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Attribute prioritization in choice experiment pre-design: suggested method and application to solid waste management service improvement

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Abstract

Most valuation problems on environmental resources possess huge list of choice-influencing attributes than the parsimony requirement of choice experiment (CE) would accommodate. As such, design-attribute determination which entails selecting the most appropriate sub-set of the entire list constitutes the first step in CE. It is based on the assessment of attributes' relative importance in interview with stakeholders. The complexity of coding and generating themes under this method limits the coverage of opinion survey on attributes' relative importance to small sample. Since average opinion is based on small sample, the risk of observing attribute non-attendance which is a recent problem in CE will be higher. Against this background, the present study suggests an alternative quantitative method of assessing attributes relative importance at the predesign stage of CE. Based on an application to solid waste management service improvement, the method was found to be simple and applicable to large sample. Since the method allows survey of opinion coverage on attributes' relative importance to large samples, we recommend its application to reduce the risk of attribute non-attendance.

Key Words: Attribute Non-attendance, Attribute Relative Importance, Discrete Choice Experiment, Solid Waste Management.

1. Introduction

Growing interest in economic valuation of environmental goods, especially based on CE method, had provoked analytical contributions on pre-modeling issues. These include the determination of the number of choice set (Rose & Bliemer, 2009), attribute selection (Guttmann et al., 2009), choice of fractional factorial design (Rose & Bliemer, 2009; Louviere et al., 2011), and the selection of relevant design attributes through interviews (Coast & Horrocks, 2007; Kløjgaard et al., 2012). Attribute non-attendance is one of the recent issues of concern in CE studies (Hess, 2012). This problem is attributable to design-attributes identification (Alemu et al., 2013; Hanley et al., 1998; Coast and Horrocks, 2007; Hensher et al., 2005). Since attribute selection is the first step in CE, the validity of such studies depend on researcher's ability to correctly specify a sub-set of all potential choice-influencing attributes about which the target population holds high preferences (Alemu et al., 2013; Mangham et al., 2008). This is despite the enormous attributes possessed by environmental goods or services (De Bekker-Grob et al., 2012).

In spite of this unique role of attribute selection, CE studies discussing how the sub-set of relevant design-attributes is determined are sparse (Mangham et al., 2008; Kløjgaard et al., 2012). Design-attribute selection is based on the perception of target population (Hanley et al., 1998; Coast and Horrocks, 2007; Mangham et al, 2008). Usually, applied studies obtain such perceptions through literature review and focus group discussions from a small sample of stakeholders (Coast and Horrocks, 2007; Kløjgaard et al., 2012). This could increase the risk of observing attribute non-attendance problem at post-design stage. This problem which had recently gained attention among analysts partly arises on account of including attributes about which some respondents hold low preference in experimental design (Alemu et al., 2013). One way to mitigate this risk is by reaching out to large sample of affected population to obtain the relative importance of all potential design-attributes relevant to a valuation problem of interest. However, the current procedure, which is based on interview feedbacks limit access to large sample due to complications of coding and generating themes from a large sample. This paper explores the use a quantitative technique which could be used to assess attributes' relative importance in large sample. This will aid researchers in reaching larger samples to obtain result that would adequately reflect the average opinion of affected population to reduce attribute non-attendance risk at post-design stage. The technique which we dub design attribute relative importance index (DARII) is based on Relative Importance

Index (RII) assessment that is commonly adopted in engineering literature. We apply it to solid waste management service improvement attributes to prioritize attribute selection for our upcoming CE study.

2. Method

2.1 Suggested Method

RII assessment is common in project risk management abound in engineering literature. It is used to determine the relative importance of variables where respondents' perceived degree of importance among variables apparently important is subjective. Since individual perception might not reflect average perception among affected population, relative importance is assessed large sample of respondents. Such assessment begins with the identification of factors or variables [17](El-Sayegh, 2008). This coincides with the first stage in CE which entails relevant design-attribute selection (Hanley et al., 1998; Mangham et al., 2009). Analogous to CE studies, the lists of important variables are occasionally identified through literature survey (El-Sayegh, 2008). More often, variables obtained from literature are augmented with more variables from expert discussions and interviews (Aziz, 2013; Bari et al., 2012). This is comparable to the first stage for identifying relevant design attributes in CE.

The sizes of RII for the properties of different variables are assessed based on perceived mean value and standard deviation. At times, they are based simply on the percentages of respondents that ascribe high scores to a variable (Ramanathan, et al., 2012). In more recent studies, some variants of perceived mean importance are also adopted (Bari et al., 2012; Aziz, 2013; Ramanathan, et al., 2012). Studies that adopt the use of mean value and standard deviation to assess attributes' relative importance calculate the magnitude using the following equation:

$$\text{Relative Importance Index, RII} = \frac{\sum_{i=1}^{i=I} W_i X_i}{\sum_{i=1}^{i=I} X_i} \qquad (1)$$

where W_i is the weight assigned to i^{th} response; for i= 1, 2, 3, until I, respectively and X_i, frequency of the i^{th} response. Note that I refers to the maximum value of the response category and its magnitude depends on the rating scale used. Usually, either five-point or seven point Likert-type rating scales are employed. Regardless of which one is used, a value of 1 signifies low effect or significance while a value of 5 or 7, as the case may be symbolizes high effect or significance. Meanwhile, analysts that adopt the modified technique assert that mean values and standard deviations of each variable or factor, assessed individually is not statistically suitable to compute relative importance across variables. They argue that magnitudes computed based on such values would not reflect any relative relationships among variables of interest to justify comparison (Bari et al., 2012). As such, this group of analysts advocated for the use of a variant of RII that yields values which are comparable in relative terms. This adjusted RII is computed based on equation (2).

$$\text{Modified Relative Importance Index, MRII} = \frac{\sum_{i=1}^{i=I} W_i X_i}{\sum_{i=1}^{i=I} X_i * I} \quad (0 \leq \text{MRII} \geq 1) \qquad (2)$$

where the size of the earlier RII in equation (1) is weighted by the maximum value (I) of the response category. The weighing magnitude depends on the rating scale used. Thus, MRII is expected to range between 0 and 1 irrespective of the rating scale adopted. The nearer an attribute's rating to 1, the higher is its perceived importance relative to others and vice versa. Thus, as implied in Kometa et al., (1994), the Likert scale is transformed to a continuum as shown in Figure 1.

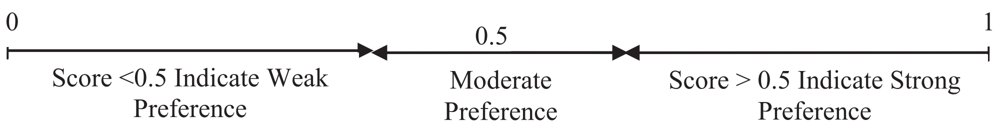

Figure 1: Interpretation of the magnitudes for design-attribute relative importance index
Source: Adopted from Kometa et al., (1994).

2.2 Application of Relative Importance Index in Choice Experiment

In adapting the computation of RII to the context of design attributes for CEs, this study sticks to the modified version which is most suited to our purpose on account of its emphasis of on relativity. The combination of

[17] Here, the factors or variables referred to in the context of engineering is adopted to denote attributes in CE

characteristic theory of value and the theory of random utility pave way for respondents' choice between different bundles of environmental goods to be observed. Thus assuming utility depends on choices made from some choice set **T** of alternative environmental goods, equation (3) shows an individual's utility function in this context.

$$U_{in} = V(A_{in}, S_n) + \varepsilon(A_{in}, S_n) \quad (3)$$

Utility obtainable from an option is presumed to depend on attributes A, of the option. Such attributes are view differently by different individuals arising from differences in their socioeconomic characteristics denoted by *S* (Hanley et al., 1998). Where one of such attributes is usually a price, cost or compensation. Thus, utility depends on attributes and attributes relative importance perception differ across individuals on account of differences in socioeconomic variables. It is therefore ideal to expect some variability in relevant design attributes. Since attributes are believed to impact on utility under CEs, respondents are asked to rate each attribute based on their perceived degree of its impact on their utility. As such its application under CEs will apply equation (3). However, the response anchor will be based on respondents' perceived impact of each attribute on utility based on response category; i= 1, 2, 3, until *I*.

2.3 Application of DARII to Solid Waste Management Improvement

Based on established procedure for design attributes determination, the study began with relevant design-attributes identification. This was achieved through literature review, expert consultations, interview with members of staff of Lagos state Waste Management Authority (LAWMA) and members of staff of the Ministry of environment. In addition, a few households from the target population were also interviewed. Attribute harvesting from literature was limited to past valuation studies on solid waste management improvement. This constituted the first step in attributes identification. Initially, twenty-three (23) attributes were identified, including five attributes specific to solid waste management services provision in Lagos. These include enforcement on defaulting tenements, waste containerization, pre-collection services, waste evacuation from canal, and door-to-door collection services.

Immediately following that was individual face-to-face interviews held with stakeholders. Based on interview feedbacks, three attributes were deemed irrelevant from the purview of stakeholders. These include water pollution, psychological fears (Pek and Jamal, 2011), and changes in the mix of collection trucks (Afroz et al., 2009, Afroz & Masud, 2011). Detailed summary from transcribed interview which follows similar procedure as explained in Coast and Horrocks (2007) is reported elsewhere. The synthesis of literature and interview feed-backs from stakeholders generated a huge set of potential design-attributes. In conformity to existing practice (Hanley et al., 1998), the irrelevant attributes were finally deleted. After the three irrelevant attributes were deleted, twenty attributes were left. The synthesis yielded four broad groups of attributes. A breakdown structure for the identified design-attributes important for solid waste management improvement is shown in Figure 1. Further, three more questions were deleted as discussed in the following subsections.

2.4 Questionnaire Content

The questionnaire was broadly divided into two sections. Section A elicits pieces of information about respondents' demographics. Whereas, section B presents the list of solid waste management services improvement attributes. Respondents were then asked to rate each of the attribute to determine the most important sub-set. Based on design-attributes breakdown structure in Figure 1, section B comprises both monetary and non-Monetary attributes. Respondents were also provided with response anchor with Likert-type rating scale for scoring their perceived importance for each attribute. Details are provided below.

2.4.1 Monetary Design-Attributes

The inclusion of monetary attribute among relevant design attributes is a fundamental practice in CE. Its inclusion within the random utility framework allows for the estimation of welfare variables such as willingness to pay (WTP) or willingness to accept-WTA (Bennett and Birol, 2010). Interview feedback revealed four important monetary attributes broadly categorized into two. These include payment for waste disposal services provision and compensation for effort and cost incurred from households' involvement in separating solid waste into designated categories. Interview result also suggested that both of these attributes could be respectively disintegrated into two. These comprise annual charge and monthly charge as well as discount on waste charge or bill and provision of free waste container.

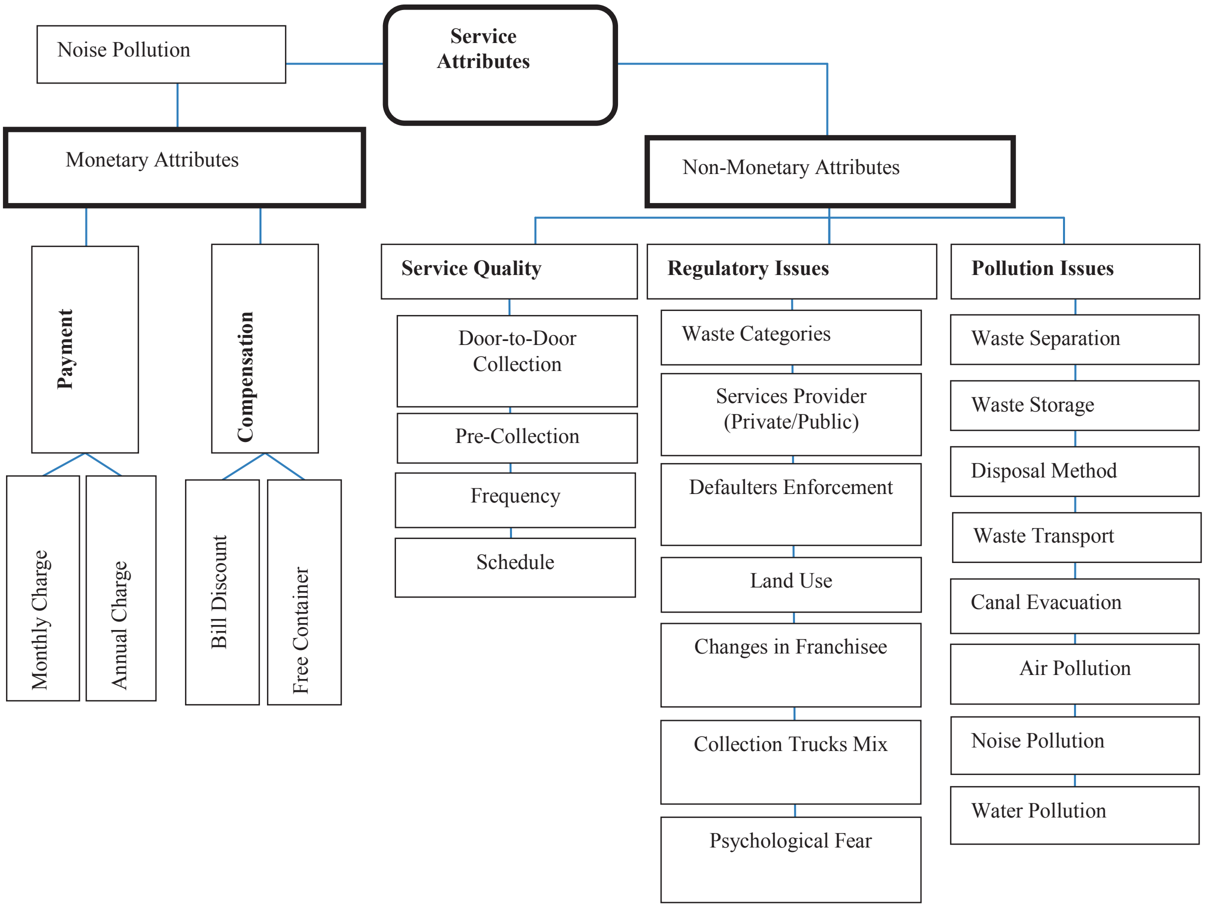

Figure 1: Solid Waste Management Services Design-Attributes Breakdown Structure
Source: Authors' Survey of Literature and Interview

Usually both measures (charges and compensation) are not included in the same CE study. The criterion depends on the objective of a study. If the estimation of WTP constitutes part of the objective, the price or tax attribute is included. Meanwhile, if the assessment of agents' WTA constitutes part of the objective, then compensation attribute is considered for inclusion. The CE application that will follow this study aims at estimating the minimum compensation amount households will be willing to accept to support source-separation. As such, payment was considered irrelevant in the present application. Yet, while compensation attribute is of interest only the bill discount was considered policy relevant. This was based on interview with Lagos state waste management authority (LAWMA). The representative noted that the government, through LAWMA, is proposing to pay a monthly waste bill reduction to the tune of 50% discount to households who segregate generated solid waste into designated categories. This policy consideration further reduces relevant design-attributes to seventeen (17) from twenty-three (23).

2.4.2 Non-Monetary Design-Attributes

In CE all attributes that do not denote cost, sacrifice, price or compensation are commonly named non-monetary attributes. The synthesis of literature survey and interview responses revealed seventeen (17) relevant design-attributes. These attributes are broadly categorized into three groups as shown in Figure 1. These include four attributes pertaining to services quality, seven regulatory attributes and eight pollution-related characteristics of the improvement plan. Under this category of attributes, pre-collection service entails waste collection from tenements using lighter vehicles prior to final transportation. In Lagos, that is done using motorized tricycle which has the advantage of accessing roads in urban slum areas which are often narrow with no asphalt or bituminous treatments. This makes such areas inaccessible to heavy compactor trucks. As such pre-collection service is usually rendered in such areas to transport the waste to compactor trucks which does the final transportation at the tar roads. Meanwhile, tenements in affluent areas feel pre-collection service is not relevant as the waste compactor trucks could collect their waste at door-step.

2.4.3 Response Anchor and Rating Scale

Having identified the important attributes, the next task was to determine which of the listed important attributes were relatively of utmost importance. Appropriate wording of response anchor is essential in enhancing respondents' understanding of the research intent. In the interview that precedes this study, respondents were asked to explain things that affect their satisfaction on services provision. In expressing their ideas, they mentioned 'importance', 'effect' and 'impact', most often. As such we chose to use "degree of impact' on respondents' satisfaction regarding the inclusion or non-inclusion of an attribute in improved services provision. This conforms to the anchor used in engineering literature. Kartam & Kartam (2001) and El-Sayegh (2008) used 'degree of impact'. Kangari (1995) and Hwang et al., (2013) used 'degree of importance'. Meanwhile, Chan and Kumaraswamy (1997) and Aziz (2013) used 'degree of effect'.

The next issue was the determination of appropriate rating scale. The most commonly used rating scale in existing studies on RII are five-point and seven-point Likert scales. For instance, Kartam & Kartam (2001), Kangari (1995), Hwang et al., (2013), Chan & Kumaraswamy (1997), Aziz (2013), El-Sayegh (2008), all used 5point Likert scale but Kometa et al., (1994) used 7-point Likert scale. Accordingly, five-point Likert scale was employed in this study. Hence, the response anchor ranged from 1 (low impact on satisfaction) to 5 (high impact on satisfaction) for the inclusion of an attribute in improved solid waste management services with source-separation.

2.5 Sampling and Questionnaire Administration

Data collection was achieved via face-to-face administration of structured questionnaire to household representatives. Questionnaires were administered by ten interviewers who were employed and exposed to training sessions. The questionnaire which only spans two pages, including demographic information, was presented along with a cover letter explaining the purpose of the research to respondents. Finally, 100 questionnaires were administered. In-home survey was employed. Since the market for solid waste management services is segmented (Adepitan, 2010), only one stratum (economically-affluent area) was chosen. Initially Apapa GRA, which is an affluent neighborhood, was chosen from this stratum but access to home owners was difficult. As such, Surulere which is a relatively less affluent community was chosen for the research. Convenience sampling was used as interviewers went home-to-home to administer questionnaire to respondents who were willing to be sampled.

3. Results and Discussions

3.1 Socioeconomic Characteristics of Households

We achieved as much as 98 percent response rate. This was expected since face-to-face interview was employed (Bateman et al., 2002). Besides, interviewers were specifically instructed to remind respondents where information was missing since the questionnaire was kept very brief. Notwithstanding, two questionnaires were excluded from analysis on account of incomplete responses. As such 98 responses were considered for analysis. Table 1 shows a summary of the survey sample characteristics. The gender distribution of the sample was 57:43 (male and female). This is similar to the state's gender distribution (2006 Census) where the male accounts for 51.8% and the female, 48.2%.

Average sample age was 35.7 years, with the least being 18 and the highest being 61 years old. Respondents were grouped according to reported ages into three cohorts of 18−24, 25−40 and above 40. These cohorts are respectively labeled young adult, middle-aged adult and older adults. Statistics shows that 9.2% of respondents are young adults, 66.3% are middle-aged, while 24.5% are older adults. About three-quarter of respondents were married while the rest were either single or divorced. About 90% of households in this affluent area had formal education ranging from primary (5.1%), secondary (19.4%) to tertiary (64.3%) while the remaining 11.2% had no formal education. This literacy rate is higher than the National average of 71.6%. This is expected since nation-wide literacy survey report shows that literacy rate is higher in Lagos than other states in Nigeria (NBS, 2010). Majority of households work in the private sector (43%), while another 34% work with the public sector. The rest 23.4% revealed that they were either unemployed or pensioners. Incomes are measured in Naira (local currency), where ₦1.00 equals $160.00 USD. No respondent reported monthly household income below ₦50,000. In higher income ranges, 70.4% respondents report monthly household income between ₦51,000 − ₦100,000, while 21.4% reported earning between ₦101,000 − ₦200,000. Meanwhile only 8.2% reported earning more than ₦200,000.

Table 1: Summary Statistics on Households' Socio-Economic Characteristics

		Frequency	Percentage
Age	18−24	9	9.2
	25−40	65	66.3
	>40	24	24.5
Gender	Female	46	42.9
	Male	52	57.1
	Single	23	23.5
Marital Status	Married	73	73.5
	Separated	2	2
Education	Never	11	11.2
	Primary	5	5.1
	Secondary	19	19.4
	Tertiary	63	64.3
Employment Type	Public	33	33.7
	Private	42	42.9
	Pensioners	7	7.1
	Unemployed	16	16.3
Income	₦10,000 − ₦50,000	0	0
	₦51,000 − ₦100,000	69	70.4
	₦101,000 − ₦200,000	21	21.4
	>₦200,000	8	8.2
Observations		98	

3.2 DARII for solid waste management services improvement

Based on survey responses, design-attributes relative importance index (DARII) was calculated using equation (2). Based on the rating scale in Figure 1, the result in Table 2 conforms to our priori expectation from interview results that all attributes finally included in this survey are important. This is evidenced by DARII >0.5 for all attributes considered. Meanwhile, for the purpose of parsimony, not all these important attributes could be included in a CE model. Previous studies on CE have not extensively detailed how this problem had been resolved in pre-design stage. The few studies that had attempted to address such have used qualitative procedure based on interviews (Coast and Horrocks, 2007; Kløjgaard et al., 2012). DARII technique proposed in this study offers an alternative quantitative approach. This is because indices obtained under this technique allows for comparison among important attributes (Chan and Kumaraswamy 1997). Besides, since it is based on large sample, it is expected to reduce attribute non-attendance in CE.

Table 2: Design-Attributes Relative Importance Index in Affluent Communities

ID	Design−Attribute Label	≤2	3	≥4	DARII	Ranking
15	Frequency	8.2	9.2	82.7	0.84*	1
13	Door-to-Door Collection	8.2	12.2	79.6	0.84*	2
17	Bill Discount	4.1	27.6	68.4	0.76	3
1	Waste Segregation	8.2	27.6	64.3	0.74*	4
10	Default Enforcement	18.4	34.7	46.9	0.74*	5
3	Storage Material	11.2	22.4	66.3	0.66	6
16	Schedule	17.3	40.8	41.8	0.65	7
12	Franchisee Rotation	16.3	49	34.7	0.63	8
8	Separation Categories	26.5	42.9	30.6	0.59	9
11	Land Use	28.6	46.9	24.5	0.58	10

*Attributes with equal magnitudes of DARII are ranked according to the percentage of respondents scoring 4 or more.

The pre-design ranking of attributes based on DARII in Table 2 shows the top ten important attributes among the seventeen (17) services attributes initially compiled. Based on the list of attributes in Table 2, franchisee rotation (rotation of services providing companies), the designated number of separate categories for source-separation and the area of land committed to disposal facility construction are among the ten top but least important in the list. Meanwhile, Frequency of waste collection, collection mode (door-to-door), and monthly discount incentive for source-separation are top on the list. Hence, DARII could generate information to guide the researcher even before experimental design in CE.

In contrast to the present qualitative technique which does not permit access to large sample, this method does allow the researcher to base attribute selection criterion on indicated relative importance. Since the indicated relative importance exhibited by DARII is based on large sample, it could reduce attribute non-attendance in the modeling stage of CE. This is expected since this problem arises on account of researcher's design of attribute about which respondents hold low preference (Hess & Hensher, 2010). Besides, there seem not to be standards in attributes selection, if studies could stick to the use of measures such as DARII, it will pave way for comparisons of results regarding the rationale for attributes selection across studies.

4. Conclusion and Recommendation

Discrete Choice Experiment is relatively a new approach in the valuation of non-market goods in environmental management. Attendant upon the growing interest in CE method, improvement in its theoretic and application issues are continuously receiving attention. It is not uncommon to find studies exploring improvements on several procedural issues in CE pre-model stage. Previous studies on methodological improvements related to CE pre-model stage have explored a few issues. These include the choice of fractional factorial design, determination of minimum number of choice set, as well as the identification and selection of relevant design attributes based on focus group interviews. The identification and selection of design-attributes constitutes the first step in CE. The validity of estimates obtained from CE study rests on researchers' ability to appropriately identify and select relevant design attributes. Design-attributes deemed relevant could be a sub-set of affected respondents' total choice-influencing attributes that are policy relevant. The latter requirement is usually the case where the commodity in question forms policy challenges.

In spite of the relevance of this stage in CE, applied studies only state the procedures through which design attributes are selected. This is usually based on interview with stakeholders. Rarely are further details presented on how selected design-attributes were decided. Meanwhile, valuation objects, commodities, or programs might possess more choice-influencing and policy-relevant attributes than CE model parsimony requirement would suggest. This is supported by Lancaster's utility approach that underlies the CE framework. Lancaster noted that as a general rule each commodity would possess more than one attribute. No finite attributes was suggested in his original paper. This will result in the selection of different attributes on similar valuation problems by different researchers. Therefore, this study was motivated by the quest for a less researcher-subjective approach that could be adopted to determine relevant design-attributes.

To achieve this, relative importance computation technique was adopted as an appropriate method. Besides explaining its compatibility with the goals of CE and how it could be applied, an example on households valuation of improvement in solid waste management services provision in Lagos was offered. Accordingly, design-attribute relative importance index (DARII) was computed for each of the policy relevant and respondents' self-reported choice-influencing attributes. The result was found to support a prior interview outcome on the importance of included attributes. This was evidenced by DARII values greater than 0.5 for all attributes.

Besides, DARII could generate information on the relative importance of each attribute where the target population is stratified. This will guide researchers on whether to impose the same design on different strata or adopt separate design for separate stratum. Based on the above exposition on the importance of DARII, we suggest future studies to compute this index for all potential design-attributes obtained through literature review and interview. This will be required especially where design-attributes are large. In such cases, researchers' subjectivity would be reduced in prioritizing what sub-set of important attributes to include in the design of experiment. If attributes held most important from respondents' purview are selected, responses will genuinely be based on trade-offs rather than randomness. This will reduce attribute non-attendance problem which had become a recent issue of concern in CE.

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