or more (this is the level of a deduction for taxpayers

347   based on Law No. 26/2012/QH13 issued by the National Assembly of the Socialist Republic of

348   Vietnam on November 22, 2012), and $D_2 = 0$ when lower than US\$385.44. In this case, the demand

349   theory for environmental goods assumes that the higher the income, the better the demand for

350   environmental quality (Lewis and Tietenberg, 2019). The non-classified variable (D_3 - dummy

351   variable) takes two values: $D_3 = 1$, if the respondent does not recycle the MSW by classifying it,

352   and $D_3 = 0$ if otherwise. Finally, we also classify by type of urban setting, which differs with respect

353   to population size and density, rates of non-agricultural labour, and architectural or infrastructure

354   amenities (where type 1> type 2>type 3). The variable Urbantype2 (D_4 - dummy variable) again

355   takes two values: $D_4 = 1$, if the respondent is in urban city type 2, and $D_4 = 0$, if otherwise. Finally,

356   Urbantype3 (D_5 - dummy variable) has two values: $D_5 = 1$, if the respondent is in urban city type

357   3, and $D_5 = 0$ if otherwise.

15

358   The CE approach is based on the multi-criteria utility theory of Lancaster (1966) combined

359   with the random utility theory of Thurstone (1927). The random utility theory states that an

360   individual consumer's utility consists of observable and unobservable parts. The observable

361   (measurable) portion of an individual's utility is based on their evaluation of the product attributes.

362   The unobservable portion is random and depends on the individual's preferences. The utility

363   function of an individual i when consuming product j is:

$$U_{ij} = V_{ij} + e_{ij} = V(Z_{ij}, S_i) + e(Z_{ij}, S_i) \tag{11}$$

365   Where V is the observable part. V_{ij} is a vector of the degree of the attributes Z of product j together

366   with the economic, social and attitudinal characteristics (S) of respondent i, e is the unobservable

367   part. Faced with a choice set consisting of many different products with different attributes,

368   consumers will choose the product that gives them the maximum utility (max U). The probability

369   that individual i chooses product j over any other product m corresponds to the likelihood that U_j

370    $> U_m$. Specifically, the probability of choosing product j of individual i (P_{ij}) will be:

$$P(i) = P(U_{ij} > U_{im}) = P(V_{ij} + e_{ij} > V_{im} + e_{im}); \forall m \in C \tag{12}$$

372   Assuming that the random component e_{ij} follows a homogeneous, independent and identical

373   distribution (IID), and follows a Gumbell or Weibull distribution, the probability that alternative

374   j is selected is estimated using Multinomial Logit (MNL) model as follows:

$$P(y_i = j \mid C) = \frac{\exp(Z_{ij}^{'}\beta + S_i^{'}\delta)}{\sum_{m \in C} \exp(Z_{im}^{'}\beta + S_i^{'}\delta)} \tag{13}$$

376   (13)

377   This study employed a Hausman and McFadden (1984) test to check whether the IIA property is

378   violated. If the IIA property is violated, the random parameter logit (RPL) is then applied. The

379   random utility function in the RPL model is as follows:

$$U_{ij} = V_{ij} + e_{ij} = Z_{ij}^{'}\beta + S_i^{'}\delta + Z_{ij}^{'}\varphi_i + e_{ij} \tag{14}$$

381 Where v is the deterministic component of the latent utility and e is the error component stochastic

382 term, $\beta + \varphi_i$ is the population mean, and $\varphi_i \sim N(0, \mu_i)$ is the stochastic deviation that represents

383 the individual's preferences relative to the average preferences in the population. Considering

384 unconditional heterogeneity in preferences across respondents and conditional on the

385 unobservable φ_i (Birol et al., 2006), Eq. (13) now changes as follows:

$$P(y_i = j \mid C)\varphi_i = \frac{\exp(Z'_{ij}\beta + S'_i\delta + Z'_{ij}\varphi_i)}{\sum_{m \in C} \exp(Z'_{im}\beta + S'_i\delta + Z'_{ij}\varphi_i)} \tag{15}$$

387 The stochastic portion of the utility in this model may be correlated among alternatives and across

388 the sequence of choices through the effect of φ_i because of an unrestricted IIA assumption. The

389 requirement of treating preference parameters as random variables is the estimation of the

390 simulated maximum likelihood. Procedurally, the maximum likelihood algorithm searches for a

391 solution by simulating n draws from distributions with given means and standard deviations. The

392 probabilities are estimated by integrating the joint simulated distribution.

393   The linear equation of utility for the choice of the jth product is written as:

$$V_{ij} = ASC + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \dots + \beta_k Z_k \tag{16}$$

395 where k is the order of the product attributes. The coefficient β can be negative or positive,

396 different for each product attribute, and is "valued" according to the subjective preferences of each

397 individual. The coefficient β will vary between groups of individuals in a population but be the

398 same for individuals in the same group. Although there are many ways to remove the mismatch

399 from the choices and improve the model fit, this research uses the MNL model to reduce the error

400 and give the most accurate results.

401   Based on formula (16), the utility function of choice A, B, and C in each set of questions

402 can be presented as follows:

403   Option A $V_1 = ASC + \beta_1 fee + \beta_2 waste + \beta_3 co2 + \beta_4 sep2 + \beta_5 sep3$

404   Option B $V_2 = ASC + \beta_1 fee + \beta_2 waste + \beta_3 co2 + \beta_4 sep2 + \beta_5 sep3$

405   Option C $V_3 = \beta_1 fee + \beta_2 waste + \beta_3 co2 + \beta_4 sep2 + \beta_5 sep3$

406   where Vj is the utility function associated with choice j, and the *ASC* is a constant for each choice

407   in the model. The marginal willingness to pay (*MWTP*) for improved properties via the proposed

408   MSW program is estimated by the marginal rate of substitution between the non-monetary

409   attribute parameter $\beta_{non-monetary\ attribute}$ and the monetary attribute factor $\beta_{monetary\ attribute}$ as

410   follows:

$$MWTP = -\frac{\beta_{non-monetary\ attribute}}{\beta_{monetary\ attribute}}.$$

411

412   The coefficients $\beta_{non-monetary\ attribute}$ and $\beta_{monetary\ attribute}$ are estimated from the MNL

413   model. The variables included in the MNL model are the attributes of the MSW management

414   service quality improvement program. These variables include the variable *fee*, variable *waste*,

415   *co2*, and two separation variables *sep2* and *sep3*. The variable *fee* represents the charging attribute

416   for increased MSW management service stated as the monthly payment the household will incur

417   for the MSW service (US\$/month). The variable *waste* (%) represents the percentage of recycled

418   solid waste. The variable *co2* is a variable representing an attribute of reduced CO_2 emissions (%)

419   from changes to waste management, while the variables *sep2* and *sep3* represent numeric attributes

420   of the possible types that MSW may need to be separated into (recycled, organic, residual). The

421   variable *sep2* is a dummy variable that takes two values: *sep2* = 1, if the number of MSW types is

422   classified into 2 types, recycled and remaining, and *sep2* = 0 if the number of MSW types is not

423   classified into any type (unclassified). The variable *sep3* is another dummy variable with two

424   values: *sep3* = 1 if the number of MSW types is classified into three categories (recycled, organic,

425   and residual), or *sep3* = 0 if the MSW is not classified into those three categories.

426   *Welfare analysis*

427   In order to compare welfare measurements from each technique, the CE is restricted to evaluate

428   the welfare impact of the same improvement presented in CVM. It means our CVM examined

18

429   only the MSW management program change, while the CE model estimates any welfare changes

430   relative to different attribute levels. For the CE the change of a suggested MSW management

431   program was valued using the following function (for further information see Boxall et al. 1996;

432   Morrison et. al, 1999; Jin et. al., 2018):

$$WTP = -\frac{1}{\beta_M}(V^0 - V^1),$$

433

434   where β_M is the coefficient of monetary attribute and is interpreted as the marginal utility income.

435   V^0 and V^1 represent the indirect observable utility before and after the change under consideration.

436   Data analysis in this paper was conducted using STATA version 14 and NLOGIT 5 statistical

437   sòtare (package for choice modeling estimation).

5. Results and discussion

5.1 Socio-economic characteristics of the respondents

440   Thirty percent of the respondents were male, and 70% were female, with the average age of

441   respondents being 49.6 years old. About 1.32% of respondents said they did not go to school. Of

442   those that had attended school 23.95% had attended elementary school, 33.68% went to secondary

443   school, 30.79% went to high school, and 10.26% went on to higher studies. With respect to

444   employment the two biggest categories, traders and homemakers, represented 33.16% and 26.84%

445   of the sample respectively. Other employment categories included retirees (10.25%), government

446   roles (6.32%), and working for private enterprize (3.42%). The majority of those who responded

447   had an average monthly income of less than US$385.44, accounting for 90.79% of those surveyed.

448   These socio-economic characteristics of respondents are consistent with population-level data

449   from the Vietnam Household Living Standard Survey (VHLSS) conducted by Vietnam General

450   Statistic Office (GSO) every two years. Therefore, the representativeness of the data in this survey

451   was confirmed.

452   *Attitudes of the respondents towards the situation of MSW*

453 Because the research was conducted in metropolitan areas, most participants received solid waste

454 collection services (98.42%). The average quantity of MSW emitted per residence is 1.84 kg per

455 day, which is collected by city sanitation workers. Although localities in the MRD have not yet

456 implemented the program of classifying MSW at source our survey results showed that 50% of

457 respondents were aware of the process behind at-source separation MSW programs (according to

458 the instructions of the Vietnam Government's Decree 38/2015/ND-CP on waste and scrap

459 management), and 67.11% have implemented it on the basis of being able to sell some waste

460 products as a small source of revenue. By contrast, 32.89% of households have no experience with

461 selling waste goods to third parties with many complaining that the amount sold does not provide

462 sufficient income to alter their behaviour. Finally, there were some respondents (2%) who stated

463 they had little concerns for or about waste classifying behavior.

464 *5.2 Estimation results from CVM and CE for the improved management program*

465 *Estimation results - CVM approach*

466 Our results found that 66.31% of respondents were willing to pay for improved MSW management

467 services which is a relatively high acceptance rate. Across the bid levels, 94.87% of respondents

468 agreed to pay the monthly cost of US$0.87; just 5.12% refused to pay. When the monthly charge

469 was increased to $2.18, 77.63% still agreed to pay. At the price of US$3.49/month, the number of

470 those who decided to pay fell to 65.27%. When the charge was raised to US$4.81/month, the

471 acceptance rate dropped to 53.84%. Only 39.47% of respondents agreed to pay the maximum

472 monthly cost of US$5.68. These outcomes are compatible with demand curve economic theory

473 and as we would expect—but encouraging given the positive levels of participation among

474 residents at the higher payment levels.

475 **Table 2. The proportion of willingness to pay for improved MSW management services**

Bid	Willing to pay	Unwilling to pay

(US$/month)	Total of observations	No. of respondents	Proportion (%)	No. of respondents	Proportion (%)
0.87	78	74	94.87	4	5.12
2.18	76	59	77.63	17	22.36
3.49	72	47	65.27	25	34.72
4.81	78	42	53.84	36	46.15
5.68	76	30	39.47	46	60.52
Total	380	252	66.31	128	33.68

476 *Source: Survey data, 2020*

477   Table 3 summarizes the findings of the Logit model used to estimate willingness to pay

478 based on the respondents' socio-economic characteristics, where the model's prediction percentage

479 is 76.58% which is both reasonable and acceptable. We next grouped households into three

480 categories: Group 1 comprised households with previous waste sorting experience, Group 2

481 households did not have any prior experience in waste separation, and Group 3 combined both into

482 a single collective. The main purpose of this exercise was to determine if significant differences

483 in WTP values exist between groups. Interestingly, Group 2 respondents reported higher WTP for

484 waste separation despite no prior engagement with such activity (Table 4), which may reflect a

485 distaste for such activity generally. Overall, the determinants of the respective WTP are consistent

486 across our three models, but there are statistically significant differences between experienced

487 waste-sorting households and those that have never undertaken this activity. The regression

488 findings also demonstrate that the parameter of the Bid variable (significant at the 1% level) has a

489 negative sign, indicating that the higher the charge for the MSW management service, the lower

490 the chance of agreeing to pay. This result is consistent with economic theory and people's

491 preference for recycling programs, depending on how much it would cost their households to

492 participate in the programs (Kipperberg and Larson, 2012). Furthermore, the data reveals that the

21

older the respondent the less likely they are WTP for increased services, possibly due to limited or fixed income constraints. This may be confirmed by the fact that those with higher incomes are more likely to pay for the proposed changes. These results conform with previous research by Rahji and Oloruntoba (2009), Pek and Othman (2010), and Altaf and Deshazo (1996), in which, age, income, family size, and employment have all been identified as socio-economic predictors of household waste handing behavior. Our results also reveal important factors which previous studies have not mentioned, where living conditions and waste types would give people different incentives to recycle. This result is somewhat consistent with Heller and Vatn's (2017) results, in which the authors argue that one of the motivations for recycling is an individual's concern for the environment.

Table 3. Logit regression results on factors affecting the willingness to pay for the improvement of the MSW management program

Variables	Model 1 - Group 1		Model 2 – Group 2		Model 3 - Combined group	
	Coef.	z value	Coef.	z value	Coef.	z value
Constant	1.67568***	3.15	2.72104***	2.76	1.75397***	3.81
Bid	-0.000017***	-6.85	-0.000016***	-4.13	-0.000017***	-8.03
Age	-0.01263*	-1.67	-0.02575*	-2.10	-0.01549**	-2.45
Male	-0.10289ns	-0.50	0.57605*	1.75	0.09211ns	0.54
Edu	0.02973ns	1.22	-0.01061ns	-0,23	0.02513ns	1.18
Income	0.95496**	2.17	1.17246**	2.27	1.02106***	3.12
Non-classified					0.31167*	1.85
Urbantype2	0.61853***	2.75	0.56527ns	1.48	0.63748***	3.04
Urbantype3	0.96389***	4.00	0.90777**	2.52	0.94405***	4.79
Log-likelihood	-128.48043		-54.00449		-184.55692	
LR chi^2(8)	76.51		42.08		116.46	

Prob > chi^2	0.0000	0.0000	0.0000
Pseudo R^2	0.2294	0.2804	0.2398
Observation	255	125	380

Note: *, **, and *** are statistically significant at 10%, 5%, and 1%, respectively, and [ns] are not statistically significant

Group 1: Households with previously sorted garbage, otherwise belong to Group 2. Sorted garbage indicates activities carried out by households, in which several recycling materials such as paper, metal, and plastic bottles are separated and then sell to informal individual waste collectors.

Respondents that did not perform MSW separation stated that this was because they did not have time to do so, or because sorted MSW required a lot of storage space. This set of respondents was also more likely to pay higher rates for change than others. Further, respondents in Type 2 and 3 urban regions were more likely to agree to pay than respondents in Type 1 urban regions. This may be explained by the fact that existing MSW management systems in Type 1 cities are more thorough than those in other urban settings and, as a result, respondents in Type 2 and 3 cities have higher expectations for increased MSW management services that are expected to contribute to environmental improvement.

The mean WTP elicited from the CVM and CE surveys are presented in Table 4. The parameter findings from the Logit model suggest that the average WTP value for increased MSW management via the CVM is US$4.81/month/household, ranging from US$4.49/month/household to US$5.47/month/household (at 1% significance level). Meanwhile, the mean WTP from the CE survey estimates is about US$4.61; or a little smaller than the CVM average. As stated above, the mean WTP for Group 1 respondents is smaller than that of other groups.

Table 4. Willingness to pay mean value estimated from CVM and CE

		MWTP	Lower Bound	Upper Bound	ASL
Group 1	CVM	4.62	4.16	5.25	0.0000

	CE	4.54 (1.80)	4.04	5.04	
Group 2	CVM	5.58	4.75	7.38	0.0002
	CE	4.84 (1.83)	4.33	5.35	
Combined group	CVM	4.81	4.49	5.47	0.0000
	CE	4.61 (1.81)	4.11	5.11	

525 Note: ASL is the significance level for hypothesis tests: H_0: WTP <= 0, H_1: WTP>0, number in parentheses are std.

526 err.

5.3 Estimation results - CE approach

528 Table 5 reveals the results of the CE approach with MNL estimation. The results indicate that all

529 the attributes are statistically significant except Sep2 and Sep3. The results show that the attribute

530 variable fee, waste type and CO_2 influence people's willingness to pay for the program to improve

531 the quality of MSW management services. The coefficient of the fee variable has a negative value,

532 showing a negative correlation to the people's decision to pay. This is consistent with the law of

533 demand and price effects. In contrast to the fee variable, the coefficients of the waste and Co_2

534 variables have a positive value, increasing the decision to pay for an improvement in MSW

535 management services, and the probability of people participating in the program. However, the

536 final fee value for the program should be calculated at a reasonable level because this is a factor

537 that reduces the probability of people participating.

538 Table 5. Estimated results of the MNL model

Variable name	Coeff.	z value
ASC	2,70137***	6,94
Fee	-0,000023337***	-16,92
Waste	1,53366*	1,82
CO_2	3,09356***	3,61
Sep2	0,11476[ns]	1,63
Sep3	0,05827[ns]	0,70
Log-likelihood	-1.161,55238	
Observation	1,965	

539 *Source: Survey data, 2020*

540   The test results of IIA property are summarised in Table 6. The values of the test statistics

541 are significantly greater than the critical value of the Chi-square distribution, which is 18.475 at

542 the 1% significance level with seven degrees of freedom. Therefore, the null hypothesis of the IIA

543 restriction is rejected. However, the constant variance assumption would be violated if the

544 alternatives Rice A and Rice B were dropped from the choice sets; indicating that using the CL

545 model approach to analyze this data may not be appropriate in terms of the IIA assumption. A less-

546 restrictive specification of the choice model was thus considered to obtain unbiased and better

547 results via an RPL model, with the results shown in Table 7.

548 **Table 6. IIA Test results**

Alternative dropped	χ^2	Degree of F	Probability
Alternative A	348,0945	6	0.0000
Alternative B	3.918,3110	6	0,0000

549 *Source: Survey data, 2020*

550 The results of the RPL regression model reveal the attribute determinants of any WTP decision in

551 support of improved MSW management services (Table 7*).* A*cross* all *three models* the attribute

552 variables charge, waste, *co2*, *sep2*, and *sep3* impacted people's willingness to pay for a program

553 to increase. The coefficient of the fee variable has a negative sign, indicating that the charge has a

554 negative link with the respondents' payment decision. The coefficients for waste, co2, sep2, and

555 sep3 on the other hand have a positive sign, indicating a favorable link to the choice to pay more

556 to increase MSW management services. As a result, when the MSW management program is

557 improved by gradually raising the proportion of recycled MSW, reducing the rate of CO_2 emitted

558 from MSW treatment, and categorizing additional categories of MSW, people are more inclined

559 to participate in the program.

560 **Table 7. Estimated results of RPL model on the determinant of households' willingness to**

561 **pay for source-separation of solid waste**

	Model 1 - Group 1	Model 2 – Group 2	Model 3 - Combined group

25

Variable name	Coeff.	z value	Coeff.	z value	Coeff.	z value
Fee	-0.000088***	-9.09	-0.000081***	-5.65	-0.000089***	-10.89
Waste	11.07539***	6.05	8.69775***	3.20	10.38837***	6.61
CO_2	17.07812***	6.29	22.96321***	4.45	19.61559***	7.74
Sep2	0.40276***	2.70	0.55241**	2.42	0.47944***	3.73
Sep3	0.20030^{ns}	0.95	1.07653***	3.40	0.50683***	2.86
Log-likelihood	-698.86745		-325.51282		-1,029.320	
Observations	4,065		1,812		5,877	
Chi^2	222.36		119.38		348.39	
$Prob > Chi^2$	0.0000		0.0000		0.0000	

562

563 However, the payment charge for program improvements should be calculated at an appropriate

564 level because this is a factor that may reduce the likelihood of resident participation. Further, our

565 results provide evidence of a strong positive relationship between *sep3* and WTP by Group 2

566 members as well as those in the combined Group 3. This effect is not statistically significant for

567 Group 1. Therefore, at source separation of MSW into the three categories (recycled, organic and

568 residual) is not significantly correlated with an increased WTP. The MWTP values for each of the

569 program's attribute characteristics were generated based on the RPL regression findings (Table 8).

570 Table 8 illustrates that individuals are interested in the attributes focused on in our research.

571 Interestingly, Group 2 has the highest mean WTP for three of the attributes (*co2, sep2, sep3*) and

572 the lowest MWTP for the *waste* attribute. This result conforms with the CVM findings. It is

573 possible that this result is reflective of the perceptions and characteristics of households on MSW

574 separation, as explained above, where households with lower education and income may not

26

575 expect many environmental benefits (or attributes) from this behavioural change. However, chief

576 among these attributes is a reduction in CO_2 emissions, where the marginal willingness to pay for

577 the attribute (US\$9.61/month) is nearly twice as high as the marginal willingness to pay for the

578 attribute of increasing recycling rate (US\$5.09/month) and forty times the marginal willingness to

579 pay for separate types of solid waste. This result is consistent with previous studies (e.g., Sakata,

580 2007), which found that individuals in Japan are prepared to pay a premium to minimize dioxin

581 emissions. This result also suggests that the willingness to pay for the program's features is more

582 than the present charge of around US\$1.13/month/household or US\$3.40/year/person, indicating

583 a favorable indicator for the enhancement of the quality of MSW management services (World

584 Bank, 2018). Environmental attributes have been considered important factors that determine

585 household willingness to contribute to sorting programs. Consistent with previous studies, this

586 research indicates that concerns related to waste and CO_2 increase household willingness.

587 Furthermore, Sep2 and Sep3 which are related to environmental concerns also motivate higher

588 willingness (Heller and Vatn (2017). Once again though, the cost of the program associated with

589 recycling will be critical, where the fee variable clearly shows a negative influence on WTP.

590 **Table 8. WTP for program attributes (US\$/month)**

Variables	MWTP (Confidence interval 95%: Lower bound to Upper bound)		
	Group 1	**Group 2**	**Combined group**
Waste	5.48*** (3.71 to 7.24)	4.65*** (1.91 to 7.39)	5.09*** (3.60 to 6.58)
CO_2	8.45*** (6.17 to10.71)	12.27*** (8.03 to 16.52)	9.61*** (7.62 to 11.60)
Sep2	0.20*** (0.06 to 0.34)	0.30** (0.06 to 0.53)	0.23*** (0.11 to 0.36)

	0.10^{ns}	0.57***	0.25***
Sep3	(0.10 to 0.31)	(0.27 to 0.89)	(0.08 to 0.42)

591

592   More importantly, as the current fee structure is insufficient to cover the existing collection,

593 transportation, and treatment of solid waste where the total cost is US$1.68/month/person (World

594 Bank, 2018) the opportunity to reduce the financial burden on the state budget is significant. This

595 is important for a country such as Vietnam where economic development is essential but budget

596 constraints are typically high. According to the Vietnam Ministry of Finance (2015), state budget

597 expenditures on MSW management have more than quadrupled from US$266,809.42 in 2010 to

598 US$488,222.70 in 2015. The capacity to address that shortfall, and aid policymakers to implement

599 Prime Ministerial Directive 33 (2020) as a result of this research, offers an important contribution

600 toward expanding waste management and reuse capacity in Vietnam.

6. Conclusions and policy implications

602 Finding from this paper should be interesting and useful to policy-makers, especially in developing

603 countries that are struggling to implement and maintain effective MSW programs. We find

604 positive rates of WTP for increased MSW management services among those that have previously

605 engaged with waste separation activity and those that have not; where interestingly those that have

606 not undertaken the behaviour previously may be willing to pay higher rates for the service. This

607 may indicate some reluctance to engage in separation activity for revenue purposes (where such

608 income generation is possible), but still manifest as a willingness to participate in waste separation

609 for collection purposes. This specific finding may have to be tested further through focus sessions

610 and additional interviews with members from that group. However, we do find that separation

611 services offered under any increased MSW program are correlated with an increased willingness

612 by residents to pay for that service.

613   The WTP estimates are broadly consistent across the two survey approaches and show no

614   statistically significant difference. This finding is consistent with the limited number of previous

615   studies that have compared welfare estimates between these two approaches. An additional driver

616   of higher WTP appears to be any reduction to CO_2 emissions provided by environmental changes

617   under a changed program. Environmental concerns have grown in relevance for Vietnamese

618   residents in recent years, likely driving some of the findings reported in this study. Responses

619   collected via the CVM survey suggested an average willingness to pay of US\$4.81/month, while

620   the CE survey WTP estimate was US\$4.61/month—again consistent with other studies that show

621   CVM estimates can often be higher than those of CE. However, the difference here is negligible

622   as shown and offers a clear price range for policy-makers to consider adopting; and one that is

623   well above the current US\$0.86/month revenue for existing services, and also higher than the

624   US\$1.68/month real costs of Vietnamese MSW operations.

625   When implementing the proposed program changes it will be critical for management

626   agencies to strengthen their communication programs in order to raise awareness of environmental

627   benefits that can stem from improved MSW and the source-separation of household waste. These

628   awareness-raising activities should initially focus on households with higher incomes that already

629   actively participate in environmental-related activities in their areas. However, at the margin,

630   further useful policy advice has been provided by our study from discrepancies between the CVM

631   and CE welfare estimate approaches. While the CVM survey determined an economic worth of

632   changes to the existing solid waste management program, by contrast, the CE survey enabled us

633   (and Vietnam's policy-makers) to estimate the economic worth of key MSW management

634   program attributes. Respondents, in this case, have reported a willingness to engage in separation

635   behaviour, and pay for the MSW services required to collect, process and reuse that waste. This is

636   an important finding, as recycling habits are frequently seen as a component of everyday activities

637   that are significantly influenced by patterns; where further government efforts to incentivize those

638 who would prefer the status quo (~33% in this case) may assist in motivating change and full

639 adoption of improved MSW practices. This could involve rewards for those that do the right thing,

640 or neighborhood competitions related to waste separation activity. In any case, our research

641 provides useful insight for governments in developing countries to manage the growing problem

642 of waste management and recycling needs into the future.

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