Economic Valuation of Air Quality in Kenya

By

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Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of Doctor of Philosophy in Environmental Economics

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DEDICATION

To Lillian, Ruth, Roseanne, Michael and Zephaniah

DECLARATION

I, Hilary Kaburi Ndambiri, declare that this thesis that I submit for the award of the degree of Doctor of Philosophy in Environmental Economics of the University of Pretoria, South Africa, is entirely my original work and has not been submitted for the award of any degree in this or any other university.

Notably, the first three sections of this thesis have been published in journals. I take responsibility for all inaccuracies in exclusions or reasoning found in this thesis.

Hilary Kaburi Ndambiri	…… …….	……..……
Name	**Signature**	**Date**

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ABSTRACT

This thesis employs stated preferences to estimate the economic value of air quality in Kenya through motorized emission reductions in the city of Nairobi. Firstly, it uses the contingent valuation (CV) method to evaluate individuals' preferences associated with motorized emission reductions in the city together with an account of how these preferences are affected by respondent uncertainty. Secondly, it employs the discrete choice experiments (DCEs) to analyze the implicit prices that motor vehicle owners in the city would be willing to pay towards specific motorized emission reduction attributes. Lastly, the thesis examines the relative performance of several DCE models and how best they are able to account for preference variation in the analysis of choice data. Notably, in the contingent valuation framework, three formats are used to draw preferences from individuals, namely, the conventional payment card format, which assumes that respondents are certain about their preferences; the stochastic payment card and the polychotomous payment card formats,

which both assume that respondents are uncertain about their preferences. The details of both CV and DCE analysis are discussed in four separate sections that follow, which together complete this thesis.

The first section looks at the stated preferences for motorized emission reductions in the city of Nairobi based on the conventional payment card approach. In this case, interval regression analysis is used to estimate individuals' preferences for motorized emission reductions in the city. The second section compares welfare estimates across stated preference and uncertainty elicitation formats for air quality improvements in the city of Nairobi using welfare estimates elicited through the conventional payment card, stochastic payment card and the polychotomous payment card formats. Both parametric and nonparametric approaches are employed to analyze welfare estimates across the stated preference and uncertainty elicitation formats.

The third section investigates the scope effects of respondent uncertainty in contingent valuation with evidence still from motorized emission reductions in Nairobi. Welfare values for motorized emission reductions are also elicited from respondents through the conventional payment card, stochastic payment card and the polychotomous payment card formats and then analyzed using parametric and nonparametric approaches. The fourth and final section looks at the stated preferences for motorized emission reduction attributes in the city of Nairobi based on a discrete choice experiment. In this case, several behavioural models, namely, the multinomial logit (MNL), mixed logit (MXL), scaled multinomial logit (S-MNL), generalized multinomial logit (G-MNL) and the generalized mixed logit (G-MXL) are also estimated to explore their relative performance and how best they are able to account for preference variation in the analysis of choice data.

The analytical results from the first section show that individuals in the city of Nairobi are, on average, willing to contribute Kshs. 396.60 ($3.97) and a median of Kshs. 244.98 ($2.45) for improved air quality management in the city through motorized emission reductions. This is about 2.04% and 1.26% of respondents mean income, respectively. The results imply that the concerned authorities in the city could formulate a motorized emission reduction plan for air quality improvement as there is evidence of considerable public support for such a plan. In the second analysis section, the study finds that certain respondents have higher and statistically different welfare estimates from uncertain respondents. This means that respondent uncertainty is found to have a downward effect on the underlying welfare estimates of individuals for air quality improvement in the city. As a result, policy makers in the city and beyond ought to account for respondent uncertainty in welfare analysis in order to arrive at precise estimates of welfare change. In the third analysis section, the study results show that although respondents captured in the survey pass the scope test, certain respondents state significantly larger willingness to pay amounts for larger emission reductions than for smaller reductions when compared with uncertain respondents. The implication is that while respondents are generally found to be sensitive to the scope of motorized emission reductions for air quality improvement in the city, respondent uncertainty is however found to lower their sensitivity to scope. As for the fourth and final analysis section, the study results reveal that motor vehicle owners in the city are willing to pay positive amounts towards specific motorized emission reduction attributes. The G-MXL formulation is also found to dominate all the other models interms of model performance based on the Bayesian Information Criteria (BIC) and also in accounting for preference variation in the choice data.

On the whole, this thesis concludes that indeed respondent uncertainty has significant effects on welfare and scope sensitivity of individuals in stated preferences. Consequently, an account for respondent uncertainty and preference variation among respondents in stated

preferences is crucial as this would provide valid estimates of welfare change to planners and policy makers. The G-MXL model is also found appropriate in choice analysis due to its superior performance in providing better estimates of welfare change and in accounting for preference variation in the choice data.

Key words: Discrete choice experiment, contingent valuation, respondent uncertainty, scope sensitivity, payment card, stochastic payment card, polychotomous payment card, air quality, motorized emissions reductions.

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LIST OF ACRONYMS AND ABBREVIATIONS

CFC	Chlorofluorocarbon
CO	Carbon monoxide
CO_2	Carbon dioxide
CV	Contingent valuation
HDV	Heavy-duty vehicle
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
O_3	Ozone
Pb	Lead
PC	Payment card
PPC	Polychotomous payment card
PM	Particulate matter
SO_2	Sulphur dioxide
SO_3	Sulphur trioxide
SO_x	Sulphur oxides
SPC	Stochastic payment card
VOCs	Volatile organic compound
WHO	World health organization
WTA	Willingness to accept
WTP	Willingness to pay

CHAPTER ONE
GENERAL INTRODUCTION

1.0 Introduction

In this chapter, background information is presented regarding economic valuation, contingent valuation method, respondent uncertainty, discrete choice experiments and the global nature of motorized emissions. This is followed by the statement of problem, the study objectives and hypotheses, study approaches and methods and finally the layout of the study.

1.1 Economic valuation

Central to the discussion on air quality degradation has been the effect it has on individuals and to the environment and also the costs it may impose on both health care and air clean-up plans (Leger, 2001). Given that air quality improvement is an environmental public good, economic valuation methods have thus been considered as the most appropriate tools for attaching monetary values for changes in air quality (Saelensminde, 1999; Wardman and Bristow, 2004; Wang and Whittington, 2005; Wang and Zang, 2008). Notably, attaching monetary values to air quality improvements is generally considered a difficult undertaking as air quality is unpriced and therefore no established markets for its trading (Hanemann, 1994; Diena *et al.*, 1998). Therefore, economic valuation is the name given to the process of assigning monetary values to non market goods and servives such as air quality, pollination services and biological diversity. Subsequently, environmental economists are able to avail vital information for use in policy formulation and in the management of such non market goods (Freeman, 1993; Hanemann, 1994; Carson, 2000).

There are two methods that environmental economists have used in the valuation of non market goods (Mitchell and Carson, 1989; Bateman *et al.*, 2002; Mendelsohn and Olmstead,

2009), namely: the revealed methods and the stated preference methods. The revealed preference methods employ surrogate markets to find correlations between the real market behaviour and the non market good in question. They rely on market observations to capture the value of environmental goods that are not themselves traded in any market but are in a way connected with other marketed goods. Revealed preference methods use regression techniques to estimate the underlying values associated with the behavioural decisions. Most commonly used revealed preference techniques include the hedonic pricing, travel cost, damage function and the quality adjusted life year. Conversely, revealed preference methods have a serious methodological problem that they only capture the use values of the valuation good in question. Since these methods fail to isolate the non-use elements of value, stated preference approaches are often employed.

In stated preference approaches, surveys or experimental interactions with respondents are used to construct hypothetical markets for the good under valuation. The hypothetical markets are, in this case, used to induce individuals to reveal either their willingness to pay (WTP) for the provision of a non market good that increases their utility or their willingness to accept (WTA) compensation for the provision of a non market good that decreases their utility. The most common forms of stated preference techniques are the DCEs and the CV method. As use and non use elements of value are both captured in these techniques, they are more preferred in the economic valuation of the non market goods than the revealed preference methods.

In this study, therefore, CV and the DCE methods were employed in the economic valuation of air quality in the city of Nairobi, Kenya. The goal of the study was to use the CV framework to evaluate individuals' preferences that are associated with motorized emission reductions in the city, account for the effects of respondent uncertainty on individuals'

preferences, employ DCEs to analyze the implicit prices that motor vehicle owners in the city are willing to pay towards specific motorized emission reduction attributes, examine the relative performance of several DCE models and finally give an account on how best the DCE models are able to account for preference variation in the analysis of choice data. These methods are briefly described in the section that follows.

1.2 Contingent valuation

The CV method is a survey-based approach used to assign monetary values to non market goods and services. First proposed by Ciriacy-Wantrup in 1947, its first real world application was done by Davis in 1963 while estimating the value hunters and tourists placed on a recreational wilderness area in the Maine woods, USA. The method gained further popularity in 1989 when it was used to assess environmental damage costs following the Exxon Valdez oil spill in Prince William Sound in USA. Ever since, the relevance of the method in estimating welfare benefits and costs of non market goods and services has been on the rise (Mitchell and Carson, 1989; Carson, 2000; Venkatachalam, 2004; Ataguba *et al.*, 2008; Ndebele, 2009; Hoyos and Mariel, 2010; Petrolia and Kim, 2011; Martínez-Espiñeira and Lyssenko, 2012; Al-assaf, 2014) with wide application in areas such as water and air quality management; health management; waste management; forest conservation; groundwater protection; outdoor recreation; wetland restoration; preservation of wilderness areas, endangered species, and cultural heritage sites; improvements in public education and public utility reliability; reduction of food and transportation risks and health care queues; and provision of basic environmental services such as drinking water. Since the CV framework is consistent with the microeconomic theory of welfare analysis (Freeman, 1993), the method is often used to estimate compensating and equivalent variation by directly eliciting individuals' WTP and/or accept compensation for non market goods and services under consideration (Mitchell and Carson, 1989).

The early CV surveys involved researchers simply asking people how much they were willing to pay for environmental amenities in an 'open-ended' question design (Mitchell and Carson, 1989). Nevertheless, such open-ended value elicitation questions became limited in their ability to provide precise estimates of welfare change. For that reason, 'close-ended' discrete choice questions were developed where respondents could give "YES or NO" responses to one or more specified bids used for assigning values to environmental amenities. The advantage of the 'close-ended' discrete choice questions over the 'open-ended' questions was that they reduced the cognitive burden of the respondents in answering the CV questions. As a result, the discrete choice questions became popular tools for eliciting individual preferences for environmental amenities in many CV surveys (Carson, 2000; Venkatachalam, 2004; Carson and Hanemann, 2005).

The CV approach has, however, suffered from a number of issues (Venkatachalam, 2004). One of the issues has been whether different preference elicitation questions result in the same welfare values. Kealy and Turner (1993), Brown *et al.* (1996), Ready *et al.* (2001), Blaine *et al.* (2005) and Champ and Bishop (2006) have noted that responses elicited using 'open-ended' and 'close-ended' question formats are significantly different especially for public environmental goods. For instance, Champ and Bishop (2006) note that 'close-ended' questions tend to produce larger welfare values than the 'open-ended' questions.

Another important issue about CV is whether the obtained WTP varies according to the level of change in the environmental good or service concerned – sensitivity to goods' scope (Whitehead *et al.,* 1998; Dupont, 2003; Czajkowski and Hanley, 2009). That is, would the WTP for improved air quality depend on whether the planned change is 25% or 50%? Ordinarily, it would be expected that higher levels of environmental goods or services would be preferred to lower levels and therefore, record a higher WTP than with lower levels.

Nonetheless, empirical evidence about this expectation is mixed as some authors have found limited or no evidence of sensitivity to good's scope (Boyle *et al.*, 1994; Loomis and Ekstrand, 1997; Dupont, 2003; Heberlein *et al.*, 2005; Czajkowski and Hanley, 2009). Some studies have even reported WTP values that are less than the expected change associated with the environmental good.

Hypothetical bias is yet another issue that has preoccupied researchers in CV surveys. The hypothetical nature of CV surveys has been shown to lead to unrealistic behavioural problems as respondents either give too high or too low WTP values. One of the main reasons advanced in the literature for the inconsistent WTP values has been the inherent respondent uncertainty that is seen to arise from the hypothetical markets posed in the CV surveys. Other reasons include lack of trust for the provisioning authority for the environmental good under consideration and also the perception among respondents that the hypothetical responses given in CV surveys have no consequences either in policy and/or in the actual provision of the good (List and Gallet, 2001; Whitehead and Cherry, 2007).

Because the prevalence of hypothetical bias tends to over predict the actual values of the goods being valued, it is thus considered as a serious methodological issue (Murphy *et al.*, 2005; Svensson, 2010) that has led to a number of techniques being advanced to address it. One of the techniques is the certainty correction or accounting approach, which attempts to capture respondent uncertainty in the estimation of WTP values (Li and Mattson, 1995; Loomis and Ekstrand, 1998; Harrison, 2006; Sund, 2009; Moore *et al.*, 2010). The certainty correction procedure is supposed to ensure that the valuation answers given by respondents are a good predictor of the real market values that can be used to provide accurate policy decisions (Li and Mattson, 1995; Loomis and Ekstrand, 1998; Ready *et al.*, 2001; Konsenius, 2009; Sund, 2009).

However, previous attempts to correct for respondent uncertainty have yielded inconsistent results (Shaikh *et al.,* 2007; Akter *et al.,* 2008; Martínez-Espiñeira and Lyssenko, 2012) when compared with studies where respondents are conventionally taken to be certain. Such mixed findings have led to inadequate flow of accurate and consistent empirical valuation information, which could be relied upon to predict the real market situations and to inform policy (Shaikh *et al.,* 2007; Martínez-Espiñeira and Lyssenko, 2012). With further calls for more empirical work on respondent uncertainty correction in non market valuation (Chang *et al.,* 2007; Shaikh *et al.,* 2007; Akter *et al.,* 2008; Bateman *et al.,* 2008; Blomquist *et al.,* 2009; Brouwer, 2009; Moore *et al.,* 2010; Lyssenko and Martínez-Espiñeira, 2011; Martínez-Espiñeira and Lyssenko, 2012), this study therefore purposed to look into the issue in greater detail by evaluating both welfare and scope effects of respondent uncertainty in CV.

1.3 Respondent uncertainty in contingent valuation

Respondent uncertainty, also known as preference uncertainty, refers to the situation whereby respondents in a survey fail to know with certainty their true preferences for an environmental good or service owing to the hypothetical markets posed during the valuation process (Li and Mattsson, 1995). Conventionally, CV method has always assumed that respondents know their utility functions with certainty and that they can give true WTP values for the good and/or a service they are asked value (Alberini *et al.,* 2003; Akter *et al.,* 2008). This notion stems from microeconomic theory of household behaviour where individuals are assumed to know their preferences and could therefore, state their true WTP for any change in the quality, quantity or even the composition of the good under consideration with certainty (Akter *et al.,* 2009).

Nonetheless, this assumption that CV respondents are certain about their preferences is a strong one (Ready *et al.,* 1995) since the CV approach seeks to elicit preferences for

environmental amenities in hypothetical markets and from respondents who may not have the cognitive capacity to make trade-offs between their money and the environmental goods in question (Wang, 1997; Champ *et al.,* 1997; Alberini *et al.,* 2003; Shaikh *et al.,* 2007; Sund, 2009). As a result, the incidence of respondent uncertainty may lower the efficiency of the WTP estimates and therefore, make them poor predictors of the real market situations that could inform welfare policies or investment programs (van Kooten *et al.,* 2001; Whitehead and Cherry, 2007; Akter *et al.,* 2008). As such, researchers (e.g. Li and Mattson, 1995; Alberini *et al.,* 2003; Shaikh *et al.,* 2007; Akter *et al.,* 2008; Brouwer, 2009) have stressed the impotance of capturing respondent uncertainty in non market valuation studies such as CV.

In stated preferences literature, there are two main approaches that have been developed to deal with the issue respondent uncertainty (Brouwer, 2009), namely: a) the ex post decision ratings where respondents are asked to rate their WTP certainty on a scale of 0 to 10 (Li and Mattsson, 1995; Champ *et al.,* 1997) and b) the polychotomous elicitation formats where respondent uncertainty is measured through ordinal categories such as 'Don't Know/Not Sure' or 'Definitely Yes, Probably Yes, Unsure, Probably No, Definitely No' (Ready *et al.,* 1995; Alberini *et al.,* 2003). A number of variants have also been developed from the two approaches, namely: (i) the stochastic payment card (Wang, 1997), which matches valuation bids to a combination of both certainty scale ratings and the polychotomous arrangement for expressing preference uncertainty and (ii) the polychotomous payment card questions (Welsh and Poe, 1998; Ndambiri *et al.,* 2016), which matches valuation bids only to the polychotomous arrangement for expressing respondent uncertainty.

Despite considerable effort in the development of these approaches and their subsequent application by researchers to measure preferences for policy change, their results have been mixed (Akter *et al.,* 2008; Petrolia and Kim, 2011) and the number of comparative studies

limited (Shaikh *et al.*, 2007; Martínez-Espiñeira and Lyssenko, 2012). Subsequently, this has restricted the available empirical valuation evidence for predicting the real market situations and to inform policy to only a few studies (Shaikh *et al.*, 2007; Martínez-Espiñeira and Lyssenko, 2012). Although the issue of respondent uncertainty has been a preoccupation in applied research involving CV (e.g. Chang *et al.*, 2007; Shaikh *et al.*, 2007; Blomquist *et al.*, 2009; Brouwer, 2009; Moore *et al.*, 2010; Lyssenko and Martínez-Espiñeira, 2011; Martínez-Espiñeira and Lyssenko, 2012), welfare and especially the scope effects of respondent uncertainty are not well known. As result, this study sought to enhance our knowledge by evaluating both welfare and the scope effects of respondent uncertainty in CV surveys.

With a case application to the valuation of a policy to reduce motorized emissions in the city of Nairobi, individual preferences were drawn using three CV question formats, namely: the conventional payment card (PC)[1], the stochastic payment card (SPC)[2] and the polychotomous payment card (PPC)[3] formats. It was expected that relevant policy and methological information would be availed to the scientific community for better policy formulation and effective assessment of air quality management programmes especially in the urban areas.

1.4 Discrete choice experiments

DCEs refer to the quantitative techniques used by researchers to elicit individual preferences (Mangham *et al.*, 2009). The technique was first used by Louviere and Hensher (1982) in

[1] A preference certainty elicitation format where respondents are presented with an ordered range of values and asked to tick the highest amount that they would be willing to pay for the improvement of air quality.

[2] A preference uncertainty elicitation format where respondents are presented with an ordered range of values as in PC, but now accompanied by probabilities ranging from zero to one and headed under five ordinal certainty scales: 'definitely yes', 'probably yes', 'not sure', 'probably no' and 'definitely no' related to their preference uncertainty.

[3] A preference uncertainty elicitation format where respondents are presented with an ordered range of values as in SPC, with no probabilities, but headed under five ordinal certainty scales: 'definitely yes', 'probably yes', 'not sure', 'probably no' and 'definitely no' that relate to their preference uncertainty.

transportation economics and later by Louviere and Woodworth (1983) in the marketing field as a method of studying consumer choice behaviour. In environmental economics, the first application was carried out by Adamowicz *et al.* (1994) and ever since, the method has been widely used for obtaining crucial information on resource allocation problems regarding situations where standard markets are nonexistent.

In a typical DCE, survey respondents are offered a set of alternatives that have been grouped into different choice sets and described by different attributes at different levels and then asked to choose their most preferred alternative from each choice set. The arrangement of the choice results lets the probability of an alternative being chosen to be modeled in terms of their attributes. As a result, higher levels of a desirable attribute in an alternative, ceteris paribus, are expected to have greater utility associated with a given option and are therefore more likely to be chosen by respondents and vice versa. It therefore allows researchers to discover how individuals' value the certain attributes of a good or service over other different hypothetical alternatives based on individual values placed on each attribute.

The DCEs present several advantages particularly over the frequently used CV method. To begin with, the method is capable of estimating a monetary indicator of the WTP for one additional unit of a non-monetary attribute (attribute value) and this is argued as the most important advantage of the DCE method over the CV. One important drawback in stated preference methods and especially in CV surveys is that they are predisposed to give biased results owing to their hypothetical nature (Diamond and Hausman, 1994; Mitchell and Carson, 1989). As such, DCEs have been argued to minimize some of the potential biases related to CV such as protest responses, strategic behavior, yeah saying and range bias. This is accomplished by allowing respondents to make a choice from a choice set in sequence of choice sets. Moreover, the sequential process permits the elicitation of additional information

for use in data analysis (Holmes and Adamowicz, 2003). DCEs are also argued to reduce the insensitivity to scope (embedding) problem often encountered in CV surveys by allowing internal consistency checks so that the analytical models are fitted on subsets of choice data (Alpízar *et al.,* 2001). Another advantage of the DCEs over the CV approach is that they are cheap to conduct because they can value different policy attributes using one single and more informative questionnaire (Hanley *et al.,* 2001).

Nevertheless, the method also presents some problems that have more to do with the description of the environmental good presented for valuation in relation to its attributes. For instance, owing to the cognitive burden posed by DCEs, respondents can view the good in question differently from the one described and therefore, evaluate either less, more or some other attribute other than the one presented in the study by the researcher (Bateman *et al.,* 2002). Besides, DCEs are less efficient in causally related attributes frequently found in ecosystems functioning as the orthogonality between the attributes does not permit the use of the attributes where the existence of one attribute depends on the existence of another previous attribute. It is also argued that DCEs are sensitive to the experimental design and therefore hard to believe that they resolve the hypothetical bias problem often found in stated preferences (Hanley *et al.* 2001). An additional disadvantage is that repeated responses by individuals in the DCE surveys can cause statistical problems due to possible correlation between them (Adamowicz *et al.,* 1998b). Furthermore, the increased complexity of choice tasks pushes respondents to use some rules of the thumb and other heuristics to reduce task complexity. This may, in turn, lead to irrational choice behaviour among respondents and hence, increased statistical errors (Swait and Adamowicz, 1996). Bateman *et al.* (2002) have also found significant insensitivity to scope in separate DCEs when respondents are presented with too many choice sets.

Notwithstanding all these problems, DCEs still provide an optimistic vehicle that can be used by researchers to address many environmental resource allocation problems. The fact that DCEs can handle any valuation problem because they use constructed markets makes them very attractive for application in the estimation of economic values for non market goods. In this study, the DCE approach was employed to assess the implicit prices associated with motorized emission reduction attributes in the city of Nairobi, Kenya. Several behavioural models, namely, the multinomial logit (MNL), mixed logit (MXL), scaled multinomial logit (S-MNL), generalized multinomial logit (G-MNL) and the generalized mixed logit (G-MXL) were also estimated to explore their relative performance and how best they were able to account for preference variation in the analysis of choice data. It was expected that the information sought would provide relevant policy information on the choice behaviour of individuals regarding emission reduction attributes and also methodological information on the relative performance of the different models and how best they account for preference variation in choice data.

1.5 Motorized emissions

Motorized emissions are substances generated by fuel combustion and evaporation from motor vehicles (ADB, 2008). Common motorized emissions include carbon monoxide (CO), oxides of nitrogen (NOx), oxides of sulphur (SOx), volatile organic compounds (VOCs), ozone (O_3), lead and particulate matter (PM) which include dust, smoke and other solid particles (Gwilliam, 2003; Schwela, 2004; Fazal, 2006). These emissions are largely harmless if they are in low concentrations. However, they become pollutants if their concentrations escalate to the extent that they begin to cause adverse effects on humans and the environment (WHO, 2005; Amin, 2009).

Worldwide, the use of motor vehicles has been on the rise since 1950s (Gwilliam, 2003; Schwela, 2004). Although motorization rate has decreased in the industrialized countries, increased urbanization and industrialization coupled with high population growth has led to accentuated use of motor vehicles throughout the world. For instance, in 1950, there were approximately 53 million cars on our roads and streets. But half a century later, the worldwide car fleet is over 500 million with an average increase of 9 million cars per year (ARPEL, 2001). This has led to car fleet saturation, increased traffic jams and large amounts of emissions especially in the urban areas where the car population is high (ARPEL, 2001; Gwilliam, 2003).

Currently, motor vehicles are considered to produce more air pollution than any other single human activity in the world (Walsh, 2005) accounting for 80-90 % of total air pollutants. The most common fuel types used by motor vehicles are gasoline for light-duty vehicles and diesel fuel for heavy-duty vehicles. Pollutants emitted from gasoline fueled vehicles are carbon monoxide (CO), hydrocarbons (HCs) and oxides of nitrogen (NO_X) while from diesel fueled vehicles, pollutants include oxides of sulphur (SOx) and particulate matter (PM) (Johnson *et al.*, 2000; ARPEL, 2001; Gwilliam, 2003; Walsh, 2005; UN-HABITAT, 2006).

In Latin America, air pollution in many urban centres exceed national and regional standards and the guidelines provided by World Health Organization (WHO). The most common urban air pollutants in the region include nitrogen oxides (NOx), carbon monoxide (CO), volatile organic compounds (VOCs), ozone (O_3), sulphur dioxide (SO_2), particulate matter (PM), and lead. Motor vehicles account for 99 percent of total CO emissions, 54 percent of hydrocarbons, and 70 percent of NOx in Mexico City; 96 percent of CO, 90 percent of hydrocarbons, 97 percent of NOx, and 86 percent of SO_2 in São Paulo; and 94 percent of CO, 83 percent of hydrocarbons, and 85 percent of NOx in Santiago (Gwilliam, 2003; Schwela,

2004; UN-HABITAT, 2006). In Asia, road traffic has also led to increased urban air pollution, especially the volatile organic compounds (VOCs), CO, NOx and PM. The use of uncontrolled diesel and two stroke engine vehicles among Asian cities is considered the most important source of air pollution. A large motorcycle fleet coupled with overcrowding has made Asian cities have the largest emissions per passenger per kilometer travelled, especially in areas where the two stroke engines are used. Thus, population exposure to traffic emissions in Asia is also considered high due to their close proximity to street canyons that have poor dispersion conditions (Schwela, 2004; IGES, 2007; ADB, 2008; Amin, 2009).

In Africa, air pollution in many urban areas arises mainly from industrial and transport sectors. Although the manufacturing sector is responsible for some part of the air pollution, the transport sector is considered the highest polluter in key cities like Cairo, Nairobi, Johannesburg, Cape Town and Dakar. Transportation is also considered to emit tonnes of reactive atmospheric gases mainly NO_x, SO_x, VOCs and other toxic particulate species as a result of diesel and gasoline combustion. The growing population of used cars and poor road networks has also led to traffic congestion with huge impacts on fuel wastage and air pollution (Gwilliam *et al.,* 2004; Schwela, 2004; UN-HABITAT, 2006).

In Kenya, the degradation of air quality has been due to increased urbanization, high economic development and fast population growth (Odhiambo *et al.,* 2010). Nairobi, which is the largest town and the capital city of the Republic of Kenya, is regarded as the most polluted metropolitan area in Kenya (Vliet and Kinney, 2007; Kinney *et al.,* 2011). Nairobi's pollutants emanate mainly from public and private transport, which together account for about 90% of total emissions. Motorized emissions comprise a range of pollutants that include PM, CO, SOx, NOx and a wide range of volatile organic compounds (VOCs) (Vliet and Kinney, 2007; Odhiambo *et al.,* 2010; Kinney *et al.,* 2011).

Since urban air quality is essential to human health and the natural environment, the deterioration of air quality through motorized emissions may therefore have had significant impacts on the welfare of a large number of people. Thus, to assess the economic desirability of a policy proposal for reducing motorized emissions, it might be important to estimate the economic value of the benefits that would accrue to the people. From the literature, both market and non market based approaches have been used to estimate such values. As mentioned earlier, market based methods rely on the market data and are therefore feasible only when there is sufficient market data. Conversely, when market data is insufficient or unavailable, non market valuation methods are used. With no market data for the economic benefits that may arise from reducing motorized emissions in the city of Nairobi, this study adopted a non market valuation approach through CV and DCEs to conduct an economic valuation of air quality improvement through motorized emission reductions in the city of Nairobi, Kenya.

1.6 Statement of the problem

The economic valuation of environmental policy proposals involves the analysis of both market and non market value of the benefits and costs that may accrue from the implementation of the proposed policies. However, in the recent past, more attention has shifted towards the valuation of non market benefits owing to the challenges involved in the estimation and use of such values for policy purposes. Since 1960s, a number of non market valuation techniques have been developed and of these techniques, CV and the DCE methods have emerged as the most commonly used approaches by researchers in informing economic decisions about public investment programs and societal welfare. However, these approaches are riddled with controversies such as welfare and scope effects of respondent uncertainty in CV due to the hypothetical market scenaios that are posed to respondents. For the DCE approach, there are controversies regarding the implicit prices derived from different

behavioural models, relative performance of the behavioural models and also how best these models are able to account for preference variation in the choice data. This study was conducted to address some of the CV and DCE controversies mentioned above with a case application to stated preference data on motorized emission reductions drawn from residents of the city of Nairobi, Kenya. This case example was inspired by the need to provide important policy information on public preferences for air quality improvements in the city since air quality problems to human health and to the environment were reaching unprecedented levels. As such, the information sought would assist the government to find an ideal policy framework to regulate vehicular emissions.

1.7 General objective of the study

Therefore, the general objective of this study was therefore to carry out an economic valuation of air quality improvements in the city of Nairobi, Kenya using CV and DCE approaches so as to provide more valuation information that could be used by all relevant stakeholders to inform economic decisions on air quality management policies and investment programmes.

1.8 Specific objectives of the study

The specific objectives were:

a) To evaluate individuals stated preferences for improved air quality management in the city of Nairobi based on the payment card approach.
b) To estimate and compare the welfare estimates of individuals across stated preference and uncertainty elicitation formats for air quality improvements in the city of Nairobi.
c) To assess the scope effects of respondent uncertainty in contingent valuation with valuation evidence from motorized emission reductions in the city of Nairobi.

d) To analyze the implicit prices for motorized emission reduction attributes among car owners in the city of Nairobi.
e) To explore the relative performance of MNL, MXL, S-MNL, G-MNL and G-MXL and how best they are able to account for preference variation in choice analysis.

1.9 Hypotheses of the study

The hypotheses tested in the study were:

a) That the underlying policy value for motorized emission reductions among individuals in the city of Nairobi is positive.
b) That respondent uncertainty has no significant effect on the welfare estimates of individuals for motorized emission reductions in the city of Nairobi.
c) That respondent uncertainty has no significant effect on the sensitivity of individuals to the scope of motorized emissions reductions in the city of Nairobi.
d) That the underlying implicit prices for motorized emission reduction attributes among car owners in the city of Nairobi are positive.
e) That the G-MXL model specification performs relatively better than the other models and also accounts for preference variation better than the other behavioural models.

1.10 Approaches and methods of the study

Based on the CV framework, the study purposed to assess both welfare and scope effects of respondent uncertainty on the underlying preferences of individuals elicited using three elicitation approaches, namely: the conventional payment card, the stochastic payment card and the polychotomous payment card approaches. The underlying preferences were evaluated based on the mean WTP method, which was expected to yield the mean welfare value of the policy to reduce motorized emissions in the city of Nairobi and to test and compare both welfare and scope effects of respondent uncertainty in CV. As such, both interval and random

effects probit regression models were employed to draw the lines of best fit for the study as exposited in the CV literature. In relation to the DCE method, the study also purposed to look at the stated preferences for motorized emission reduction attributes in the city of Nairobi. In this case, implicit prices that motor vehicle owners in Nairobi were willing to pay towards certain motorized emission reduction attributes were analyzed using the delta method. Several behavioural models, namely, the multinomial logit (MNL), mixed logit (MXL), scaled multinomial logit (S-MNL), generalized multinomial logit (G-MNL) and the generalized mixed logit (G-MXL) were also estimated to explore their relative performance and how best they are able to account for preference variation in the analysis of choice data. All this analysis was accomplished using STATA software v.13 and Nlogit 5.

1.11 Outline of the study

The first section of this thesis has generally given the background information about the study. In the second section, information on the stated preferences for improved air quality management in Nairobi based on the payment card approach is presented. In the third section, information on individuals' welfare estimates across stated preference and uncertainty elicitation formats for air quality improvements in the city of Nairobi is presented. In the fourth section, information on the scope effects of respondent uncertainty in contingent valuation method with evidence from motorized emission reductions in Nairobi is presented. In the fifth section, information on the stated preferences for motorized emission reduction attributes in Kenya based on a DCE is presented while the sixth, also the final section of this study, presents a general summary, conclusions and recommendation derived from the study findings. Moreover, this section also provides the policy and methodological implications that can be drawn from the entire study.

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CHAPTER TWO

Stated preferences for improved air quality management in Nairobi, Kenya

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Abstract

This study uses contingent valuation (CV) framework to assess individuals' preferences for improved air quality management through motorized emission reductions in the city of Nairobi, Kenya. A conventional payment card (PC) is used to draw preferences from individuals through a one-off payment in order to estimate the mean and the median willingness to pay (WTP) for air quality improvements in the city. Through interval regression analysis, the study finds individuals are, on average, willing to pay Kshs. 396.60 ($3.97) and a median of Kshs. 244.98 ($2.45) to improve air quality management in the city, about 2.04% and 1.26% of respondents mean income, respectively. These amounts are found to increase with male gender, individuals' income, certainty about future income and residing in an urban area. The amounts, however, decline with age, residential distance from nearby roads and motor vehicle ownership. On the whole, the study finds significant public support towards improved air quality management, which may be vital for the creation and implementation of air quality management programs in the city.

Key words: Contingent valuation, payment card, interval regression, willingness to pay, air quality, motorized emission reductions.

2.1 Introduction

Worldwide, the continuous upsurge in the number of motorized vehicles in most urban areas has raised enormous concerns over the effects motorized emissions have on the air quality of urban environments (Lilley, 2000; Gwilliam, 2003; Cadle *et al.,* 2004). Although most transportation modes emit pollutants into the atmosphere through the combustion of liquid fossil fuel, the relative abundance of pollutants vary depending on the exact composition of the fuel and the details of the combustion conditions (Colvile *et al.,* 2001; Cadle *et al.,* 2004). Some of the leading motorized emissions by mass include carbon monoxide (CO), nitrogen oxides (NO_x), sulphur oxides (SO_x), volatile organic compounds (VOCs) and the particulate matter (PM_x) (Colvile *et al.,* 2001; Schwela 2004; Fazal, 2006; Asian Development Bank, 2008). These emissions are largely harmless if they are in low concentrations but, harmful if their concentrations escalate to levels that cause adverse effects on humans and the environment (Ababio, 2003; Amin, 2009). Furthermore, they are mostly ground level sources of pollution highly capable of rendering maximum impact on the general population (Ackerman *et al.,* 2002; Gwilliam and Johnson, 2004; Schwela 2004; Vliet and Kinney, 2007).

In Nairobi, the growth of motorized traffic has been singled out as the major source of low air quality since motorized emissions account for about 90% of total emissions (Odhiambo *et al.,* 2010; Omwenga, 2011). Toxic gases such as CO, NO_x, SO_x and PM_x are in high concentrations as a result of increased urban expansion and motorization that is linked to the rapid economic development experienced in the last decade. Consequently, most city residents are exposed to elevated concentrations of motorized emissions that potentially pose serious long-term effects on human health and quality of the urban environments (Vliet and Kinney, 2007; Odhiambo *et al.* 2010; Kinney *et al.* 2011). For instance, CO causes blood clotting when it reacts with haemoglobin. PM_x are carcinogenic especially those that

penetrate deep into the lungs. Exposure to NO_x leads to shortness of breath, chest pains and changes in lung function while SO_x causes cardiovascular diseases and bronchitis with detrimental effects to asthmatics (WHO, 2006).

Notwithstanding these effects, authorities in the city of Nairobi are yet to formulate a policy that averts the potential risks from motorized emissions, given that the city has resident and daytime populations of 3.1 and 4.2 million people, respectively. The reason behind this problem is that available studies on air quality in Nairobi so far (Mulaku and Kariuki, 2001; Vliet and Kinney, 2007; Odhiambo *et al.,* 2010; Kinney *et al.,* 2011) deal only with the technical aspects of measuring concentrations of pollutants in the air. This means that policy information available is only limited to technical aspects, yet sufficient knowledge on the socioeconomic aspects of the policy is also needed for effective management of air quality. Therefore, the purpose of this study was to provide the missing policy information by assessing the stated preferences of the people towards improved air quality management in the city of Nairobi, Kenya.

Notably, in both developed and developing countries, several studies have previously been carried out to estimate individuals' preferences for air quality improvements. For instance, Carlsson and Johansson-Stenman (2000) estimate individuals' preferences for air quality improvement in Sweden using the open ended question format. They find that individuals are, on average, willing to pay about 2000 Swedish Krona ($232.79) per year. The WTP amounts are found to increase with respondents' income, wealth and education. They are larger for men, people owning a house, people living in more polluted areas and members of environmental organizations, but smaller for the retired people. In Manila, Philippines, Fabian and Vergel (2002) use double-bounded discrete choice format to estimate commuters'

preferences for improved air quality from public transport vehicles. They find that respondents are willing to pay an increase in fare by as much as 1.24 Philippine Peso ($0.02).

In Poland, Dziegielewska and Mendelsohn (2005) employ dichotomous choice question to analyze preferences of Polish citizens towards the harmonization of Polish air pollution standards with the European Union (EU) standards. They find that Polish citizens value the benefits of managing pollution much less than other citizens from richer EU nations, which means that the suspension of the harmonization process seemed critical and needed to be based on the nations' economic prosperity. Wang *et al.* (2006) use an open-ended question to estimate peoples' preferences for improved air quality in the urban areas of Beijing. They find that people are, on average, willing to pay 143 Chinese Yuan ($21.03) per household per year. The WTP is also found to be an increasing function of income and education level, but a decreasing function of age and household population. It is larger for residents in the urban areas than those in the suburbs.

Wang and Zang (2008) evaluate peoples' preferences for improved air quality based on a variety of hypothetical open-ended questions in Ji'nan, China. They find that 59.7% of respondents are, on average, WTP 100 Chinese Yuan ($14.70) per person per annum. Some of significant factors found to influence individuals WTP are expenditure incurred while treating respiratory diseases, individuals' income and the number of workers in the family. In Mashhad, Iran, Firoozzarea and Ghorbani (2011) use open ended questions and the Heckman procedure to estimate peoples' preferences for air pollution reduction together with the respective determinants. They find that the total monetary value of air quality improvement in the high-polluted region is higher (about 7.134 billion Rials ($219,562) per month) than in the middle-polluted region (about 5.242 billion Rials ($161,332) per month). Age, having a

child, gender, household income, education level and having a car are found to be significant factors for peoples' WTP for improved air quality in Mashhad.

Moreover, Du and Mendelsohn (2011) use the double-bounded valuation format with a single follow-up question to evaluate the preferences of Beijing residents to sustain the improved quality of air experienced during Beijing's Olympic Games. The results show that the mean annual WTP per household ranges between 22,000 and 24,000 Chinese Yuans ($3,234 – 3,529). Finally, Donfouet *et al.* (2013) analyze peoples' preferences for air quality improvements in Douala, Cameroon, through hypothetical referendum scenario. Respondents are also given an overnight time to think about their responses to the valuation questions. The results show that people are, on average, WTP $0.40 per month for improved air quality, which is about 0.02% of their annual income. The overnight time-to-think is also found to have a negative effect on individuals' valuation decisions since it lowered the WTP values by 40%.

It is evident that except for China among other nations and Cameroon in the African context, the number of socioeconomic studies dealing with issues on improved management of air quality is limited. Such studies, if undertaken, may provide important policy information that could be used for addressing the prevalence of air quality problems especially among the rapidly urbanizing cities in the developing world. This study therefore sought such policy information by analyzing peoples' preferences for improved air quality management in the city of Nairobi, Kenya, based on data from the conventional payment card format.

The rest of the paper is structured as follows: Section 2 presents the theoretical framework. Section 3 describes the survey methodology. Section 4 presents the empirical results and discussion and Section 5 concludes the paper.

2.2 Theoretical framework

Most empirical studies on peoples' preferences for air quality improvement have hitherto been conducted using non market valuation methods. The use of non market valuation methods has been justified because air quality is an environmental public good that is unpriced and hence, has no established market for its trading (Wang and Mullay, 2003; Wang and Whittington, 2005; Wang *et al.*, 2006; Wang and Zang, 2008; Du and Mendelsohn, 2011). These methods are broadly classified into two (Mitchell and Carson, 1989; Mendelsohn and Olmstead, 2009): a) the revealed preference methods (e.g. travel cost and hedonic pricing) and b) the stated preference methods (e.g. contingent valuation and choice experiments).

Under the revealed preference methods, proxy markets are used indirectly to attach monetary values on policy proposals by finding correlations between the real market behaviour of individuals and the policy proposal in question. However, under the stated preference methods, hypothetical markets are used directly to attach monetary values on the policy proposals by asking people about their WTP for a proposal that enhances their welfare or willingness to accept (WTA) compensation for a proposal that decreases their welfare.

An important limitation of the revealed preference methods is that they can only attach monetary values on policy proposals through the observation of real market transactions. In cases where it is impossible to observe real market transactions, the stated preference methods are preferred (White *et al.* 2001; Bateman *et al.*, 2002; Venkatachalam, 2004). For this reason, this study employed the CV framework, which is a stated preference technique, to assess peoples' preferences for improved air quality management in the city of Nairobi as real market transactions for air quality improvements are unavailable and could only be proxied through stated preferences. The CV framework was preferred over the choice

experiment approach because it would easily provide both use and nonuse values of the policy proposal in question (Mitchel and Carson, 1989; Carson, 2000).

The CV methodology is rooted deeply in the neo-classical welfare economic theory of consumer behaviour on expenditure minimization (Mitchell and Carson, 1989; Freeman, 1993). In this case, consider the following general expenditure function for an individual living in the city of Nairobi:

$$e(p, q, u) = y \tag{1}$$

where p is the price vector, q is the quality of air in the city, u is the level of utility, and y is the minimum income that is necessary to allow the individual to maintain utility level u given prices p and level of air quality, q, in the city. Furthermore, consider the situation where a policy is proposed to improve air quality management through motorized emission reductions. The policy, thus, outlaws all activities which are detrimental to air quality. The individual is then asked about the amount she would be willing to pay to reduce motorized emissions. The expenditure function for the initial period before the policy proposal would be:

$$e\ (p, q_0, u_0) = y_0 \tag{2}$$

where u_o is the initial level of utility that the individual could enjoy given prices p, q_o is the initial level of air quality in the city and y_o represents the minimum level of income required to attain utility level u_o. Since the new policy is expected to improve air quality in the city, the new expenditure function would therefore be of the form:

$$e\ (p, q_1, u_0) = y_1 \tag{3}$$

where q_1 is the quality of air after the implementation of the proposed policy and y_1 represents the minimum income level required to attain utility level u_o after the

implementation of the proposed policy. The level of utility, u_o, is held constant since Hicksian welfare measures assume that utility remains constant. Hence, the individual's WTP for improved air quality would be a compensating variation measure since an individual would have to part with a certain amount for the improvement to occur. The compensating variation (C) is equal to the individual's WTP and is given by difference between the expenditure functions $y_1$and y_0, that is:

$$C = WTP = \ y_1 \ - \ y_0$$
$$= \ \{e\ (p, q_1, u_0)\} \ - \ \{e\ (p, q_0, u_0)\} \quad (4)$$

The quality of air in the city after the implementation of the proposed policy, q_1, is supposedly greater than the initial quality of air, q_o. As utility and prices are held constant, y_1 (the minimum income level required to attain utility level u_o after implementation of the proposed policy) is less than y_0. Therefore, the compensating variation would be negative meaning that an individual has to pay some dollar amount to attain the improved level of air quality management.

2.3 Survey design

2.3.1 Study area

The city of Nairobi is located on the south-eastern end of Kenya's agricultural heartland, at approximately 1° 9'S, 1° 28'S and 36° 4'E, 37° 10'E. It has eight administrative divisions occupying an area of about 696 Km^2 with an altitude that varies between 1,600 and 1,850 metres above sea level. Although the city covers only 0.1 per cent of Kenya's total surface area, it carries about 8 per cent of the country's total population and about 25 per cent of Kenya's urban population (Central Bureau of Statistics (CBS), 2009). Due to high population growth, the demand for transport in the city has been on the rise leading to increased motorization and hence, unprecedented levels of motorized emissions.

2.3.2 Population and sample

The city's resident population is estimated at 3.1 million people (CBS, 2009) spread over the eight administrative divisions. As such, simple random sampling procedure was used to select 61 respondents from each of the eight administrative divisions constituting the city of Nairobi to make an overall sample of 488 respondents for the entire study. This sampling procedure was chosen because it offered all city residents an equal chance of being part of the study sample. Subsequently, the survey data was collected from each of the administrative divisions as they could conceptually be regarded as separate populations upon which interviews could be performed independently.

2.3.3 Survey technique

The study employed personal interviews based on interviewer administered questionnaires to collect information from respondents. This method was chosen because it could enable the interviewer to motivate respondents to participate fully in the interview process, probe unclear responses and convey intricate information on the subject of study to the respondents (Arrow *et al.*, 1993; Dillman, 2000). The questionnaire was divided into five sections, namely: a) a background section that sought respondents' general knowledge of air pollution in Nairobi; b) a section describing the motorized emission reduction plan; c) a section describing both positive and negative effects of the motorized emission reduction plan; d) a section having the valuation and the debriefing questions and; e) a section that sought information on respondents' socio demographic characteristics.

2.3.4 Survey implementation

A pre-test survey was conducted on the survey questionnaire upon thirty respondents using the open ended value elicitation format as recommended in Haab and McConnell (2002). Respondents were asked to comment on the suitability of the questions in the questionnaire,

paying close attention to wording, clarity, relevance and interpretation of each question in the survey among other anomalies. Bid ranges were also obtained from the pre-test from which the mean, median, minimum and the maximum WTP values were determined. Based on the responses and comments provided by the respondents in the exercise, a final survey questionnaire was prepared and administered to the 488 respondents.

2.3.5 Environmental good valued

A policy proposal for improved air quality management through motorized emission reductions in Nairobi constituted the public good of interest that was valued in the study. Notably, motorized emissions differ enormously from one vehicle to another such that an accurate description of some definite level of emission reduction is difficult and could be misleading. As a result, a valuation question that sought for a 50% reduction of motorized emissions in the city was posed to respondents and the values they gave were used to estimate the mean and the median WTP values for the study sample.

2.3.6 Payment vehicle

The popular payment vehicles used by researchers in CV surveys include fees, taxes and amenity bills. However, Morrison *et al.* (2000) note that some of payment vehicles can raise objections and protest responses among survey participants and hence, bias the survey results. Following Fonta *et al.* (2010), this study chose to use a special trust fund, a neutral kind of payment vehicle managed by a trustee, so as to minimize objections and protest responses among the participants. In this fund, respondents were hypothetically required to make a one-time contribution towards the exclusive purpose of reducing motorized emissions in Nairobi. It was expected that the payment vehicle would enhance the credibility of the hypothetical scenario posed as opposed to other alternative payment vehicles such as fees, taxes or

amenity bills often linked with protest responses in CV (Morrison *et al.*, 2000; Sayadi *et al.*, 2009).

2.3.7 Valuation scenario

In this case, the valuation section of the study offered respondents with relevant information to ensure that they understood the current air quality situation of the city, that is: *"The City of Nairobi is one of the most polluted urban areas in Kenya. It is characterized by high concentrations of toxic gases such as carbon monoxide (CO), sulphur oxides (SO_x), nitrogen oxides (NO_x), hydrocarbons (CH_4), lead (Lb) and particulate matter (PM_x) among others. These gases are emitted mainly from public and private vehicles, which account for over 90% of total emissions. High concentration of these gases in the atmosphere has affected the natural and built environment and most importantly human health leading to respiratory and heart diseases among others."*

Respondents were then presented with a hypothetical improvement scenario to ensure that they also understood what they were really paying for: *"Suppose stakeholders comprising government and private sector agencies are planning to introduce a policy that will restore air quality to standards prescribed by World Health Organization (WHO). Therefore, they come up with a "special motorized emission control trust fund" into which individuals contribute money to ensure problems to the natural and built environment and human health associated with motorized emissions are eliminated. Suppose also the contribution into the trust fund is a onetime payment for the exclusive purpose of policy formulation and implementation to reduce motorized emissions..."*

Respondents were then asked the valuation question so as to state the amounts they were willing to pay to reduce motorized emissions. They were asked to answer the valuation

questions as truly as possible and envision that they would actually contribute to the trust fund, ensuring that their decision was perceived as having real consequences for their disposable household budget (Carson and Groves, 2007).

2.3.8 Valuation format

The study used the PC format to elicit peoples' preferences based on a comprehensive policy proposal that would control motorized emissions in the city of Nairobi. Under this format, respondents were given cards where they were asked to circle the highest amount they would be willing to pay for emission reductions. Out of the responses given, inferences were made about their true WTP, which was equal to or greater than the circled value but less than the next higher value (Cameron and Huppert, 1989). This format was chosen because respondents had the advantage of easily and visually scanning through a given set of value intervals (Cameron and Huppert, 1989) and hence, determine the range within which their WTP lie. Furthermore, the kind of data obtained through this format is less scattered and therefore, does not require larger samples to obtain robust estimates. The format does not suffer from yeah-saying and starting point bias like other CV formats (Mitchell and Carson, 1993). Although PC questions are theoretically susceptible to range and mid-point bias, there is little empirical evidence of the existence of range or mid-point bias (Klose, 1999; Ryan *et al.,* 2004). Besides, while the format still has the possibility of yielding protest zeros, it has not been found to give very high proportion of protest zero responses compared to other CV formats (Klose, 1999; Hanley *et al.,* 2003). Thus, the valuation question was formulated as follows:

"*Suppose the presented policy to reduce emissions from motorized vehicles and improve air quality management in the city of Nairobi will actually be implemented to reduce the current*

amount of emissions, what is the maximum amount of money you would be willing to pay one-off to the special trust fund to achieve this? (circle or tick a single amount on the card)."

The PC included 15 different amounts, namely: Kenya Shillings (KES). 0, 25($0.25), 50($0.50), 75($0.75), 100($1.00), 150($1.50), 200($2.00), 250($2.50), 300($3.00), 400($4.00), 500($5.00), 800($8.00), 1000($10.00), 1500($15.00) and finally Kshs. 2,000($20.00), in which case respondents were only required to circle one single amount on the card. Notably, the 15 different values on the payment were used as generated from the pilot study. Thus, the intervals in the cards were not changed to avoid introducing of any form bias related to payment card design.

2.3.9 Estimation method

Following Cameron and Huppert (1989), interval regression analysis was used to estimate the mean and the median WTP values from responses generated through the PC format. Letting WTP_L be the maximum amount that a respondent would pay and WTP_U be the lowest amount that a respondent would switch to a 'No' rather than a 'Yes' response, the individual's WTP is therefore taken to lie somewhere in the switching interval (WTP_L, WTP_U). To adjust for the skewed distribution of WTP responses, the lognormal transformation of the WTP responses is preferred, hence:

$$Log\ WTP_i = g_i'\varpi + \xi_i \quad (5)$$

where g_i denotes the characteristics of the respondent or the valuation good in question, ξ_i stands for the normally distributed random variable with zero mean and standard deviation σ, and ϖ are the regression coefficients. Assuming that WTP is a random variable (Welsh and Poe, 1998), the probability that a respondent would select a given monetary amount is:

$$Prob(yes) = prob(WTP_i \geq WTP_L) = 1 - Q_{WTP}(WTP_L) \quad (6)$$

where $Q_{WTP}(WTP_L)$ is the cumulative distribution function of the random WTP variable. The probability that the WTP would fall between any two monetary thresholds is:

$$Prob(WTP_U > WTP_i \geq WTP_L) = Q_{WTP}(WTP_U) - Q_{WTP}(WTP_L) \quad (7)$$

which results in the corresponding log-likelihood function for *n* number of respondents as:

$$Log(L) = \sum_{i=1}^{n} Log\left\{Q_{WTP}\left(\frac{WTP_U - \varpi g_i'}{\sigma}\right) - Q_{WTP}\left(\frac{WTP_L - \varpi g_i'}{\sigma}\right)\right\} \quad (8)$$

With further assumption that the stochastic term is normally distributed, ϖ and σ can be estimated and then used to compute the mean and median WTP values. Thus, the mean WTP $= e^{(g_i'\varpi + \sigma^2/2)}$ and median WTP $= e^{(g_i'\varpi)}$. Here, g′ is taken as the vector of mean values of explanatory variables, ϖ as the vector of estimated coefficients and σ as the estimated standard variance.

2.4 Empirical results and discussion

2.4.1. Socio-demographic characteristics of the respondents

Table 2.1 presents the socio-demographic characteristics of the respondents. As shown, the average age of the respondents was 31.5 years with men accounting for the largest share (62%) of the respondents. A large proportion of respondents had attained secondary level of education and had an average household size of about 3 people. Respondents' mean annual income was Kshs. 19,400 ($194) with a large section of the respondents (83%) indicating they were certain about their future incomes. The results also show that most respondents

resided close (212 metres) to nearby roads with a large share of the respondents living in the urban areas (69%) as opposed to the suburbs (31%). Only a minority of respondents (18%) said they owned a motor vehicle. Further results also show that people in Nairobi were familiar with air pollution problem, even though they differed in the way they interpreted it. While 88% of the respondents defined it as the contamination of air with smoke and dust particles, 12% termed it as bad odour from rotting waste and smoke. In regard to the main sources of air pollution, 55% of respondents mentioned motor vehicles as the main source of air pollution followed by factories (25%), burning of waste by households (19%) and finally, farming activities (5%).

Table 2.1 Socio-demographic characteristics of the respondents and their measurement

Variable	Variable description and type	Mean	Std. error	Min	Max	Sign
Age	Number of years respondent has lived (continuous variable).	31.50	0.37	20	65	±
Gender	Share of male respondents (dummy variable: 1=male; 0=otherwise).	0.62	0.02	0	1	+
Education	Education of the respondent (categorical: 1= no education; 2=standard; 3=secondary; 4= tertiary; 5=university).	3.61	0.05	1	5	+
Income of Household	Average annual earnings (continuous variable).	19,400	215	4,400	68,000	+
Household size	Number of members in the household (continuous variable).	3.49	0.06	1	6	-
Distance to nearby roads	Length from nearby road in meters (continuous variable).	212	2.36	21	300	-
Vehicle ownership	Whether or not the respondent owns a vehicle (dummy variable: 1=own; 0=otherwise).	0.18	0.02	0	1	-
Future income certainty	Whether or not the respondent is certain about future incomes (dummy variable: 1=certain; 0=otherwise).	0.83	0.02	0	1	+
Area of residence	Whether or not the respondent resides in the urban area or in the suburbs (dummy variable: 1=urban; 0=otherwise).	0.69	0.02	0	1	+

Serious problems that most respondents associated air pollution with were respiratory in nature (71%) due to bad odour, dust particles and vehicular smoke. Despite these concerns from the public, the concerned authorities had however, done little to address the problem. As a result, some policy measures recommended by respondents to contain the situation included the use of: quality fuels (51%); fuel efficient motorized vehicles (18%); improved road infrastructure (13%); traffic regulation and control (12%) and; the construction of bicycle lanes to enhance the use of bicycles (1%). It was also found that majority (62%) of respondents prefered the use of a special fund as the payment vehicle to support their proposed strategies as opposed to donating their labour (17%), being charged a pollution tax (15%) or the use of amenity bills (6%). As such, the use of the special trust fund in the study was found to have wide acceptance among respondents.

Table 2.2 presents the analysis of various types of WTP responses derived from the study. The survey had a total of 488 respondents. Out of this total, about 417 respondents (85%) indicated a positive WTP for the motorized emission reductions and 71 respondents (15%) gave a zero WTP value. To separate protest responses from true zeroes, a closed-ended debriefing question was presented to respondents to justify why they had a zero WTP for air quality improvements. Thus, four possible alternatives were presented to respondents, namely: a) because air quality improvement has no value to me. b) because it is the responsibility of the government; c) because of many other basic financial commitments and; d) because it is the responsibility of motor vehicle owners.

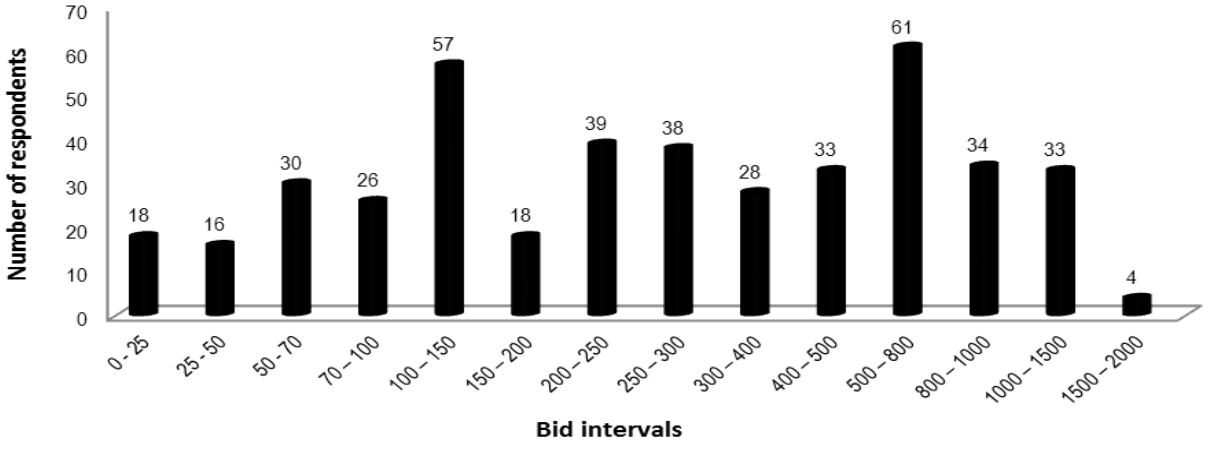
Table 2.2 Summary of the willingness to pay responses

WTP Responses	Frequency	%
Positive willingness to pay responses	417	85
True zero willingness to pay responses	18	4
Analytical sample size	435	89
Protest responses	53	11
Total sample size	488	100

Following Strazzera *et al.* (2003), the first (a) and the third (c) responses were classified as true zero values while the other two as protest responses since they did not address the value of the public good in question but, some objection as to who should really pay for air quality improvements. Based on the above classification, 18 respondents (4%) were therefore considered to have given a true zero WTP value while 53 (11%) gave a protest response. In line with the standard practice in valuation studies (Wang, 1997; Whitehead *et al.*, 1998; Wang and Whittington, 2000; Brouwer, 2009), the protest responses were dropped off from the analysis. Therefore, only 435 responses, about 89% of the initial sample size, were subjected to further analysis.

Figure 2.1 presents different bid amounts used in the study together with responses against each bid amount. Out of the 15 bids presented, respondents were supposed to indicate their maximum WTP for air quality improvements in Nairobi. The bids were truncated from below at Kshs. 0 and from above at Kshs. 2,000. As shown in the table, 18 (4%) respondents stated a maximum WTP of Kshs. 0 while 4 (1%) respondents stated Kshs. 1,500. On the whole, most respondents stated Kshs. 500 (14%), Kshs. 100 (13%), Kshs. 200 (9%) and Kshs. 400 (8%) as their individual maximum WTP.

Figure 2.1: The distribution of the willingness to pay responses



2.4.2. Mean willingness to pay and the determinant factors

As shown in Table 2.3, the study found that respondents were, on average, willing to pay Kshs. 396.60 ($3.97) and a median value of Kshs. 244.98 ($2.45) to improve air quality management in the city, which is about 2.04% and 1.26% of the respondents mean income, respectively. To assess factors influencing individuals WTP, several socio-demographic characteristics of the respondents, namely, age, gender, income, distance resided by respondents from a nearby road, motor vehicle ownership, respondents certainty about future income and area of residence were regressed against the grouped data on WTP. Further results of the interval regression analysis are as shown in Table 3.

Table 2.3 Interval regression results on factors explaining individual willingness to pay

Variable	Coefficient	Std. errors
Age	-0.119***	0.010
Gender	0.375***	0.028
Household income	0.532***	0.051
Distance to nearby road	-0.022	0.273
Vehicle ownership	-0.192*	0.043
Certainty of future income	0.196*	0.034
Area of residence	0.442*	0.075
Constant	3.872***	0.221
Log likelihood	-992.11	
Number of observations	435	
LR chi2 (7)	283.12	
Probability > chi2	0.0000	
Mean WTP (in Kshs.)	396.60	
Standard error	17.11	
Median WTP (in Kshs.)	244.98	
Bootstrapped 95% confidence intervals	361.10 - 432.08	

Explanatory notes:
*, ** and *** denote $p < 0.1$, $p < 0.05$ and $p < 0.01$.
Respondent age (continuous variable); Gender (dummy: 1=male, 0=otherwise); Household income (continuous); Distance (continuous); Owner of motorized vehicle (dummy: 1=own, 0=otherwise); Certain of future income (dummy: 1=certain, 0=otherwise); Area of residence (dummy: 1=urban, 0=otherwise).
.

As indicated in Table 2.1, it was hypothesized that age of the respondent would either have a positive or a negative relationship with the individuals' WTP. This is because older people may, on one hand, feel susceptible to the effects of motorized emissions and therefore, be more willing to pay than the younger people. However, they may on the other hand have a lower WTP value because of the trade-offs they may have to make within the household such as supporting the family in the payment of school fees. The results, nonetheless, showed the existence of a negative relationship between respondents' age and their WTP, which implies that younger people were more willing to pay for improved air quality management than older people. These results are similar to those by Carlson and Johansson-Stenman (2000) and Wang et al (2006) who find that younger individuals would pay more for air quality improvement plans than older individuals. However, Wang and Mullay (2006) come up with the contrary findings where older people are willing to pay more than the young people for air quality management programmes.

A positive relationship between gender and the WTP was also hypothesized and the results came out as expected, which means that men were more willing to pay for improved air quality management than women. The most probable reason is that men have more access to information than women and would therefore be more informed about the negative effects of vehicular emissions together with the need for emission controls than would be women. Another reason is that they also control budgets within the household. This outcome correlates well with similar outcomes in Carlson and Johansson-Stenman (2000) and Wang and Zang (2008).

Household income is another important variable used in the study to explain individuals' decisions to pay for improved air quality management. It was expected that individuals with higher incomes would be more willing to pay for emission reductions as opposed to those

with lower incomes, which would conform to economic theory (Loomis and Ekstrand, 1998). The results were positive and they theoretically validated the outcomes of the study. A similar outcome is found in many other CV studies including Carlson and Johansson-Stenman (2000), Wang *et al.* (2006), Wang and Mullay (2006) and Wang and Zang (2008) among others.

The distance variable was used to assess whether or not the WTP would vary with distance since the perceived effects of motorized emissions were likely vary with distance from a nearby road. The findings gave evidence of a negative though statistically insignificant relationship, which means that respondents living closer to nearby roads were more willing to pay for improved air quality management than their counterparts residing further away from the roads. This finding could be attributed to the fact that people residing closer to the roads may have the perception that they are more affected by emissions than their counterparts residing further away from the roads and hence, be more willing to pay for air quality improvements.

Studies by Carlson and Johansson-Stenman (2000) and Wang *et al.* (2006) also came up with similar findings that people living in high polluted areas are more willing to pay than those living in the low polluted areas. As for the relationship between motor vehicle ownership and the WTP, a negative relationship was expected because of the public good nature of the air quality improvements. The results came out as expected where motor vehicle owners were found more willing to pay for air quality improvements than non motor vehicle owners. These results however, differ from those by Firoozzarea and Ghorbani (2011) who found that car owners are more willing to pay than non-car owners. Notably, the share of car owners in this study was quite low and this could partly explain why these results differ.

Whether or not individuals' certainty about their future incomes would have a positive effect on the WTP variable was also sought in the study and as predicted, it was found that individuals' who were certain about their future incomes were more willing to pay than those uncertain about their future incomes. Finally, the study also found a positive relationship between area of residence and individuals' WTP. As in Wang *et al.* (2006), it means that urban residents were more willing to pay for improved air quality management due to high air pollution than their counterparts in the suburbs where air pollution is low.

2.5 Conclusions and recommendations

This study purposed to analyze individuals' preferences for improved air quality management through motorized emission reductions in the city of Nairobi, Kenya based on responses from the contingent valuation PC format. The research was inspired by the need to estimate the policy value of implementing an air quality improvement program for the city since air quality problems were on the rise owing to rapid urbanization experienced during the last decade. Initial findings show that people in Nairobi are well aware of the air pollution problems in the city upon which they identify motor vehicles as the primary cause of air quality problems due to the emission of toxic gases and dust particles into the atmosphere.

In addition, Nairobi residents have also been found to be familiar with the adverse health and environmental effects of motorized emissions such that most of them are willing to pay positive amounts towards emission reductions in the city. While a few people are willing to pay true zero amounts towards the same course citing overwhelming financial commitments within the household, a few others give protest responses against the air quality improvement plan saying the government and/or the motor vehicle owners should bear the responsibility of the air clean-up plans. In monetary terms, individuals in the study are, on average, willing to pay Kshs. 396.60 ($3.97) for improved air quality management. The median WTP value is

Kshs. 244.98, which is equivalent to $2.45. Some important factors found to affect peoples' WTP decision for air quality improvements include age, gender, income, motor vehicle ownership, certainty about future income and the area of residence.

Since air quality problems continue to worsen in Nairobi due to increased motorization, the city authorities could now use the estimated mean and median WTP to benchmark their budget and policy proposals for motorized emission reductions. Based on the study findings, these budget and policy proposals could also be adjusted for the socio-demographic characteristics of the individuals as they have been found to be important determinants of the peoples' WTP decision. The valuation estimates could also be used to determine the economic efficiency of air quality improvement programs in the city and beyond since peoples' preferences are now evident. All in all, more studies are required to further our understanding on the policy values of tackling specific problems (e.g. respiratory diseases, damage to city buildings and contamination of the city water dam) that arise from motorized emissions. Such studies may provide varied additional information to decision makers on how to deal with different air quality problems in a developing country context.

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CHAPTER THREE

Comparing welfare estimates across stated preference and uncertainty elicitation formats for air quality improvements in Nairobi, Kenya

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Abstract

The effect of preference uncertainty on estimated willingness to pay (WTP) is examined using identical payment cards and alternative uncertainty elicitation procedures in three split samples, focusing on air quality improvement in Nairobi. The effect of the stochastic payment card (SPC) and polychotomous payment card (PPC) are compared with a conventional payment card (PC). Substantial financial support is found for improved air quality in Nairobi, with approximately 85 percent of the whole sample stating a positive WTP. The way WTP values are elicited, with and without ability to express preference uncertainty, has significant effect on WTP welfare estimate. Allowing respondents to express experienced uncertainty when stating WTP value yields more conservative, but less accurate WTP values for inclusion in policy analysis. The PPC seems to hold most promise since it is easier to understand and imposes less cognitive burden on survey participants than the SPC in a developing country context.

Key words: Preference uncertainty, payment card, stochastic payment card, polychotomous payment card, air quality, motorized emissions.

3.1 Introduction

Stated preference (SP) elicitation procedures in non market valuation have been challenged by their hypothetical nature and are due to, among others, respondent unfamiliarity with many of the environmental goods and services involved subject to substantial preference uncertainty (Champ and Bishop, 2001; Alberini *et al.*, 2003; Brouwer, 2011). While some degree of preference uncertainty can be taken away by providing respondents with more information or allowing them to gain more experience making unfamiliar choices and value statements, some preference uncertainty has been argued to always remain as a result of the existence of incomplete, fuzzy preference structures and the cognitive burden often imposed on participants in SP surveys (e.g. Wang, 1997; van Kooten *et al.*, 2001; Shaikh *et al.*, 2007).

Several procedures have been introduced since the mid 1990's to capture the degree of preference uncertainty in SP research. Overviews of these approaches are provided in several places (e.g. Ready *et al.*, 1995; Ekstrand and Loomis, 1998; Samnaliev *et al.*, 2006; Shaik *et al.*, 2007; Akter and Bennett, 2008; Martinez-Espiñeira and Lyssenk, 2012), and vary from ex post decision ratings to polychotomous choice formats to indicate the level of certainty respondents place on valuation bids. Other procedures used to deal with respondents' preference uncertainty include payment cards, which show possible value ranges to help respondents identify their values and match respondent valuation bids against a combination of numerical certainty scale ratings or ordinal categories reflecting the degree of experienced choice uncertainty. The former numerical certainty scales have been referred to as stochastic payment cards (SPC) in the literature (e.g. Wang, 1997; Wang and Whittington, 2005) as opposed to deterministic payment cards (PC) without the ability to explicitly rate one's preference uncertainty (e.g. Rowe *et al.*, 1996). Here we will refer to the latter ordinal certainty scale as the polychotomous payment card (PPC), following the terminology used for

similar alternative willingness to pay (WTP) elicitation formats (e.g. Welsh and Poe, 1998; Johannesson *et al.*, 1998; Samnaliev *et al.*, 2006; Chang *et al.*, 2007).

An important unresolved methodological issue in the SP literature remains that various studies examining the impact of these approaches on WTP, in particular using different combinations of WTP and uncertainty elicitation formats, have come up with different results, making it hard if not impossible to conclude which of these approaches is preferred, in particular for practical policy and decision-making. While some studies report that a certain preference uncertainty calibration method yields higher and more efficient WTP welfare estimates, others report more conservative and less efficient WTP values (Petrolia and Kim, 2011). There is yet another group of studies that has found no significant differences between valuation formats that account for preference uncertainty (e.g. Vossler *et al.*, 2003). Often, a wide range of different WTP elicitation and uncertainty elicitation formats are applied in these existing studies. As a result, these SP research findings may not give reliable policy signals for informed decision-making. Several authors have therefore argued in favor of more comparative analysis of alternative formats for investigating preference uncertainty so as to facilitate our improved understanding of its effects in non market valuation.

For that reason, the main objective of this paper is to add to the empirical evidence base and compare the WTP welfare estimates elicited from three different types of payment cards: the ordinary payment card (PC) without any reference to preference uncertainty, the SPC and the PPC, with an application to the valuation of air quality improvements from traffic emission reductions in Nairobi, Kenya. Although several SP studies exist related to improved air quality in major cities around the world, particularly in developing countries such as Beijing in China (Wang *et al.*, 2006; Du and Mendelsohn, 2011) and Manila in the Philippines (Fabian and Vergel, 2002), none of these studies explicitly account for preference uncertainty.

An exception is the study by Wang and Whittington (2000), who valued an air pollution control program in Sofia, Bulgaria, applying a single bound dichotomous choice WTP question and a SPC. The former produced significantly higher mean WTP values than the latter, but it is not possible to attribute this to SP uncertainty due to the use of two different WTP elicitation formats. In this study, we assess the impact of preference uncertainty on stated WTP whilst controlling for the role of the WTP elicitation format by using one and the same payment card.

The remainder of this paper is organized as follows. Section 2 presents the research methodology in more detail and is followed by a description of the case study area and the data collection procedure in Section 3. Section 4 presents the main results and Section 5 concludes.

3.2 Methodological framework

3.2.1. Survey design

The survey consisted of three main parts. The first part included easy, warm-up questions eliciting respondents' general awareness, perception and knowledge of air pollution in Nairobi, including questions about how far they live from the main road and whether or not they own a motorized vehicle. This was followed in the second part by the introduction of a plan for the reduction of emission levels from motorized vehicles in the city of Nairobi and respondents' WTP for such a plan. The third and final part of the survey contained questions related to respondents' socio-demographic and economic household characteristics. In this section, we focus mainly on the presentation of the public good in question (air quality improvement) and the WTP and preference uncertainty elicitation formats. This is then followed in the next section by a discussion of the underlying econometric models.

The emission reduction plan for the city of Nairobi was explained to respondents, as in most SP studies focusing on air quality improvements in big cities (e.g. Wang and Mullay, 2006; Wang and Zhang, 2008), in text only without any visual aids as for instance in Shechter *et al.* (1991). From the pretests, it became clear that respondents' overall awareness of air pollution from motorized traffic is very high, making it relatively easy to convey the implications of current and possible future emission levels and reductions thereof to respondents. Respondents were informed about current emission levels of different toxic gases (carbon monoxide (CO), sulphur oxides (SO_x), nitrogen oxides (NO_x), hydrocarbons (CH_x), lead (Lb) and particulate matter (PM_x)) from both public and private transportation vehicles and the impacts of these emissions on human health in general terms such as risk of respiratory illnesses. Reference was made to the reduced visibility in the early morning and late evening as a result of the dark colored smoke coming out of the vehicles' exhaust pipes and also the discoloration of buildings alongside the main roads and in the vicinity of the main bus stops in the city.

After this, an emission control program for the city of Nairobi was presented, emphasizing the need for more regulation and monitoring of motorized vehicles on the roads in Nairobi by the City Council's Directorate of Motor Vehicle Inspections (DMVI), including more strict control over the import of old cars from abroad. Respondents were informed that such intensified regulation and inspection of motorized vehicles require additional funding. The current budget of the DMVI does not suffice to impose more strict measures to meet existing air quality standards in Nairobi. Additional funding will be needed for more effective and improved regulatory capacity.

Next, respondents were asked whether they would be willing to contribute to a special trust fund that is managed by trustee to finance the required additional regulatory power in order to

effectively reduce current emission levels from motorized transportation by 50%. To this end, a special trust fund would be introduced into which respondents could make a one-off contribution on a voluntary basis as this appeared to be the most preferred payment vehicle compared to increased income taxation, public transportation costs for those who do not own a motorized vehicle or increased fuel costs for private vehicles. Although such a voluntary trust fund may induce free riding and possibly lack incentive compatibility as argued by Carson and Groves (2007), alternative payment vehicles such as those mentioned above evoked considerable protest response during the pretest and were therefore considered inappropriate. Respondents were informed that the money in the special trust fund would be used exclusively to effectively reduce emission levels. Also the link to the City Council's DMVI and its role in regulating and monitoring urban traffic was expected to increase the credibility of the policy scenario and the effective use of the payment. Finally, respondents were asked to answer as truthfully as possible and imagine they actually would contribute to the trust fund, ensuring that their decision was perceived as having real consequences for their disposable household budget (Carson and Groves, 2007).

Three different payment cards were used in three split samples to elicit WTP to reduce current emission levels in Nairobi and improve air quality. The bid amounts on these cards were based on the pre-test survey. This pretest generated 15 of such bids, ranging from KSh 0 to 2,000. The three different cards are reproduced in the Annex to this paper. Using a conventional PC (e.g. Rowe *et al.*, 1996), respondents were presented with an ordered range of values and asked to tick the highest amount that they would be willing to pay for the improvement of air quality. Maximum WTP was assumed to be equal to or greater than the ticked value but less than the next higher value (Cameron and Huppert, 1989). All respondents in the three split samples were asked the same following valuation question:

"*Suppose the presented policy to reduce emissions from motorized vehicles and improve air quality in the city of Nairobi will actually be implemented and reduce the current amount of emissions, what is the maximum amount of money you would be willing to pay one-off to the special trust fund to achieve this? (tick or circle a single amount on the card).*"

Since this elicitation format does not account for preference uncertainty, it was used as the control group with which the subsequent two preference and preference uncertainty elicitation formats were compared.

In the SPC version, respondents were offered the same range of values, but this time accompanied by probabilities ranging from zero to one headed under five ordinal certainty scales: 'definitely yes', 'probably yes', 'not sure', 'probably no' and 'definitely no'. For every value presented on the payment card respondents were asked to select the probability that they would actually pay the specific amount shown. This way the certainty of WTP responses is explicitly embedded in the analysis by allowing respondents to express their degree of preference certainty related to each bid amount (Wang, 1997). The elicitation format takes an individual's valuation of the proposed environmental improvement as a random variable with an associated distribution rather than a single point value as in conventional PC responses. Respondents who were presented the SPC were asked the following valuation question:

"*Suppose the presented policy to reduce emissions from motorized vehicles and improve air quality in the city of Nairobi will actually be implemented and reduce the current amount of emissions, how certain are you that you would actually one-off pay the amounts of money shown on this card to the special trust fund to achieve this? (tick or circle your level of certainty to pay each of the amounts on the card).*"

Finally, in the PPC elicitation format respondents were again presented with the same range of values as before, but this time only with the five ordinal levels related to their preference uncertainty. Using this format respondents are still allowed to explicitly express their level of certainty about each bid amount on the payment card, but based on five instead of eleven uncertainty levels. The valuation question was in this case identical to the one for the SPC.

An important advantage of these latter two value elicitation approaches is that besides allowing respondents to simultaneously express their level of certainty when considering various bid amounts, it circumvents possible starting point bias and some of the difficulties inherent in the process of bid selection (Welsh and Poe, 1998). This increases the precision of the estimated parameters and central tendency estimates (Wang and He, 2011). An important disadvantage of the payment cards is that they have been shown to introduce possible range and midpoint bias (e.g. Ryan *et al.*, 2004). However, because we use identical cards in this study across the three split samples, if present, this possible bias is expected to impact value estimates in the same way across the three treatments.

3.2.2. Econometric models and hypothesis testing

The different elicitation formats generate interval and discrete choice data or combinations thereof, and were therefore analysed using interval and random effects probit regression models. Starting with the interval regression model, this model is based on the underlying assumption that a respondent's true maximum WTP is at least as high as the amount crossed on the payment card, but less than the next highest amount listed on the card (Cameron and Huppert, 1989). Suppose the WTP function for the i^{th} respondent is specified as:

$$Log(WTP_i) = x_i'\beta + \varepsilon_i \quad (1)$$

where WTP is the latent dependent variable, x_i is a vector of explanatory variables, β the associated regression coefficients and ε_i is a normally distributed random variable with zero mean and variance σ^2. Suppose furthermore also that an individual's true value, WTP_i, is known to lie within the interval (Q_i, Q_{i+1}), then the probability distribution would be:

$$Prob(Q_i \leq WTP_i \leq Q_{i+1}) \quad (2)$$

For left-censored data for which a lower bound is not known, the probability distribution would be:

$$Prob(WTP_i \leq Q_{i+1}) \quad (3)$$

and for right-censored data for which an upper bound is not known, it would be:

$$Prob(Q_i \leq WTP_i) \quad (4)$$

This implies that also the *log(WTP_i)* lies between *log(Q_i)* and *log(Q_{i+1}).* Each pair of individual thresholds for *log(WTP_i)* could then be standardized to show that the probability that respondent i will select a WTP amount w_i is:

$$Prob(w_i) = \varpi\left(\frac{log\ Q_i - x_i\beta}{\sigma}\right) - \varpi\left(\frac{log\ Q_{i+1} - x_i'\beta}{\sigma}\right) \quad (5)$$

where ϖ is the cumulative standard normal density function. The log likelihood function for a sample of n independent observations can be written as:

$$Log\ L = \sum_{i=1}^{n} Log\left[\varpi\left(\frac{log\ Q_i - x_i\beta}{\sigma}\right) - \varpi\left(\frac{log\ Q_{i+1} - x_i'\beta}{\sigma}\right)\right] \quad (6)$$

Under the assumption that the stochastic term is normally distributed, both β and σ can be estimated and used to calculate the mean and median WTP:

$$\text{Mean WTP} = e^{(x_i'\beta + \sigma^2/2)} \quad (7)$$

$$\text{Median WTP} = e^{(x_i'\beta)} \quad (8)$$

In this case, x_i' is taken as the vector of mean values of the explanatory variables, β is the vector of estimated coefficients and σ is the estimated error variance.

In the case of the SPC and the PPC, respondents are asked a series of choices such that more than one observation is collected from each individual. Respondents are asked to indicate their level of payment certainty for each of the bid amounts presented on the payment cards and this leads to the generation of panel data observations where individual-specific variation remains fixed across the discrete choices. Consequently, a random parameter model is chosen to analyse these choice data, following, for example, Loomis (1997) and Imaz *et al.* (2014).

The panel data regression model for the policy proposal on vehicular emission reductions can be formulated as follows:

$$z_{ij}^{*} = x_{ij}'\varphi_j + \varepsilon_{ij} = x_{ij}'\varphi_j + \mu_i + v_{ij} \quad (9)$$

where the dependent variable z_{ij}^{*} is the measurable component of respondent preference uncertainty comprising the probability scores for the certainty levels of the bid amounts

associated with the air quality improvement, x'_{ij} is a *1 x k* vector of individual respondent characteristics, φ_j is a *k x 1* vector of associated variable coefficients and ε_{ij} is the error term, which comprises, in this case, the random error due to variation among respondents (person-specific variation) μ_i and the random error due to random variation across discrete choices (differences among observations) v_{ij}. These error terms are assumed to be normally distributed with a mean of zero and variance of σ_μ^2 and σ_v^2 respectively. While z_{ij}^* is not observable, the binary part z_{ij} can be observed, meaning that an individual respondent would be uncertain about paying a given bid amount if the WTP associated with the air quality improvement is less than the bid amount that has to be paid. Thus:

$$z_{ij} = 1 \; if \; WTP_{ij} \leq BID \tag{10}$$

$$z_{ij} = 0 \; otherwise \tag{11}$$

The probabilistic discrete choice model can therefore be specified as:

$$z_{ij} = Prob(\, x_{ij}\varphi_j + \varepsilon_{ij} \leq BID) \tag{12}$$

Although the random effects model can be estimated either as a logit or probit model, the probit specification is in this case employed due to its popularity in discrete choice data analysis, deriving from the fact that the two error terms of the model have identical distributions, which allow simple functional forms for the estimators (Wooldridge, 2002).

Based on the three different value and preference uncertainty elicitation formats used in the study in three split samples, four hypotheses were formulated and tested. These are listed below.

$$H_0^1: wtp_{ir}^{PC} - wtp_{ir}^{SPC} = 0 \quad (13)$$

$$H_0^2: wtp_{ir}^{PC} - wtp_{ir}^{PPC} = 0 \quad (14)$$

$$H_0^3: wtp_{ir}^{SPC} - wtp_{ir}^{PPC} = 0 \quad (15)$$

$$H_0^4: wtp_{re}^{SPC} - wtp_{re}^{PPC} = 0 \quad (16)$$

The first three hypotheses compare the estimated mean WTP values from the three different SP elicitation formats using the same interval regression (*ir*) estimation procedure, allowing us hence to conclude whether the inclusion of explicit preference uncertainty elicitation procedures has a significant effect on stated WTP. The last hypothesis compares the same estimated mean WTP values based on the SPC and PPC, but this time using the random effects (*re*) probit model.

3.3 Study area and data collection

Nairobi, the capital city of Kenya, is found in the south-eastern part of the country. The metropolitan area covers approximately 696 km^2, and is located at an altitude varying between 1,600 and 1,850 metres above sea level (CBS, 2009). The city is home to about 8 percent of the country's total population and 25 percent of Kenya's urban population (CBS, 2009). Population growth in Nairobi has been immense over the past 5 decades from just over 343 thousand in 1962 to about 3.1 million in 2009 and an expected 3.8 million in 2015 (CBS, 2009). Important driving factors behind this population growth include better economic prospects and market access, opportunities for higher education, and higher wage employment (NEMA, 2010). The rapid increase in population has led to an unprecedented sprawl of informal settlements, increased motorized traffic and corresponding impacts on air quality in the city. In addition, the difference between the resident (more than 3.1 million) and daytime populations (more than 4.2 million) implies an enormous amount of motorized traffic every day into and out of the city. Traffic growth has thus been singled out as the

major source of air pollution in Nairobi, accounting for about 90 percent of the total emissions into the air (Odhiambo *et al.,* 2010). According to a study by Kinney et al. (2011), the city has high concentrations of toxic gases, such as CO, SO_x, NO_x, CH_4, Lb and PM_x. As a result, many Nairobi residents are exposed to elevated concentrations of vehicular emissions, which pose serious long-term human health risks (Vliet and Kinney, 2007; Odhiambo *et al.*, 2010; Kinney *et al.*, 2011). Vehicle emission levels and the potential impact on human health have been measured in these existing studies, but so far no studies have been carried out measuring public perception of air quality problems in Nairobi to inform policy and decision-making related to urban planning and traffic management.

A large scale survey was carried out in the 8 administrative divisions that form the city of Nairobi (CBS, 2009) after thorough pre-testing of the survey instrument. The pre-test served, among others, to establish the range of bid values for the payment cards. In the final survey, Nairobi residents over the age of 18 were interviewed in-person by trained interviewers in the local language on the main streets in these 8 administrative units on a random 'next to pass' basis, aiming to end up with a representative sample of the population in Nairobi as a whole. Respondents were randomly assigned to one of the three WTP elicitation formats, and an attempt was made to have a more or less equal distribution of respondents over the three formats. In total 1,460 interviews were fully completed, divided over 3 split samples of 488 (PC), 480 (SPC) and 492 respondents (PPC).

3.4 Results

3.4.1. Sample characteristics

The main socio-demographic and economic sample characteristics are presented in Table 3.1 Most respondents (64%) were male, aged 32 years, with secondary education, coming from an average household size of 3 people, and living in the urban part of Nairobi (57%). Mean

disposable income of the respondents was KSh 18,567 ($185.67). Although the distribution of respondents across the 8 administrative units is representative for the city as a whole, we are unable to conclude so about household income due to the lack of reliable statistical data for Nairobi. Most respondents (63%) stated that they are confident that their future income will remain at its current level. Although only a small share of the sample population (17%) owns a motor vehicle, most respondents reside close (192.7 meters) to nearby main roads. The outcome of the Kruskal–Wallis chi-square test statistic in Table 1 shows that the three split samples differ significantly in terms of household income, education level, household size, residing in the urban area, certainty of future income, and the distance respondents live to nearby roads, meaning that these factors have to be controlled for in the computation of the WTP welfare estimates.

The study also attempted to assess respondents' awareness and perception of air pollution and health risks. Awareness levels are very high. However, although 88 percent of the respondents defined air pollution correctly as the contamination of the air they breathe with toxic smoke and dust particles and 71 percent was aware of the impacts on people's respiratory system, 12 percent thought it was mainly about bad odour from decaying waste and smoke. Moreover, contrary to the available statistical data, only 55 percent of the respondents identified motor vehicles as the main source of air pollution in Nairobi, followed by factories (25%), the burning of waste by households (19%) and peri-urban farming activities (5%). Almost all respondents agreed that air pollution is a big problem in Nairobi that had to be more effectively addressed by the local authorities. Among the possible solutions, respondents identified the use of improved quality fuels, fuel efficient motor vehicles, improved road infrastructure, and traffic regulation and control.

Table 3.1: Socio-demographic sample characteristics across the three samples with different preference elicitation formats

Variable	PC		SPC		PPC		Whole sample		Kruskal-Wallis test	
	Mean	Std. error	Mean	Std. error	Mean	Std. error	Mean	Std. error	Chi-square	p-value
Share of male respondents.	0.62	0.02	0.64	0.02	0.65	0.02	0.64	0.01	1.12	0.571
Respondent age.	31.5	0.37	32.0	0.38	32.5	0.38	32.0	0.35	3.60	0.166
Education level.	3.61	0.05	3.34	0.04	3.47	0.04	3.47	0.03	16.98	0.000
Household income.	19,400	215.3	17,500	194.2	18,800	208.6	18,567	205.3	9.28	0.010
Household size.	3.49	0.06	3.79	0.05	3.60	0.05	3.63	0.03	21.84	0.000
Share living in urban area.	0.69	0.02	0.52	0.02	0.51	0.02	0.57	0.01	34.05	0.000
Distance to nearby main road.	212.0	2.36	169.9	1.89	196.1	2.18	192.7	2.13	25.92	0.000
Share owning motorized vehicle.	0.18	0.02	0.16	0.02	0.19	0.02	0.17	0.01	1.83	0.401
Share certain about future income.	0.83	0.02	0.52	0.02	0.54	0.02	0.63	0.01	31.48	0.000

Explanatory Notes:
PC (payment card); SPC (stochastic payment card); PPC (polychotomous payment card).
Respondent age (continuous variable); Share of male rspondents (dummy: 1=male, 0=otherwise); Education level (categorical: 1=no education; 2=primary school; 3=secondary school; 4=tertiary education; 5=university degree); Household income (continuous); Household size (continuous); Distance (continuous); Share owning motorized vehicle (dummy: 1=own, 0=otherwise); Share certain about future income (dummy: 1=certain, 0=otherwise); Share living in urban area (dummy: 1=urban, 0=otherwise).

3.4.2. Mean WTP across value and preference uncertainty elicitation formats

WTP responses across the different payment card values and corresponding bid intervals are presented in Table 3.2, distinguishing between the three preference and uncertainty elicitation formats. Overall, 84 percent of all respondents supported the proposed emission control program and stated a positive WTP. The most frequently ticked WTP values on the payment cards are KSh 50 ($0.5), 100 ($1.00), 200 ($2.00), 400 ($4.00) and 500 ($5.00) (by 50 percent of the respondents). Ten percent of the responses fall in the three highest bid intervals. Those stating a zero WTP were asked why in order to identify possible protest response. Based on these reasons, 10 percent of all the responses were classified as protest and 6 percent as legitimate zero bidders. The most important protest reasons were that car owners should pay or that air quality was the responsibility of the government. Following common practice in the CV literature (e.g. Strazzera *et al.*, 2003; Dziegielewska and Mendelsohn, 2007), these protest responses were omitted from further analysis, while the true zero votes were kept in[4]. This yields a total of 1,315 useable responses. The distributions of these WTP responses across the three elicitation formats excluding the protest response are significantly different at the 1 percent level (the Kolmogorov-Smirnov test results are available from the authors upon request). Based on these WTP responses, mean WTP values were estimated, including their standard errors and 95 percent confidence intervals based on 10,000 replications bootstrapping in Stata 13 (Table 3.3), in order to test the hypotheses presented in Section 2.3. T-tests are used to test the equality of the estimated mean WTP values.

[4] No significant differences were detected between protest and non-protest respondents in a simple logit regression analysis regressing respondent participation in the contingent market on a number of socio-demographic respondent characteristics, implying the absence of selection bias.

Table 3.2: WTP responses across the three preference elicitation formats

		PC		SPC		PPC		Whole sample	
Bids (KSh)	**Bid interval**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Protest	-	53	11	35	7	57	12	145	10
0	0 - 25	18	4	28	6	46	9	92	6
25	25 - 50	16	3	8	2	79	16	103	7
50	50 - 70	30	6	60	13	65	13	155	11
75	70 – 100	26	5	30	6	24	5	80	5
100	100 – 150	57	12	46	10	35	7	138	9
150	150 – 200	18	4	24	5	16	3	58	4
200	200 – 250	39	8	46	10	37	8	122	8
250	250 – 300	38	8	30	6	24	5	92	6
300	300 – 400	28	6	24	5	30	6	82	6
400	400 – 500	33	7	60	13	32	7	125	9
500	500 – 800	61	13	34	7	24	5	119	8
800	800 – 1000	34	7	32	7	11	2	77	5
1000	1000 – 1500	33	7	8	2	12	2	53	4
1500	1500 – 2000	4	1	15	3	0	0	19	1
Total		488	100	480	100	492	100	1460	100

Explanatory Notes:
PC - payment card; SPC - stochastic payment card; PPC - polychotomous payment card.

The mean WTP values estimated using interval regression are all significantly different from each other, with the elicitation formats accounting for preference uncertainty generating lower WTP values than the conventional PC without addressing preference uncertainty[5]. Of the two payment cards addressing preference uncertainty, the PPC format generates the lowest mean WTP. The same result is found when comparing mean WTP estimates based on the random effects probit model in Table 3. Here too the PPC format yields the lowest mean WTP of the two uncertainty preference elicitation formats.

In order to assess the implications of accounting for preference uncertainty on the efficiency of the WTP welfare estimates, the relative measure of variation (RMV) was calculated by dividing the difference between the upper and lower bound 95 percent confidence interval by mean WTP (e.g. Loomis and Ekstrand, 1998). Based on the interval regression estimates, the RMV is slightly higher for the uncertainty elicitation formats (0.20 and 0.22 for the SPC and PPC formats respectively) than for the conventional PC (0.18), implying that the reduction in welfare estimate due to preference uncertainty is at the expense of statistical efficiency. Consistent results are found when calculating the variation coefficients (standard errors divided by mean WTP) across the preference and uncertainty elicitation formats. The RMV values are also higher for the lower PPC WTP than the SPC WTP based on the random effects probit model.

[5] T-statistics are 6.917 ($p<0.01$), 8.641 ($p<0.01$) and 1.900 ($p<0.06$), respectively when comparing mean WTP based on the PC and the SPC, the PC and the PPC, and the SPC and the PPC elicitation format. The t-test statistic is 5.600 ($p<0.001$) when comparing the SPC and PPC mean WTP values based on the random effects probit models.

Table 3.3: Estimated mean WTP values (KSh/household) for improved air quality in Nairobi based on different preference and uncertainty elicitation formats and estimation procedures

	PC_{ir}	**SPC_{ir}**	**PPC_{ir}**	**SPC_{re}**	**PPC_{re}**
Mean WTP.	396.6	246.5	213.6	364.9	346.5
St. error.	18.1	12. 7	11.8	2.9	1.7
% of income	2.13	1.33	1.15	1.97	1.87
95% confidence intervals.	361.1 - 432.0	221.7 - 271.4	190.4 - 236.9	330.8 - 397.4	303.3 - 387.9
Number of observations.	435	445	435	445	435

Explanatory Notes:
PC - payment card; SPC - stochastic payment card; PPC - polychotomous payment card.
ir - interval regression; re - random effects probit regression.

3.4.3. Explaining willingness to pay

Interval regression was also used to estimate the relationship between respondents' WTP and a number of socio-demographic respondent characteristics. The results are presented in Table 3.4. As before, a distinction is made between the three different preference and uncertainty elicitation formats. Explanatory factors that are significant across all three elicitation formats are household disposable income, respondent certainty about the household's future income, and whether or not the respondent owns a motorized vehicle. The first two variables influence stated WTP, as expected, in a positive way, with respondents belonging to higher income groups and respondents who are certain about their future income stating on average a higher WTP. Respondents who own a motorized vehicle such as a car or motor are willing to pay on average significantly less to a special trust fund to reduce emission levels and improve air quality. A possible explanation for this negative relationship is that these respondents may prefer to invest directly in their own motorized vehicle, such as a filter on the exhaust pipe or improved fuel use efficiency of their motors.

A respondent's age has a negative influence on stated WTP in all three models, implying that younger respondents are willing to pay on average more than older respondents, but this variable is only statistically significant in the estimated models based on the PC and SPC, not the PPC. Also the distance respondents live from the nearest main road has a negative impact in all three models, implying distance-decay since respondents who live nearer to the main road are expected to benefit most from a reduction in emission levels, but this variable is only significant for the two elicitation formats that account for preference uncertainty.

Table 3.4: Interval regression results explaining stated WTP across the three preference and uncertainty elicitation formats

	PC		SPC		PPC	
Explanatory factor	**Coefficient estimate**	**Std. error**	**Coefficient estimate**	**Std. error**	**Coefficient estimate**	**Std. error**
Constant.	3.885***	0.216	3.452***	0.207	4.133***	0.415
Gender.	0.374***	0.014	0.019	0.302	0.048	0.254
Responsents age (in years).	-0.117***	0.006	-0.191***	0.014	-0.039	0.195
Household income (in Kenya Shillings).	0.531***	0.019	0.483***	0.038	0.305***	0.020
Distance to nearby main road (in meters).	-0.022	0.256	-0.168***	0.010	-0.112**	0.015
Owner of motorized vehicle (1=yes; 0=no).	-0.191*	0.032	-0.352**	0.068	-0.524***	0.046
Certain of future income (1=yes; 0=no).	0.194*	0.039	0.634***	0.057	0.444***	0.031
Log likelihood.	-996.19		-1040.22		-1067.96	
Likelihood Ratio (LR) chi-squared (6 d.o.f.).	281.72		185.96		52.85	
p > LR chi-squared.	0.001		0.001		0.001	
Number of observations.	435		445		435	

Explanatory Notes:
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.
PC (payment card); SPC (stochastic payment card); PPC (polychotomous payment card).
Respondent age (continuous variable); Gender (dummy: 1=male, 0=otherwise); Household income (continuous); Distance (continuous); Owner of motorized vehicle (dummy: 1=own, 0=otherwise); Certain of future income (dummy: 1=certain, 0=otherwise).

Finally, men are willing to pay on average significantly more than women in all three models, but only significantly so in the model based on the conventional PC. A possible explanation for this positive effect is that men often decide on financial matters in a household and control the household budget. Access to information and therefore higher awareness levels has been suggested as another possible explanation in the specific context of air quality in both developed and developing countries (Carslsson and Johansson-Stenman, 2000; Wang and Zhang, 2008).

3.4.4. Explaining preference uncertainty

In order to also examine what factors determine preference uncertainty, a random effects probit model was estimated relating the certainty scores expressed in the SPC and the PPC elicitation formats to the same socio-demographic and other respondent characteristics as before. The results are presented in Table 3.5 for the two different uncertainty elicitation formats. The random effects model accounts for the cross-section nature of the available data, i.e. the fact that every respondent indicated for every payment card value how certain (s)he was she would actually pay the specific amount of money. This gives more than 6 thousand observations per model based on 435 and 445 respondents. The dependent variable in this case is a binary variable representing preference uncertainty. The categories 'not sure,' 'probably no' and 'probably yes' are recoded as uncertain responses and given the value 1. The 'definitely yes' and 'definitely no' responses were regarded as certain responses and given the value 0. Socio-demographic explanatory factors common to both models are household income, distance to the nearest main road, and whether the respondent owns a motorized vehicle. The latter two variables have a positive impact on preference uncertainty, meaning that the likelihood that a respondent is uncertain about his or her WTP response increases as respondents live further away from the main road or own a car.

Table 3.5: Random effects probit regression results explaining stated preference uncertainty

	SPC		PPC	
Explanatory factor	**Coefficient estimate**	**Std. error**	**Coefficient estimate**	**Std. error**
Constant.	0.057	0.517	-1.089**	0.554
Gender.	-0.408*	0.214	-0.091	0.237
Age (in years).	-0.243*	0.148	-0.077	0.134
Household income (in Kenya Shillings).	-1.287***	0.121	-0.606***	0.113
Area of residence.	-0.292	0.202	-0.323	0.224
Distance to nearby main road (in meters).	0.345***	0.068	0.171**	0.087
Owner of motorized vehicle.	0.999***	0.341	0.978***	0.364
Certain of future income.	-0.971***	0.206	-0.343	0.233
Bid level (in Kenya shillings).	0.012***	4.25e-05	0.009***	2.97e-04
Bid level-squared.	-3.86e-06***	1.75e-07	-2.86e-06***	1.31e-07
Log likelihood.	-1682.42		-1976.01	
Wald chi-squared (9 d.o.f.).	900.40		1083.49	
$p >$ chi-squared.	0.001		0.001	
Number of observations.	6675		6525	
Number of respondents.	445		435	

Explanatory Notes:
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.
SPC (stochastic payment card); PPC (polychotomous payment card).
Respondent age (continuous variable); Gender (dummy: 1=male, 0=otherwise); Household income (continuous); Area of residence (dummy: 1=urban, 0=otherwise); Distance (continuous); Ownership of motorized vehicle (dummy: 1=own, 0=otherwise); Share certain about future income (dummy: 1=certain, 0=otherwise);

The reverse relationship is found for household income. Here, the likelihood of being uncertain about WTP decreases as respondents earn more money. A respondent's certainty about his or her future income level also has a negative relationship with preference uncertainty (respondents who trust their income to stay at least the same as before are less likely to be uncertain about their stated WTP), but is only statistically significant in the model based on the SPC. A similar relationship between income and preference uncertainty is reported in Brouwer (2011). In the same model, older men are also less likely to be uncertain than women. The impact of age on preference uncertainty is just significant at the 10 percent level. Akter *et al.* (2009) and Brouwer (2011) find the same relationships between respondent sex and age and preference uncertainty.

Finally, like Loomis and Ekstrand (1998), Brouwer (2011) and Logar and van den Bergh (2012), the study confirms the presence of a U-shaped relationship between preference uncertainty and the bid value respondents are asked to pay. The significant positive impact of bid level on preference uncertainty indicates that a higher (lower) bid value results, all else being equal, in a higher (lower) likelihood of being uncertain. The significant negative quadratic effect of the bid level implies that there is a range of values in between the lower and higher bids where respondents are more likely to be uncertain. This is likely the range where a respondent's true WTP is located.

3.5 Conclusions and recommendations

The study presented here aimed to examine the effect of preference uncertainty in SP research on estimated WTP welfare estimates. The existing valuation literature is ambivalent about the effect of controlling for preference uncertainty in SP studies, with some finding a higher and others a lower welfare estimate. Similar results are found for the statistical efficiency of the WTP welfare estimates. We control for the possible influence of the

preference elicitation format and use an identical payment card containing the same range of values, and add different preference uncertainty elicitation procedures. The effect of two such preference uncertainty elicitation treatments on stated WTP, the stochastic payment card and a polychotomous uncertainty approach, are analyzed in split samples, using the conventional payment card without any reference to preference uncertainty as a control group. A major advantage of the approaches presented here is that we circumvent arbitrary recoding procedures often used in the CV literature where uncertain yes responses to certain bid amounts are converted into no responses. Given the hypothetical nature of SP research and the lack of familiarity with paying for public environmental goods, respondents are expected to experience considerable uncertainty when participating in SP surveys. This may substantially affect welfare estimation in policy analysis. In this study we focused on a pollution control program targeting toxic emissions from motorized vehicles in Nairobi, Kenya to improve air quality in one the fastest growing metropolitan cities in Sub-Saharan Africa.

The study shows that there exists substantial financial support for improved air quality in Nairobi, with approximately 85 percent of the whole sample stating a positive WTP and protest being limited to 10 percent. The way these WTP values are elicited, with and without the ability to express preference uncertainty, has a significant effect on the final welfare estimate to be included in policy analysis. This study confirms findings most commonly reported in the literature that accounting for preference uncertainty significantly reduces estimated WTP (e.g. Ekstrand and Loomis, 1998; Samnaliev *et al.*, 2006; Chang *et al.*, 2007; Brouwer, 2011). However, less obvious is to what extent this also produces more or less efficient welfare estimates. In this study, we show that allowing respondents to express the experienced (un)certainty that they will actually pay the stated WTP values also yields less efficient WTP values, implying less accurate value estimates for inclusion in policy analysis.

More specifically, mean WTP is reduced by 38 percent when applying the SPC compared to the conventional PC and by 46 percent when comparing the PPC with the PC. The corresponding level of WTP imprecision increases by 13 and 22 percent, respectively. Although other WTP elicitation formats have been argued to be more incentive compatible, the payment card and the open-ended WTP elicitation formats have been shown to produce the most conservative WTP estimates in the SP literature. As shown in this study, these estimates are reduced even further when accounting for preference uncertainty, and hence provide an important lower bound with which the implementation costs of the motorized emission reduction program in Nairobi can be compared. For application in a developing country context with a considerable share of illiterate survey participants, the PPC approach furthermore seems to hold most promise since it is easier to understand and imposes less of a cognitive burden on survey participants than the SPC. However, more similar valuation studies will be needed to arrive at a final conclusion.

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CHAPTER FOUR

Scope effects of respondent uncertainty in contingent valuation: Evidence from motorized emission reductions in the city of Nairobi, Kenya

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Abstract

This study analyzed the scope effects of respondent uncertainty in contingent valuation (CV) by evaluating whether willingness to pay (WTP) estimates were sensitive to changes in the magnitudes of motorized emission reductions in the city of Nairobi, Kenya. The WTP estimates were elicited through the conventional payment card (PC), stochastic payment card (SPC) and the polychotomous payment card (PPC) formats. While SPC and PPC formats were used to capture respondent uncertainty, the PC format captured respondent certainty regarding the amounts individuals were WTP for emission reductions. Based on parametric and nonparametric analysis, the results show that certain (PC) respondents stated significantly larger WTP amounts for larger emission reductions than for smaller reductions. Conversely, uncertain (SPC and PPC) respondents stated smaller amounts for larger emission reductions than certain (PC) respondents. The implication is that though respondents were sensitive to the scope of motorized emission reductions, respondent uncertainty lowered their sensitivity to scope.

Key words: Contingent valuation, respondent uncertainty, scope sensitivity, payment card, stochastic payment card, polychotomous payment card, air quality, motorized emissions.

4.1 Introduction

Contingent valuation (CV) is a survey-based non market valuation approach used to elicit the policy values of providing environmental goods and services (Mitchell and Carson, 1989; Freeman, 1993; Smith, 1993). On a specific hypothetical scenario and detailed description of the good, people are asked directly to state how much they would be willing to pay for its provision or how much they would be willing to accept as compensation for its withdrawal (Carson, 2000; Mendelsohn and Olmstead, 2009). Therefore, CV approach can circumvent the absence of markets by inferring policy values of providing environmental goods and services from the choices of individuals found in the real market (Mitchell and Carson, 1989; Freeman, 1993; Smith, 1993).

The fact that CV approach is based on asking individuals how much they would be willing to pay or willing to accept based on hypothetical markets, as opposed to observing their behavior in the real market, has been a source of enormous controversy among researchers (Gregory *et al.,* 1993; Polasky *et al.,* 1996; Champ *et al.,* 1997; Johannesson *et al.,* 1998; van Kooten *et al.,* 2001; Alberini *et al.,* 2003). One of the controversies focuses on whether estimates of economic value are sensitive to goods' scope. That is, whether willingness to pay (WTP) or accept (WTA) estimates increase or decrease satisfactorily with changes in the composition, quantity or quality of the environmental goods being valued (Kahneman, 1986; Hausman, 1993; Carson, 1997; Svedsater, 2000). While some studies have shown significant evidence of respondents' insensitivity to goods' scope (Kahneman and Knetsch, 1992; Beattie *et al.,* 1998; Hammitt and Graham, 1999; Svedsater, 2000), others have shown significant sensitivity to scope (Smith and Osborne, 1996; Carson, 1997; Smith, 1999) while still others have pointed to the possibility of having scope sensitivity and insensitivity within the same study (Bateman *et al.,* 2004; Heberlein *et al.,* 2005).

There are several reasons why scope insensitivity is observed in practice and they include: amenity misspecification (Carson and Mitchell, 1993), framing or embedding effects (Randall and Hoehn, 1996), warm glow effects (Heberlein *et al.,* 2005) and the declining marginal existence values (Rollins and Lyke, 1998). Insensitivity to scope has also been linked to respondents' lack of familiarity with payments for environmental goods in hypothetical markets often leading to constructed preferences (Brouwer, 2009). Such lack of familiarity with environmental payments has, as well, been shown to be an important determinant of the underlying respondent uncertainty in CV (Loomis and Ekstrand, 1998; van Kooten *et al.,* 2001; Veisten *et al.,* 2004; Brouwer, 2009).

Respondent uncertainty is defined as respondents' state of indecisiveness about the amounts they are willing to pay for the provision of environmental goods and services (Polasky *et al.,* 1996; van Kooten *et al.,* 2001; Shaikh *et al.,* 2007; Brouwer, 2009; Logar and van den Bergh, 2012). Like scope sensitivity, it has also remained a contested issue in the CV literature for about two and a half decades. Researchers have not only studied the sources and welfare effects of respondent uncertainty but also the procedures for analyzing response uncertainty (Ready *et al.,* 2001; Alberini *et al.,* 2003; Samnaliev *et al.,* 2006; Shaikh *et al.,* 2007; Blomquist *et al.,* 2009; Brouwer, 2009; Moore *et al.,* 2010; Martinez-Espineira and Lyssenko, 2012). These procedures have, nonetheless, yielded inconsistent findings about the real welfare effects of respondent uncertainty (Akter and Bennett, 2008; Petrolia and Kim, 2011; Martinez-Espineira and Lyssenko, 2012). In most, but not all cases, respondent uncertainty has resulted in more conservative estimates of the WTP although at the expense of statistical efficiency. Even so, the scope effects of respondent uncertainty remain largely unknown as there is no known study that has analyzed respondent uncertainty in relation to sensitivity to goods' scope. The purpose of this paper was therefore to analyze the link between respondent uncertainty and scope sensitivity and thereby make a novel contribution

to the current CV literature. The analysis was merited by the fact that it would provide essential methodological inferences for welfare analysis since policy formulation and implementation may involve some aspects of public uncertainty and/or insensitivity to changes in either composition, quality or quantity of goods or services being provided to the public (Gyldmark and Morrison, 2001; Veisten *et al.,* 2004).

For this reason, WTP responses in the study were elicited from 'within' and 'between' respondents using payment card (PC), stochastic payment card (SPC) and the polychotomous payment card (PPC) formats with a case application to the valuation of motorized emission reductions in the City of Nairobi, Kenya. The PC format conventionally elicits preferences on the assumption that respondents know their WTP with certainty (Mitchell and Carson, 1989; Hanley *et al.,* 2003; Ryan *et al.,* 2004) while SPC (Wang, 1997; Wang and Whittington, 2005) and PPC (Welsh and Poe, 1998; Wang and He, 2011) formats do the same though with the assumption that respondents are uncertain about their WTP. Moreover, each of the these formats can be used ascertain whether or not WTP estimates are sensitive to goods' scope but, in this case, estimates from SPC and PPC formats were used to provide comparative information that would capture the effects of respondent uncertainty on individuals' sensitivity to scope as the PC estimates act as the yardstick.

The rest of the paper is organized as follows. Section 2 provides a brief review of literature on respondent uncertainty and scope sensitivity in CV. Section 3 discusses the motorized emission situation in the city of Nairobi. Section 4 describes the survey design. Section 5 presents the study findings and discussion and section 6 concludes.

4.2 Respondent uncertainty and scope sensitivity in contingent valuation

Contingent valuation studies have traditionally been based on the assumption that respondents know their preferences with certainty. Thus, responses to welfare analyses have mostly been elicited through payment card (PC), bidding games (BG), open-ended questions (OE), single bounded (SB) and double bounded (DB) formats among other variants (Li and Mattson, 1995; Ready *et al.,* 1995; Loomis and Ekstrand, 1998). Some empirical studies have however shown that respondents may not after all know their preferences with full certainty (Champ *et al.,* 1997; Johannesson *et al.,* 1998; Ready *et al.,* 2001; van Kooten *et al.,* 2001; Shaikh *et al.,* 2007). This is because preferences tend to be ambiguous (Wang, 1997) and are more generally affected by the policy environment of the good being provided (Dominguez-Torreiro and Solino, 2011). In addition, preferences are elicited within hypothetical markets and from respondents probably with insufficient cognitive ability to make trade-offs between their money and the good being valued (Ready *et al.,* 1995; Champ *et al.,* 1997; Wang, 1997; Alberini *et al.,* 2003; Shaikh *et al.,* 2007; Sund, 2009).

As a result, it has become important to model WTP estimates using value elicitation formats that account for respondent uncertainty such as SPC and PPC formats among others (Champ *et al.,* 1997; Wang, 1997; Welsh and Poe, 1998; van Kooten *et al.,* 2001; Wang and Whittington, 2005). These formats account for respondent uncertainty by allowing respondents to express their degree of uncertainty against bid values that are presented on a numerical or ordinal certainty scale. What has not been clear, though, has been the link between respondent uncertainty and sensitivity to changes in the magnitude of the good under valuation, otherwise known as scope sensitivity. It involves testing whether respondents are willing to pay significantly more for larger provisions and/or less for smaller provisions in terms of composition, quality or quantity of the environmental public good in question (Carson, 1997; Czajkowski and Hanley, 2009).

Scope sensitivity analysis may be internal ('within' respondent) or external ('between' respondent). In the internal version, the same respondent is asked to state his/her WTP for different magnitudes of the environmental good being valued while in the external version, two different magnitudes are valued by different respondents using split samples (Bateman *et al.,* 2004; Czajkowski and Hanley, 2009; Loomis *et al.,* 2009). With appropriate regression models, scope analysis may also be conducted by testing whether parameters of interest in the model are significantly different from zero (Hanley *et al.,* 2003; Loomis *et al.,* 2009). Unlike the external test of scope, the internal version of scope is easily passed by respondents' because of their urge to uphold the 'internal consistency' of their WTP answers (Heberlein *et al.,* 2005; Czajkowski and Hanley, 2009). Nonetheless, it is still important to conduct the internal test of scope since it allows pairwise comparison of WTP estimates for each respondent within the sample and therefore, control for heterogeneity among respondents (Adamowicz *et al.,* 1999; Czajkowski and Hanley, 2009).

Bateman *et al.* (2004) also notes that study designs in scope analysis can either use stepwise or advance disclosure of the valuation questions. In stepwise disclosure, the full sequence of valuation questions is revealed to respondents only as the survey proceeds. Therefore, the approach comes with an element of surprise that can strategically affect responses to the valuation questions. However, whether or not valuation questions are a surprise is immaterial from economic theory because it says nothing about it. For the advance disclosure, the full sequence of valuation questions is revealed to respondents before they are asked to state what they would be willing to pay. In this case, there are no surprises although strategic incentives, which are constant throughout the valuation process, may still be found. In addition, study designs in scope analysis may be constructed in a way in which changes in the magnitude of goods being valued are presented to respondents in a bottom-up or top-down manner. In the bottom-up approach, the less inclusive good is valued first followed by the more inclusive

good. In contrast, top-down approach involves the valuation of the more inclusive good first followed by the less inclusive good.

Following Bateman *et al.* (2004), the study used the advance disclosure design to elicit WTP for the different magnitudes of motorized emission reductions, which were presented to respondents in a bottom-up and top-down manner. For instance, in the bottom-up advance disclosure, the valuation questions were first revealed to respondents before they were asked to state what they would pay for "25%" and "50%" magnitudes of motorized emission reduction. The reverse case applied for the top-down advance disclosure. The use of the percentage approach to proxy different magnitudes of emission reductions follows similar applications by Shechter and Kim (1991), Carlson and Johansson-stenman (2000), Wang *et al.* (2006), Loomis *et al.* (2009) and Firoozzarea and Ghorbani (2011).

4.3 Motorized emissions in the City of Nairobi

The city of Nairobi is located at the south-eastern end of Kenya's agricultural heartland, at about 1° 9'S, 1° 28'S and 36° 4'E, 37° 10'E. It covers an area of about 696 Km^2 with an altitude varying between 1,600 and 1,850 metres above sea level (CBS, 2009). It is divided into eight administrative divisions, namely, Central, Dagoreti, Embakasi, Kasarani, Kibera, Makadara, Pumwani and Westlands. The city's population is about 8 per cent of the country's total population and 25 per cent of Kenya's urban population (CBS, 2009). The population is estimated to have grown from 343,500 people in 1962 to about 3.1 million in 2009 and by 2015, it is expected to hit the 3.8 million mark (CBS, 2009). There are several reasons that have motivated population growth in Nairobi, which include better economic prospects, opportunities for higher education, higher wage employment and the attraction of Nairobi as a market for goods and services (NEMA, 2010).

Rapid increase in population has led to unprecedented sprawl of informal settlements, increased poverty levels, increased motorization and attendant air pollution within the city. With the growth of motor vehicle population in the city, motorized emissions are considered a major source of air pollution accounting for about 90% of total emissions (Odhiambo *et al.,* 2010). For instance, the population of vehicles on the city's roads was 207,340 vehicles in 2004 and by 2008 over 300,000 vehicles were operating on city's roads. Out of the 300,000 vehicles, 36% were private cars, 27% were public transport vehicles and a whole 37% constituted city residents walking to different destinations because of the expensive public transport that could also not meet the rising demand for transport in the city (MORPW, 2009). With increased emission of toxic gases such as carbon monoxide, hydrocarbons, oxides of sulphur and nitrogen, and inhalable and respirable particulate matter (Kinney *et al.* (2011), many Nairobi residents are exposed to air quality problems (Odhiambo *et al.,* 2010; Kinney *et al.,* 2011), which potentially pose serious long-term implications for health and to the environment (Vliet and Kinney, 2007; Odhiambo *et al.,* 2010; Kinney *et al.,* 2011).

Even though problems posed by motorized emissions have been a cause of concern among local authorities (NEMA, 2010), the city lacks a comprehensive management policy for motorized emissions. It would therefore be desirable for the city authorities to draft such a policy given the huge number of resident and daytime populations within the city, approximately 3.1 and 4.2 million people, respectively. The drafting of such a policy can only be attained if peoples' preferences for a policy proposal to reduce motorized emissions are known. Nonetheless, not much is known about peoples' preferences because studies available so far on air quality in Nairobi (Mulaku and Kariuki, 2001; Odhiambo *et al.,* 2010; Vliet and Kinney, 2007; Kinney *et al.,* 2011) deal only with the technical aspects of measuring concentrations of pollutants in the air and their possible effects on human health and the environment. As a result, policy information on the socioeconomic aspects of the population

that is pertinent towards the formulation of emission management policy is lacking. Therefore, this case application was useful on the premise that the missing policy information would be provided and thereby set precedence for improving air quality management in the city.

4.4 Survey design

4.4.1 Environmental public good considered in the study

Motorized emission reduction constituted the environmental good of interest in the study upon which internal and external scope sensitivity tests were conducted. The internal test of scope analyzed the 'within respondent' bottom-up and top-down mean WTP for emission reductions while external scope test only analyzed the 'between respondent' bottom-up mean WTP estimates. The reason behind the latter case is that the top-down estimates would potentially be biased as they are asked second (Bateman *et al.*, 2004; Nielsen and Kjaer, 2011). For instance, in the internal test of scope, half of the respondents surveyed under PC, SPC and PPC formats were, on one hand, requested to value 25% emission reduction first followed by a question on what they would pay for a 50% emission reduction (the bottom-up approach). The remaining half was, on the other hand, asked to value 50% emission reduction first followed by a question on how much they would pay for a 25% emission reduction (the top-down approach). As such, the following hypotheses were formulated to capture the internal test of scope scenario described above for the three formats:

	Bottom-up approach (BU)	**Top-down approach (TD)**
(a)	$H_0: wtp^{pc}_{BU(25\%)} = wtp^{pc}_{BU(50\%)}$	$H_0: wtp^{pc}_{TD(50\%)} = wtp^{pc}_{TD(25\%)}$
	$H_1: wtp^{pc}_{BU(25\%)} < wtp^{pc}_{BU(50\%)}$	$H_1: wtp^{pc}_{TD(50\%)} > wtp^{pc}_{TD(25\%)}$
(b)	$H_0: wtp^{spc}_{BU(25\%)} = wtp^{spc}_{BU(50\%)}$	$H_0: wtp^{spc}_{TD(50\%)} = wtp^{spc}_{TD(25\%)}$
	$H_1: wtp^{spc}_{BU(25\%)} < wtp^{spc}_{BU(50\%)}$	$H_1: wtp^{spc}_{TD(50\%)} > wtp^{spc}_{25\%}$
(c)	$H_0: wtp^{PPC}_{BU(25\%)} = wtp^{PPC}_{BU(50\%)}$	$H_0: wtp^{PPC}_{TD(50\%)} = wtp^{PPC}_{TD(25\%)}$
	$H_1: wtp^{PPC}_{BU(25\%)} < wtp^{PPC}_{BU(50\%)}$	$H_1: wtp^{PPC}_{TD(50\%)} > wtp^{PPC}_{TD(25\%)}$

That is, the mean WTP for 25% (50%) motorized emission reductions is significantly lower (higher) than the mean WTP for 50% (25%) emission reductions 'within' respondents surveyed under PC, SPC and PPC formats, respectively.

As for the external tests of scope, the mean WTP from half the sample that was asked to value 50% emission reduction first and another half of the sample that was asked to value 25% emission reduction first were estimated and compared. The following hypotheses were formulated to capture the external test of scope scenario for the three formats:

Bottom-up approach (BU)

(d) $H_0: wtp^{pc}_{BU(25\%)} = wtp^{pc}_{BU(50\%)}$

$H_1: wtp^{pc}_{BU(25\%)} < wtp^{pc}_{BU(50\%)}$

(e) $H_0: wtp^{spc}_{BU(25\%)} = wtp^{spc}_{BU(50\%)}$

$H_1: wtp^{spc}_{BU(25\%)} < wtp^{spc}_{BU(50\%)}$

(f) $H_0: wtp^{PPC}_{BU(25\%)} = wtp^{PPC}_{BU(50\%)}$

$H_1: wtp^{PPC}_{BU(25\%)} < wtp^{PPC}_{BU(50\%)}$

That is, the mean WTP for 25% (50%) motorized emission reduction is significantly lower (higher) than the mean WTP for 50% (25%) emission reductions 'between' respondents under PC, SPC and PPC formats. In order to test these hypotheses, boostrapped means of the WTP estimates from PC, SPC and PPC formats were obtained and compared based on the t-test analysis. It was expected that individuals would adjust their payments upward for a larger (50%) emission reduction and downward for a smaller (25%) reduction in emission.

4.4.2 Payment vehicle for the environmental good

Suitable selection of payment vehicles is, by and large, regarded as important in CV studies because it minimizes the induction of strategic behavior among respondents resulting to inaccurate WTP responses (Morrison *et al.,* 2000; Carson and Groves, 2007). Popular payment vehicles used in CV studies consist of prices, fees, taxes, trust funds and amenity

bills. The use of these payment vehicles can, however, lead to negative reaction and protests among respondents suppose they have an objection against the mode of payment and, therefore bias the survey results (Morrison *et al.,* 2000). Following Fonta *et al.* (2009), this study employed a neutral-type of payment vehicle known as the special trust fund, which is managed by a trustee. In this fund, respondents were asked to make a onetime payment towards the exclusive purpose of air quality management through motorized emission reductions. Although this payment vehicle is subject to free riding problem among respondents, it was preferred to prices, fees, taxes and amenity bills as people in Nairobi are habitually opposed to increases in prices, fees, taxes and other similar payment vehicles. Notably, the city has a history of litigations, negative reactions and comments against increases in prices, fees, taxes or amenity bills.

4.4.3 Value elicitation formats

The study used the conventional payment card (PC), stochastic payment card (SPC) and the polychotomous payment card (PPC) formats to elicit WTP from individuals. In the PC format, respondents were presented with an ordered range of threshold values where they were asked to peruse through the values and circle the highest amount that they would be willing to pay (Mitchell and Carson, 1989). The information gathered was, then, taken to mean that respondents' WTP was equal to or greater than the circled value but less than the next higher value (Cameron and Huppert, 1989). Respondents were asked the following valuation question:

"*Suppose the presented policy to reduce emissions from motorized vehicles and improve air quality in the city of Nairobi will actually be implemented and reduce the current amount of emissions by X%, what is the maximum amount of money you would be willing to pay one-off to the special trust fund to achieve this? (circle or tick a single amount on the card).*"

Although PC valuation questions are theoretically vulnerable to forms of range and midpoint bias, empirical evidence is scarce about the existence of range bias or midpoint bias (Klose, 1999; Ryan *et al.*, 2004). Since PC format conventionally assumes that respondents know their WTP with certainty (it does not account for respondent uncertainty), it was in this case used as a yardstick against which estimates from SPC and PPC formats were compared.

For the SPC format, respondents were offered an array of bids with probabilistic values under ordinal certainty scales labeled as ‘‘definitely yes’’ ‘‘probably yes’’ ‘‘not sure’’ ‘‘probably no’’ and ‘‘definitely no” (Wang, 1997). For every bid amount presented on the card, individuals were asked to select a number as a probability response value that they would accept to pay the selected amount. Essentially, the method explicitly embeds uncertainty into the analysis by letting respondents to state their own degree of certainty about their answers to each of the bid amounts offered. Subsequently, it becomes possible to perform statistical analysis of the responses taking into account the different levels of certainty (Wang and Whittington, 2000; 2005). Respondents were thus presented with the following valuation question:

“*Suppose the presented policy to reduce emissions from motorized vehicles and improve air quality in the city of Nairobi will actually be implemented and reduce the current amount of emissions by X%, how certain are you that you would actually one-off pay the amounts of money shown on this card to the special trust fund to achieve this? (circle or tick your level of certainty to pay each of the amounts on the card).*”

The main limitation of this format is the likelihood of raising the same type of range bias found in the PC application. As for the PPC format, respondents were also presented with a broad range of bids as in the PC format, but this time, only the ordinal levels labeled as

‘‘definitely yes’’ ‘‘probably yes’’ ‘‘not sure’’ ‘‘probably no’’ and ‘‘definitely no” were presented to allow them to express their level of uncertainty for every amount offered (Welsh and Poe, 1998). Notably, no probabilistic values were provided to respondents as is the case with SPC. As such, the following valuation question was offered to the respondents:

“Suppose the presented policy to reduce emissions from motorized vehicles and improve air quality in the city of Nairobi will actually be implemented and reduce the current amount of emissions by X%, how certain are you that you would actually one-off pay the amounts of money shown on this card to the special trust fund to achieve this? (mark x against your level of certainty to pay each of the amounts shown on the card)”

Like the SPC, the PPC format also introduces respondents' uncertainty into the analysis and circumvents the incentives for starting point bias and other difficulties inherent in the process of bid selection. This, in turn, increases the precision of the estimated parameters and central tendency estimates (Welsh and Poe, 1998; Wang and He, 2011). However, the PPC format has the possibility of inducing the same type of range bias that is found in PC and SPC applications.

4.4.4 Study area and population

Nairobi is Kenya’s capital and the largest city with eight administrative divisions that together form Nairobi County. It occupies an area of about 696 Km^2 that lies adjacent to the eastern edge of the Rift Valley with an average elevation of 1724 metres above sea level (CBS, 2009). It has a moderate climate characterized by relatively sunny summers, cool winters and a modest rainfall. Besides trade, agriculture and industrial manufacturing, the city also acts as the headquarters of most government, private and international organizations. The population of Nairobi constitutes the main driver of environmental change. It stands at 3.1

million people, which is about 8 per cent of the country's total population and about 25 per cent of Kenya's urban population (CBS, 2009). Factors influencing population change include better economic prospects, opportunities for higher education, higher wage employment and the attraction of Nairobi as a market for goods and services (NEMA, 2010). These factors have led to rapid population change in the city resulting into unprecedented sprawl of informal settlements, increased poverty levels, increased motorization and the attendant air pollution in the city.

4.4.5 Study sample and the survey instrument

In the survey, a three-way randomized split sample approach based on PC, SPC and PPC formats was used to select a representative sample of 1464 respondents from the eight administrative divisions that form city of Nairobi. In the first split sample, respondents were subjected to the PC valuation format while in the second and third split samples, respondents were subjected to SPC and PPC valuation formats, respectively. Each split sample had about 488 different respondents earmarked for the survey and drawn from the eight administrative divisions to ensure representativeness of the sample to the population of interest. The survey adopted personal interviews based on interviewer administered questionnaires to collect information from respondents. The questionnaire, which had been translated into the local language, had five sections, namely: a) a background section that sought respondents' general knowledge of air pollution in Nairobi; b) a section describing the motorized emissions reduction plan; c) a section describing both positive and negative effects of motorized emissions reduction plan; d) a section having valuation and the debriefing questions and; e) a section that sought respondents' information on socio-demographic and economic characteristics.

4.4.6 Piloting and survey implementation

Before the implementation of the survey, a thorough pilot test of the survey instrument was conducted on thirty respondents where respondents were asked to comment on the suitability of the questions in the survey. Bid amounts were also generated from the pilot survey out of which the mean, median, minimum and the maximum WTP values were determined. Based on the responses and comments provided by the respondents, a final questionnaire for the survey was prepared. Enumerators were also trained on what the study entailed, the contents in the questionnaire and how to administer the questionnaire through role-play. The implementation of the survey took place in three phases according to the different value elicitation formats used in the study.

4.4.7 Valuation scenario

The valuation section of the survey presented respondents with the following information to ensure that they understood the status quo of the city: *"The City of Nairobi is one of the most polluted urban areas in Kenya. It is characterized by high concentrations of toxic gases such as carbon monoxide (CO), sulphur oxides (SO_x), nitrogen oxides (NO_x), hydrocarbons (CH_4), lead (Lb) and particulate matter (PM_x) among others. These gases are emitted mainly from public and private vehicles, which account for over 90% of total emissions. High concentration of these gases in the atmosphere has affected the natural and built environment and most importantly human health leading to respiratory and heart diseases among others."*

Respondents were then presented with the following hypothetical improvement scenario to ensure that they understood what they were paying for: *"Suppose stakeholders comprising government and private sector agencies are planning to introduce a policy that will restore air quality to standards prescribed by World Health Organization (WHO). Therefore, they come up with a "special motorized emission control trust fund" into which individuals*

contribute money to ensure problems to the natural and built environment and human health associated with motorized emissions are eliminated. Suppose also the contribution into the trust fund is a onetime payment for the exclusive purpose of policy formulation and implementation to reduce motorized emissions..."

Respondents were then asked the valuation questions earlier mentioned so as to state the amounts they were willing to pay to reduce two different magnitudes (25% and 50%) of motorized emissions through bottom-up and top-down advance disclosure of valuation questions. The bid amounts took on fifteen different values, namely: Kenya shillings (Kshs). 0, 25, 50, 70, 100, 150, 200, 250, 300, 400, 500, 800, 1000, 1500 and Kshs. 2,000, which were obtained from a thorough pre-test survey based on the open-ended value elicitation format as recommended by Haab and McConnell (2002).

4.4.8 Statistical model

With interval data being generated in the study, scope sensitivity analysis was conducted using the interval regression model. This model was used to estimate both bottom-up and top-down mean WTP for emission reductions as well as factors explaining individuals' sensitivity to scope. The underlying assumption of the model holds that the true WTP of an individual is greater than or equal to the amount circled, but strictly less than the next highest amount shown on the card (Cameron and Huppert, 1989). In the PC format, the amounts circled were thus, used to form intervals and situate each response in a unique interval. For the SPC and PPC formats, the highest amounts individuals were definitely sure they would pay were used to form intervals into which individual responses were situated. Thus, WTP responses from each of the valuation formats were treated as intervals rather than point valuations for ease of comparison across formats (Cameron and Huppert, 1989; Welsh and Poe, 1998; Whitehead *et al.,* 2000; Bigerna and Paolo, 2011). More specifically, suppose we let R_L be the maximum

amount that respondent would pay and R_U be the lowest amount that respondent would switch to a 'No' rather than a 'Yes' response. The true WTP, WTP^*, would then lie somewhere in the switching interval [R_L , R_U], that is, $R_L \leq WTP < R_U$. Since the distribution of WTP values is often skewed, the log normal distribution is taken as the first approximation for WTP distribution (Cameron and Huppert, 1989). Therefore:

$$Log\ WTP_i = x_i'\omega + \mu_i \quad (1)$$

where x' are the characteristics of the respondent, μ is the random variable that is normally distributed with zero mean and standard variance σ, and ω are regression coefficients. The probability that a respondent would be willing to pay a given monetary amount is:

$$Prob(yes) = prob(WTP \geq R_L) = 1 - M_{WTP}(R_L) \quad (2)$$

where $M_{WTP}(R_L)$ is the cumulative distribution function of the random WTP variable. The probability that the WTP would fall between any two monetary thresholds is:

$$Prob(R_U > WTP \geq R_L) = M_{WTP}(R_U) - M_{WTP}(R_L) \quad (3)$$

which results in a corresponding log-likelihood function for n number of respondents, algebraically represented as:

$$Log(L) = \sum_{i=1}^{n} Log\left\{M_{WTP}\left(\frac{R_U - \omega x_i}{\sigma}\right) - M_{WTP}\left(\frac{R_L - \omega x_i}{\sigma}\right)\right\} \quad (4)$$

Following the assumption that the stochastic term is normally distributed, both ω and σ can be estimated and then used to calculate the mean and median WTP. As such, the mean WTP is given by $exp(x_i'\omega + \sigma^2/2)$ while the median WTP by $exp(x_i'\omega)$. Here, x' is taken as the vector of mean values of appropriate explanatory variables, ω as the vector of estimated

Table 4.1: Socio-demographic and economic variables of the respondents and the average of Nairobi's population

Variable	Variable description, type and measurement	Mean	Min	Max	Nairobi
Age	Number of years respondent has lived (continuous variable).	32.0	21	66	30.0
Gender	Share of male respondents (dummy variable: 1=male; 0=otherwise).	0.64	0	1	0.70
Education	Level of education of respondent (categorical: 1= no education; 2=standard; 3=secondary ; 4= tertiary; 5=university).	3.47	1	5	3.00
Household income (Kshs.)	Average annual earnings (continuous variable).	18,566.67	4,500	69,000	25,500.00
Household size	Number of members in the household (continuous variable).	3.63	1	6	3.00
Distance	Length from nearby road in meters (continuous variable).	192.65	20	300	150.00
Vehicle ownership	Share of respondents owning a motor vehicle (dummy variable: 1=own; 0=otherwise).	0.17	0	1	0.20
Future income certainty	Share of respondents certain about future incomes (dummy variable: 1=certain; 0=otherwise).	0.63	0	1	-
Area of residence	Share of respondents residing in the urban area (dummy variable: 1=urban; 0=otherwise).	0.57	0	1	0.60
Scope	Share of emission reduction (dummy variable: 1=50%; 0=25%).	0.50	0	1	-
Format	Share of valuation formats capturing respondent uncertainty (dummy variable: 1=captures; 0=otherwise).	0.67	0	1	-

**Nairobi's population information on future income certainty, scope and format was unavailable.*

coefficients and σ as the estimated standard variance. Notably, explanatory variables initially considered for the computation of mean WTP estimates are described in Table 1. However, stepwise regression was used to identify significant predictors of the stated WTP following Wang *et al.* (2006). Consequently, insignificant variables were dropped and the final set of variables used in the computation of the mean WTP estimates are shown in Table 6.

4.5 Findings and discussion

4.5.1 Descriptive results across the valuation formats

Descriptive results of the socio-demographic and economic characteristics of the respondents across the valuation formats are presented in Table 4.1. As shown, the mean age of the respondents was 32 years with men accounting for the largest share (64%) of the respondents. Most respondents had secondary level of education and an average household size of 3 people. The average annual income of respondents was Kshs. 18,566.67 ($218.43) with a large share of respondents (63%) saying they were certain about their future incomes. On average, respondents resided 192.65 metres from nearby roads with a majority (57%) living in the urban areas as opposed to peri-urban areas (43%). Only a minority (17%) of respondents said they owned a motor vehicle.

To assess whether or not there were significant differences among respondents' socio-demographic and economic characteristics across PC, SPC and PPC formats, the non parametric Kruskal-Wallis test was performed. As shown in the last columns of Table 2, most respondent characteristics differed significantly across the formats except for age, gender and ownership of motor vehicles. This implied that respondents' characteristics had to be controlled for in the computation of mean WTP that would be used for scope sensitivity analysis.

Table 4.2: Descriptive results on respondents' socio-economic and demographic characteristics across formats in the city

	PC		SPC		PPC		Whole Sample		Kruskal-Wallis test	
Variable	Mean	Std. error	Mean	Std. error	Mean	Std. error	Mean	Std. error	Chi-square	p-value
Age	31.50	0.37	32.00	0.38	32.50	0.38	32.00	0.35	3.60	0.166
Gender	0.62	0.02	0.64	0.02	0.65	0.02	0.64	0.01	1.12	0.571
Education	3.61	0.05	3.34	0.04	3.47	0.04	3.47	0.03	16.98***	0.000
Household income (Kshs.)	19,400	215.27	17,500	194.18	18,800	208.60	18,566.67	205.28	9.28***	0.010
Household size	3.49	0.06	3.79	0.05	3.60	0.05	3.63	0.03	21.84***	0.000
Distance to nearby road	212.00	2.36	169.90	1.89	196.05	2.18	192.65	2.13	25.92***	0.000
Vehicle ownership	0.18	0.02	0.16	0.02	0.19	0.02	0.17	0.01	1.83	0.401
Future income certainty	0.83	0.02	0.52	0.02	0.54	0.02	0.63	0.01	31.48***	0.000
Area of residence	0.69	0.02	0.52	0.02	0.51	0.02	0.57	0.01	34.05***	0.000

Explanatory Notes: *, ** and *** denote $p < 0.1$, $p < 0.05$ and $p < 0.01$.
PC (payment card); SPC (stochastic payment card); PPC (polychotomous payment card).
Age (continuous variable); Gender (dummy: 1=male, 0=otherwise); Education (categorical: 1=no education; 2=primary school; 3=secondary school; 4=tertiary education; 5=university degree); Household income (continuous); Household size (continuous); Distance (continuous); Vehicle ownership (dummy: 1=own, 0=otherwise); Future income certainty (dummy: 1=certain, 0=otherwise); Area of residence (dummy: 1=urban, 0=otherwise).

4.5.2. Scope sensitivity analysis

Notably, the survey had a target of 1464 respondents but, only 1460 respondents completed the questionnaires. While 1219 (83%) respondents indicated a positive WTP, 241 (17%) respondents stated a zero WTP. For respondents who stated a zero WTP, a closed-ended debriefing question was presented them so as to separate protest responses from true zeroes. Hence, four possible alternatives were presented to respondents, namely: i) because air quality improvement has no value to me. ii) because it is the responsibility of the Government; iii) because I have many other basic financial commitments and; iv) because it is the responsibility of motor vehicle owners.

Following Strazzera *et al.* (2003), the first and the third responses were categorized as true zeroes while the other two as protest responses since they did not address the value of the good in question but rather some objection as to who should actually pay for motorized emission reductions. Based on the above classification, 96 (7%) respondents had true zero WTP responses while 145 (10%) had protest responses. Following Mitchell and Carson (1989), Whitehead *et al.* (1998), Strazzera *et al.* (2003), Wang and Whittington (2000; 2005), Dziegielewska and Mendelsohn (2007) and Brouwer (2009), the protest responses were dropped off from the analysis. Therefore, only 1315 responses, about 90% of the sample size, were subjected to further analysis. Preliminary analysis showed clear response patterns of the bid amounts and levels of certainty. The survey found that majority of respondents (90% for the SPC and 76% for PPC) were definitely certain about paying the lowest bid amount (Kshs 25 ($0.29)) for motorized emission reductions. Likewise, majority of them (95% for the SPC and 100% for PPC) were also definitely certain that they would not pay the highest bid amount (Kshs. 2,000 ($23.5)) to reduce emissions. As for the ability to pay, the study found that majority of the respondents (26% for the PC, 27% for SPC and 22% for PPC) were in the annual income range of Kshs. 20,000-30,000 ($235-$352). The rest of the results on internal

('within' respondent) and external ('between' respondent) tests of scope, which are robust in all the three formats, are presented in Tables 3 and 4 and Table 5, respectively. Table 3 presents the results about half of the respondents presented with the bottom-up valuation questions while Table 4 presents the results about half of the respondents presented with the top-down valuation questions. The results are also presented as per the CV formats used to elicit WTP responses.

In regard to PC format, the valuation results presented in Table 4.3 indicate that respondents were on average willing to pay Kshs. 127.09 ($1.52) for reducing motorized emissions by 25% and Kshs. 206.67 ($2.43) for emission reduction by 50%. The results imply that respondents had a larger WTP for larger emission reductions than for smaller reductions. Subsequently, the null hypothesis of no significant differences in the mean WTP for the bottom-up approach to emission reduction was rejected at the 1% level of significance. For the SPC format, the study found that respondents were on average willing to pay Kshs. 68.77 ($0.81) for 25% emission reduction and Kshs. 110.77 ($1.30) for 50% reduction. In this case, respondents were also willing to pay larger amounts for larger emission reductions as opposed to smaller reductions. Conversely, these amounts are smaller compared to those under the PC format where respondents were assumed to be certain about their preferences. On the whole, the null hypothesis on the equality of mean WTP estimates for the bottom-up emission reductions was also rejected at the 1% level of significance. As for the PPC format, the mean WTP for 25% emission reduction was Kshs. 81.60 ($0.96) and Kshs. 123.02 ($1.45) for 50% reduction. Thus, respondents were also willing to pay larger amounts for larger emission reductions as opposed to smaller reductions. Like in the SPC case, the mean WTP under the PPC format was also smaller than the one for PC format where respondents were assumed to be certain about their preferences. The null hypothesis of the equality of mean WTP for the bottom-up emission reduction was rejected at the 1% level of

Table 4.3: Interval regression results on internal tests of scope sensitivity for the bottom-up motorized emission reductions in the city

Description	**PC**		**SPC**		**PPC**	
Hypotheses	$H_0: wtp^{pc}_{BU(25\%)} = wtp^{pc}_{BU(50\%)}$		$H_0: wtp^{spc}_{BU(25\%)} = wtp^{spc}_{BU(50\%)}$		$H_0: wtp^{ppc}_{BU(25\%)} = wtp^{ppc}_{BU(50\%)}$	
Percentage of emission reduction.	25%	50%	25%	50%	25%	50%
Mean WTP	127.09	206.67	68.77	110.77	81.60	123.02
Standard error	7.28	13.14	4.62	9.70	5.51	11.43
Sub-sample size	218	218	228	228	211	211
Bootstrapped 95% confidence intervals	110.47 – 143.70	175.01 – 238.33	61.63 – 75.90	99.26 – 122.27	69.99 – 93.20	105.68 – 140.36
T-test value	5.511***		4.148***		3.458***	
P-value	0.000		0.000		0.001	

Explanatory Notes: *, ** and *** denote $p < 0.1$, $p < 0.05$ and $p < 0.01$.
PC (payment card); SPC (stochastic payment card); PPC (polychotomous payment card); BU (bottom-up approach).

significance. These results imply that the mean WTP for the bottom-up internal test of scope (the 'within respondent' mean WTP for 25% emission reduction first followed by 50% reduction) were scope sensitive and that respondents passed the bottom-up internal test of scope. However, uncertain (SPC and PPC) respondents stated significantly lower amounts for larger emission reductions than certain (PC) respondents.

In Table 4.4, the survey found that the mean WTP for 50% motorized emission reduction under the PC format was Kshs. 310.05 ($3.65) and Kshs. 238.76 ($2.81) for 25% reduction. Similarly, respondents were willing to pay higher amounts for larger emission reductions as opposed to smaller reductions. Accordingly, the null hypothesis of no significant differences in the mean WTP for the top-down approach to emission reductions was rejected at the 1% level of significance. For the SPC format, respondents' mean WTP for 50% emission reduction was Kshs. 130.10 ($1.53) while that for 25% reduction was Kshs. 70.10 ($0.82). The null hypothesis on the equality of mean WTP for the top-down emission reduction was also rejected at the 1% level of significance. Notably, respondents were willing to pay higher amounts for larger emission reductions as opposed to smaller reductions. Results from the PPC format were not different from those presented above since respondents were also willing to pay more (Kshs. 85.34 ($1.00)) for larger emission reductions (50%) and less (Kshs. 49.86 ($0.56)) for smaller reductions (25%). The null hypothesis that the mean WTP estimates were equal for top-down emission reduction was rejected at the 1% level of significance. Correspondingly, the results imply that the 'within respondent' mean WTP for 50% emission reduction first followed by 25% reduction (the top-down internal test of scope) were scope sensitive and that respondents passed the top-down internal test of scope. Similar finding are reported by Loomis and Ekstrand (1997), Poe *et al.* (2000), Foster and Mouranto (2003), Bateman *et al.* (2004) and Czajkowski and Hanley (2009) among others where respondents pass the internal test of scope. However, as noted by Bateman *et al.*

Table 4.4: Interval regression results on internal tests of scope sensitivity for the top-down motorized emission reductions in the city

Description	**PC**		**SPC**		**PPC**	
Hypotheses	$H_0: wtp^{pc}_{TD(50\%)} = wtp^{pc}_{TD(25\%)}$		$H_0: wtp^{spc}_{TD(50\%)} = wtp^{spc}_{TD(25\%)}$		$H_0: wtp^{ppc}_{TD(50\%)} = wtp^{ppc}_{TD(25\%)}$	
Percentage of emission reduction	50%	25%	50%	25%	50%	25%
Mean WTP	310.05	238.76	130.10	70.10	85.34	49.86
Standard error	16.40	13.70	12.17	4.4	5.97	3.37
Sub-sample size	217	217	217	217	224	224
Bootstrapped 95% confidence intervals.	276.78 – 343.33	206.70 – 270.81	108.66 – 151.53	59.82 – 80.39	74.21 – 96.48	43.57 – 56.15
T-test value	3.349***		5.120***		5.400***	
P-value	0.001		0.000		0.000	

Explanatory Notes: *, ** and *** denote $p < 0.1$, $p < 0.05$ and $p < 0.01$.
PC (payment card); SPC (stochastic payment card); PPC (polychotomous payment card); TD (top-down approach).

(2004), respondent in this survey may as well have passed the internal test of scope owing to the urge to remain consistent with their responses.

Table 4.5 presents the results of the external ('between' respondents) tests of scope. Under the PC format, the results show that respondents were on average willing to pay Kshs. 127.09 ($1.52) for 25% emission reduction and Kshs. 310.05 ($3.65) for 50% reduction. The null hypothesis of no significant differences in the 'between respondents' mean WTP was rejected at the 1% level of significance. Under the SPC format, the survey found that respondents were willing to pay Kshs. 68.77 ($0.81) for reducing emissions by 25% and Kshs. 130.10 ($1.53) for 50% emission reduction. The null hypothesis of equality of the 'between respondents' mean WTP for emission reductions was rejected at the 1% level of significance. As for the PPC format, the survey established that the mean WTP for 25% emission reduction was Kshs. 81.60 ($0.96) and that for 50% reduction was Kshs. 85.34 ($1.00). The null hypothesis of no significant differences of the 'between respondents' mean WTP for emission reductions was, however, not rejected even at the 10% level of significance. This is because the marginal value of change in the mean WTP was quite small that it was masked by the statistical error. All in all, the results imply that the 'between respondent' mean WTP estimates for the emission reduction were scope sensitive and that respondents passed the external test of scope. Like in the earlier case, uncertain (SPC and PPC) respondents stated significantly lower amounts for larger emission reductions than certain (PC) respondents.

Except for the non significant results from the PPC format, all the other significant results imply that the 'between respondent' estimates of the mean WTP for emission reductions were scope sensitive and that respondents passed the external test of scope. Similar findings have been reported by Carson and Mitchell (1993), Whitehead *et al.* (1998), Foster and

Table 4.5: Interval regression results on external tests of scope sensitivity for motorized emission reductions in the city

Description	**PC**		**SPC**		**PPC**	
Hypotheses	$H_0: wtp^{pc}_{BU(25\%)} = wtp^{pc}_{BU(50\%)}$		$H_0: wtp^{spc}_{BU(25\%)} = wtp^{spc}_{BU(50\%)}$		$H_0: wtp^{ppc}_{BU(25\%)} = wtp^{ppc}_{BU(50\%)}$	
Percentage of emission reduction	25%	50%	25%	50%	25%	50%
Mean WTP	127.09	310.05	68.77	130.10	81.60	85.34
Standard error	7.28	16.40	4.62	12.17	5.51	5.97
Sub-sample size	218	217	228	217	211	224
Bootstrapped 95% confidence intervals	110.47 – 143.70	276.78 - 343.33	61.63 – 75.90	108.66 – 151.53	69.99 – 93.20	74.21 – 96.48
T-test value	15.246***		5.488***		0.329	
P-value	0.000		0.000		0.742	

Explanatory Notes: *, ** and *** denote $p < 0.1$, $p < 0.05$ and $p < 0.01$.
PC (payment card); SPC (stochastic payment card); PPC (polychotomous payment card); BU (bottom-up approach).

Mouranto (2003) and Loomis *et al.* (2009). Notably, PC format, which operates on the assumption that respondents know their WTP with certainty, consistently yielded larger mean WTP values than SPC and PPC formats. For instance, the format yielded Kshs. 161.88 as opposed to Kshs. 89.77 for SPC and Kshs. 102.31 for PPC formats. Following this revelation, it can be said that allowing respondents to express their level of uncertainty (as is the case with SPC and PPC formats) had a downward effect on their stated WTP and hence, their sensitivity to scope.

4.5.3 Explaining individuals sensitivity to scope

In this case, interval observations were used to explain individuals' sensitivity to scope. Prior to interval regressions, a spearman's correlation test was conducted to assess the existence of multicollinearity among the regressors shown in Table 6. Notably, the presence of large bivariate correlations with rho coefficient of 0.9 are generally used to show strong linear associations, which implies that collinearity may be a problem (Strazzera *et al.,* 2003). The results of this test, however, ruled out the presence of multicollinearity in the models as the rho coefficients of correlation were below the established rule ($\rho<0.9$) for the variables. Besides, the calculation of the Variance Inflation Factor (VIF) also justified the absence of multicollinearity among the variables since the calculations yielded a mean VIF of 1.15 against a benchmark of 10.0.

For the interval regressions, the dependent variable measured the sensitivity of individuals' WTP towards the scope of motorized emission reductions in the city of Nairobi. It was captured through interval data on the amounts respondents were willing to pay for 25% and 50% magnitudes of motorized emission reductions. This variable was regressed on the age and gender of the respondent, respondents' income, distance respondents reside from nearby roads, motor vehicle ownership, respondents' area of residence and two dummy variables,

Table 4.6: Interval regression results on factors explaining individuals' sensitivity to scope for motorized emission reductions in the city

	PC model		SPC model		PPC model		PC-SPC-PPC model	
Explanatory factor	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Age	-0.061***	0.006	-0.080***	0.005	-0.047***	0.006	-0.063***	0.004
Gender	0.228	0.146	0.258**	0.116	0.176	0.131	0.269***	0.081
Household income	1.97e-05***	5.51e-06	3.12e-05***	6.05e-06	3.80e-05***	6.51e-06	2.59e-05***	3.43e-06
Distance to nearby road	-0.006***	7.19e-04	-1.99e-04	6.82e-04	-0.004***	8.43e-04	-0.004***	4.38e-04
Vehicle ownership	-0.045	0.183	-0.111	0.174	-0.885***	0.198	-0.139	0.106
Area of residence	0.600***	0.149	0.461***	0.102	1.029***	0.112	0.857***	0.072
Scope (50%=1; 25%=0)	0.599***	0.135	0.241**	0.104	0.322***	0.118	0.042	0.074
Format (uncertain=1; certain=0)	-	-	-	-	-	-	-0.354***	0.077
lnsigma (σ)	0.350***	0.036	0.097***	0.036	0.191***	0.036	0.296***	0.021
Sigma (σ)	1.419	0.051	1.101	0.039	1.211	0.044	1.344	0.028
Log likelihood	-1204.42		-973.05		-970.15		-3249.10	
Interval observations	435		445		435		1315	
Wald chi2 (7)	4952.03		5587.42		4163.22		-	
Wald chi2 (8)	-		-		-		12494.30	
Probability > chi2	0.000		0.000		0.000		0.000	

Explanatory Notes: *, ** and *** denote $p < 0.1$, $p < 0.05$ and $p < 0.01$.
PC (payment card); SPC (stochastic payment card); PPC (polychotomous payment card).
Age (continuous variable); Gender (dummy: 1=male, 0=otherwise); Household income (continuous); Distance (continuous); Vehicle ownership (dummy: 1=own, 0=otherwise); Area of residence (dummy: 1=urban, 0=otherwise); Scope (dummy: 1=50% emission reduction, 0=25% emission reduction); Format (dummy: 1=format capturing respondent uncertainty, 0=format capturing respondent certainty).

that is, *'scope'* to capture respondents sensitivity to 25% and 50% magnitudes of emission reduction that was done by testing whether its sign is positive and statistically significant (Czajkowski and Hanley, 2009; Loomis *et al.,* 2009); and '*format*' to capture the effect of allowing respondents to express their level of uncertainty (as in SPC and PPC formats) on scope sensitivity as proxied by the amounts respondents were willing to pay for the different magnitudes of emission reduction. The effect of this variable was evaluated by analyzing its sign and statistical significance, following a procedure by Loomis *et al.* (2009). All the results are presented in Table 4.6.

As shown in the table, the likelihood functions of all the four models (PC, SPC, PPC and the PC-SPC-PPC) are all significant at 1% level of significance, which implies that the models had strong explanatory power. On the relationships among variables, the study found the existence of an inverse relationship between respondents' age and the sensitivity of respondents WTP to the scope of motorized emission reductions. This means that older persons were less likely to be scope sensitive than younger persons. A positive relationship was, on the other hand, found between respondents' gender and sensitivity to scope, which means that males were more likely to be scope sensitive than females. As for the income variable, a positive relationship with individuals' sensitivity to scope was established implying that high income individuals were more likely to be scope sensitive than low income individuals. For the distance variable, a negative relationship with individuals' sensitivity to scope was unveiled. This means that individuals living closer to nearby roads were more likely to be scope sensitive than individuals living further away from nearby roads. This finding is the result of what Brouwer *et al.* (2006) termed as distance-decay effects. On the car ownership variable, an inverse relationship was established with regard to individuals' sensitivity to scope. It means that non car owners were more likely to be scope sensitive than car

owners. This is probably because, unlike car owners, non car owners may have limited incentives for strategic behaviour suppose that the motorized emission reduction plan was to be implemented.

On the relationship between the area of residence (urban or peri-urban) and individuals' sensitivity to scope, study findings show that respondents residing in the urban areas where motorized emissions are high were more likely to be scope sensitive than respondents residing in the peri-urban areas where emissions are minimal. The *'scope'* variable emerged positive and statistically significant, which means that the survey respondents were scope sensitive and that they would pay larger amounts for larger emission reductions (50%) than for smaller reductions (25%). Hence, responses in the survey passed the scope sensitivity test. This finding compares well with findings by Loomis and Ekstrand (1997), Poe *et al.* (2000), Foster and Mouranto (2003), Bateman *et al.* (2004), Czajkowski and Hanley (2009) and Loomis *et al.* (2009) among others. As for the '*format*' variable, an inverse relationship was unveiled. It means that uncertain respondents were less likely to be scope sensitive than certain respondents. The negative sign and the statistical significance of this variable suggests that indeed, respondent uncertainty had a downward effect on individuals' sensitivity to scope. In other words, allowing respondents to express their level of uncertainty (as in SPC and PPC formats) was likely to result in lower payments for larger emission reductions than the case when respondents are assumed to be certain (as in PC format).

4.6 Conclusions and recommendations

The aim of the survey was to ascertain whether respondent uncertainty had any effect on respondents' sensitivity to goods' scope. This was done in the context of the willingness of individuals to pay for a policy proposal to reduce motorized emissions in the city of Nairobi Kenya. The study applied contingent valuation method through PC, SPC and the PPC formats to

elicit WTP values for the bottom-up (25% then 50%) and top-down (50% then 25%) emission reductions based on advance disclosure approach. This enabled testing of various hypotheses on 'within' and 'between' respondents WTP in order to ascertain whether respondents were internally and externally sensitive to scope. While the PC format conventionally assumes that respondents are certain about their WTP, SPC and the PPC formats assume that respondents are uncertain and therefore, allow them to express their level of uncertainty. Hence, the use of SPC and PPC formats, based on the findings of the PC format, enabled the testing of whether or not respondent uncertainty had influence on individuals' sensitivity to scope.

The study findings show that individual responses for motorized emission reductions in the city were both internally and externally scope sensitive except for the findings under the PPC format in the latter case. These findings are generally consistent with economic theory, which supposes that welfare estimates should be sensitive to changes in the magnitudes of the good under valuation. The results also make a novel contribution to CV literature regarding scope tests under conditions of respondent uncertainty. It was established that when individuals are given the opportunity to express their level of uncertainty, as in SPC and PPC formats, it is likely that they will be less sensitive to scope than in the case where they are assumed to be certain, as in PC format. Therefore, accounting for respondent uncertainty has the potential to lower the scope sensitivity of individuals in CV. In regard to the determinants of individuals' sensitivity to scope, the study findings show that age and gender of the respondent, respondents' income, distance respondents dwell from nearby roads, motor vehicle ownership and the area of residence have statistically significant influence on the sensitivity of individuals' WTP for emission reductions. The '*scope'* variable is positive and significant implying that respondents in the survey were willing to pay larger amounts for larger emission reductions than for smaller reductions hence, scope sensitive.

The '*format'* variable is negative and significant, meaning that allowing respondents to express their uncertainty significantly yields lower payments for larger emission reductions than when respondents are assumed to be certain about their preferences.

On the whole, the study has initiated a better understanding of the relationship between respondent uncertainty and scope sensitivity in CV. Going by the results, it is necessary for planners and policy makers in Nairobi, Kenya, Africa and beyond to account for respondent uncertainty when valuing air quality management programmes so as to come up with precise estimates of welfare change. However, this study is one of its kind in analyzing the relationship between respondent uncertainty and sensitivity to goods' scope in CV. While the results still appear to support the use of the CV method in studying the incremental benefits and costs of air quality management policies, they may only be unique to the study area and the subject under study. Therefore, more research is recommended on the subject of this study using other statistical models, other environmental goods or other countries.

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CHAPTER FIVE

Stated preferences for motorized emission reduction attributes in Kenya: A discrete choice experiment

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Abstract

This study used a discrete choice experiment (DCE) to evaluate car owners' willingness to pay (WTP) for motorized emission reduction attributes in Nairobi, Kenya. Moreover, five behavioural models, namely, the multinomial logit (MNL), mixed logit (MXL), scaled-multinomial logit (S-MNL), generalized-multinomial logit (G-MNL) and the generalized-mixed logit (G-MXL) were estimated to explore their relative performance and how best they could account for preference variation in the choice data that involved 9580 observations. Sample results revealed that car owners in Nairobi were willing to pay positive amounts towards the motorized emission reduction attributes. The G-MXL model was also found to perform better than the G-MNL, S-MNL, MXL and MNL models, according to the Bayesian information criterion. It also performed better than the G-MNL model in capturing both taste and scale variation in the choice data for this study. This implies that a G-MXL model formulation was likely to yield more precise estimates in discrete choice analysis.

Key words: Air quality, taste and scale variation, discrete choice experiment, multinomial logit, mixed logit, scaled multinomial logit, generalized multinomial logit, generalized mixed logit.

5.1 Introduction

Motorized emissions are substances generated by fuel combustion and evaporation from motor vehicles (ADB, 2008). The most common motorized emissions include carbon monoxide (CO), oxides of nitrogen (NOx), oxides of sulphur (SOx), volatile organic compounds (VOCs), ozone (O3), lead (Pb) and particulate matter (PM), which comprise dust, smoke and other solid particles (Schwela *et al.*, 2006; Gwilliam, 2003; Fazal, 2006). These emissions are largely harmless when they are in low concentrations but then, become pollutants when their concentration escalates to the extent that they begin to cause harmful effects on humans and the environment (WHO, 2006; Amin, 2009).

Motor vehicles are, on a global scale, estimated to account for 80-90 % of total air pollutants (UN-HABITAT, 2006) and therefore, considered to pollute the environment more than any other single human activity in the world (Walsh, 2005). The most common motor vehicle fuel types are petrol, used to power light-duty vehicles, and diesel, used to power heavy-duty vehicles. Some common pollutants released from petrol powered vehicles include oxides of nitrogen (NO_X), hydrocarbons (HCs) and carbon monoxide (CO) while those from diesel fueled vehicles include oxides of sulphur (SOx) and particulate matter (PM) (Johnson *et al.*, 2000; Gwilliam, 2003; Walsh, 2005; UN-HABITAT, 2006).

Although the rate of motorization is seen to fall in the industrialized countries, it is seen to rise in the developing world typically due to increased urbanization coupled with high population growth. It is estimated that the car fleet would double that of 1990 by 2020 meaning that there would be car fleet saturation, increased traffic jams and therefore, large amounts of motorized emissions by 2020 (Schwela *et al.*, 2006; Gwilliam, 2003). In Kenya, the continuous increase in the number of

motor vehicles in the last one decade has significantly contributed to the deterioration of air quality in most urban areas. Nairobi, the largest town and Kenya's capital city, is considered the most polluted metropolitan area in Kenya (Vliet and Kinney, 2007; Odhiambo *et al.,* 2010) where pollutants originating mainly from public and private transport together account for about 90% of total emissions. The range of vehicular emissions released in the city include PM, CO, SO_2, NOx and a wide range of volatile organic compounds (VOCs) (Vliet and Kinney, 2007; Odhiambo *et al.,* 2010; Kinney *et al*., 2011). These pollutants have been associated with increased prevalence of respiratory and heart diseases and the dark colouration of the built environment (Kinney *et al*., 2011). With significant adverse effects of motorized emissions on the general welfare of the people, it has become necessary for the Kenyan government to formulate policies to cut motorized emissions in the city for improved urban air quality.

Notably, the introduction and use of low emission and fuel efficient vehicles is considered promising and a potential measure that policy makers have at their disposal for fuel use reduction and thereby cut on pollutant vehicular emissions. Nonetheless, it is not well known whether motor vehicle owners in Kenya and especially in the city of Nairobi would be willing to incur additional costs to acquire these low-emission and fuel-efficient vehicles. This is because the policy research available thus far (Mulaku and Kariuki, 2001; Odhiambo *et al.,* 2010; Vliet and Kinney, 2007; Kinney *et al.,* 2011) has only dealt with the technical aspects of measuring the concentrations of pollutants in the air leaving a dearth of knowledge on the socioeconomic aspects of the policy that could also be effective in helping to cut emissions. This paper therefore purposed to provide the missing policy information by evaluating the stated preferences of the car owners' towards motorized emission reduction attributes in the city of Nairobi so as to inform the city authorities

on appropriate policy decisions they could undertake to cut on motorized emissions and improve air quality in the city.

In the past, both market and non-market approaches have been used to understand preferences that individuals have for product and/or service attributes. Market based methods have relied on market data and have been feasible only when market data is sufficient. When market data is insufficient, researchers have opted to use non-market approaches. Since market data was, in this case, insufficient to evaluate car owners' preferences for motorized emission reduction attributes in Nairobi, a non-market approach that is rooted in the valuation of non-market goods and services known as the discrete choice experiment (DCE) was employed.

In a DCE, respondents are presented with a series of choice tasks, known as choice sets, each containing a finite number of options that describe the environmental policy outcome in question (e.g. Hanley *et al*., 2005; Hensher *et al*., 2005; Louviere *et al*., 2011). Since policy options may vary according to their level of attributes, respondents are typically asked to choose their most preferred policy option. By making this choice, respondents are able to trade-off the attributes with the associated costs that come with the chosen option. This allows the researcher to analyse trade-offs that respondents make between different attributes and thereby, derive a monetary mesure of welfare change (e.g. Hanley *et al.*, 2005).

Moreover, individual respondents are also considered to have wide range of preferences about product attributes. As such, it is recommended that researchers in discrete choice analysis account for the possibility of heterogeneity or preference variation in the choice behaviour of respondents. There is however, no consensus among researchers about the best approach to model

heterogeneity in discrete choice experiments (e.g. Kragt, 2013). This study therefore purposed to make a further contribution into the DCE literature through the evaluation of five alternative behavioural models that have been developed to assess individual heterogeneity using environmental data on car owners' preferences for motorized emission reduction attributes in Kenya. The five behavioural models include the multinomial logit (MNL), mixed logit (MXL), scaled-multinomial logit (S-MNL), generalized-multinomial logit (G-MNL) and the generalized-mixed logit (G-MXL).

Policy wise, the study expected to enhance the understanding of urban authorities on how motor vehicle owners make their preference trade-offs between price and motor vehicle attributes, in this case, fuel use and exhaust gas emission levels so as to cut on motor vehicle emissions. In terms of DCE methodology, the study expected to demonstrate which model specification is better in performance and also in capturing individual heterogeneity in the choice behaviour of the respondents.

The rest of the paper is organized as follows. Section 2 describes past studies on individual heterogeneity. Section 3 presents the econometric models while section 4 describes the survey design and the choice data. Section 5 presents the results and a discussion and Section 6 concludes the paper.

5.2 Past studies on individual heterogeneity

Empirical research in the past on DCE has involved the analysis of two kinds of heterogeneity, namely, taste heterogeneity and scale heterogeneity. Taste heterogeneity means that individuals have a tendency to derive different marginal utility, say, from different policy characteristics. As

for scale heterogeneity, it means that the choice behaviour of individuals may be random and therefore associated with some degree of uncertainty. As such, one of the most popular model employed by researchers in the analysis of the choice data has been the MNL model by McFadden (1974) (e.g. Bennett and Blamey 2001; Scarpa *et al*. 2007). Though popular, this model is however restricted by the Independence of Irrelevant Alternatives (IIA) property in its parameter estimation (e.g. Kataria, 2009; Keane and Wasi, 2009) and that it cannot capture any individual heterogeneity inherent in the choice patterns of individuals. To address this problem, researchers have often interacted choice attributes with the socio-demographic characteristics of individual respondents so as to capture the individual (taste) heterogeneity of the respondents. Thus, researchers have relied heavily on the observable differences between respondents to explain the sources of individual heterogeneity.

Recent modelling approaches have however extended the MNL model into other formulations such as scaled multinomial logit (S-MNL), mixed logit (MXL), latent class logit (LCL), generalized multinomial logit (G-MNL) and the generalized mixed logit (GMXL) models to relax the IIA assumption and also account for the unobserved individual heterogeneity in the systematic component of the utility (e.g. Fiebig *et al*., 2009; Hensher and Greene, 2003; Hole, 2008). This follows from widespread acknowledgement by researchers (e.g. Hensher *et al.*, 2005; Keane and Wasi, 2009; Louviere *et al.*, 2002; Louviere and Eagle, 2006) of the need to capture both taste and scale heterogeneity in both the random and systematic components of individual utility functions for accurate policy evaluations. Notwithstanding the huge number of research evidence about heterogeneity in the random and systematic components of individuals' utility functions, only a handful of studies (e.g. Christie and Gibbons, 2011; Green and Hensher, 2010; Kragt, 2013; Scarpa *et al*. 2011) have evaluated different approaches used to model individual heterogeneity.

For instance, Greene and Hensher (2010) estimate MXL, G-MNL and G-MXL models regarding transport choices in Australia. They find that accounting for scale heterogeneity in the G-MNL model is of limited interest in the presence of unobserved taste heterogeneity that is accounted for in the MXL and G-MXL models. In the context of valuing environmental goods, Scarpa *et al*. (2011) analyze the impact of increasing the number of alternative choices and preference elicitation method on the scale parameter for a study of Alpine pastures in Europe. They compare models of scale heterogeneity to models that account for taste heterogeneity and models that include both. They find significant impacts of the number of alternatives in the choice context on scale. They note that once taste heterogeneity is addressed in a MXL specification, the scale effect is no longer significant for choice tasks with five alternatives.

Kragt (2013) estimates four approaches used for modelling individual heterogeneity, namely, the Latent class logit (LCL), MXL, S-MNL and the G-MXL using choice data for catchment environmental management in Australia. The researcher finds that the G-MXL model that accounts for preference and scale heterogeneity outperforms all the other models. Moreover, Christie and Gibbons (2011) also compare models of taste and scale heterogeneity for environmental goods. Similar to Scarpa *et al*. (2011), they find that taste heterogeneity is more important than scale heterogeneity in their case studies, with MXL and G-MXL models outperforming MNL and G-MNL models. The authors argue that G-MXL model has the potential to improve the rigour of valuation studies for unfamiliar grounds for environmental goods and services. They however call for additional research work that would shed more light on how these models compare. Following Keane and Wasi (2009), Greene and Hensher (2010), Christie and Gibbons (2011), Scarpa *et al*. (2011) and Kragt (2013) among others, this study therefore addressed the identified need for additional studies that evaluate different approaches used to

model individual heterogeneity. This is because it would further our understanding on how different behavioural models perform and account for taste and scale heterogeneity in discrete choice analysis.

5.3 The discrete choice models

5.3.1 Multinomial logit model (MNL)

Notably, the development of the multinomial logit (MNL) model by McFadden (1974) provided statistical frameworks for modeling how varying policy attributes contribute to the probability of choice. The model has been widely used in applied economics owing to its computational simplicity and closed-form model specification. It assumes that choices are consistent with independence from irrelevant alternatives (IIA) property such that for any individual, the ratio of choice probabilities of any two alternatives is entirely unaffected by the systematic utilities of any other alternative (e.g. Louviere *et al*., 2010). The MNL model is based on an indirect utility function where the indirect utility derived by respondent i from alternative j in choice set C_i is:

$$U_{ij} = V_{ij}\{Z_{ij}, S_i\} + \varepsilon_{ij} \quad (1)$$

where V_{ij} is the observable deterministic component and ε_{ij} is the unobserved stochastic component. V_{ij} is a function of both the attributes of the alternative options and the status quo in choice set (Z_{ij}) and the characteristics of the respondent (S_i). Respondent i chooses alternative j if $U_{ij} > U_{ik}$ for all $j \neq k$ in C_i. As such, the probability of choosing alternative j by respondent i is:

$$Prob_i(j|C_i) = \{V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik}\}$$
$$= \{V_{ij} - V_{ik} > \varepsilon_{ik} - \varepsilon_{ij}\} \quad (2)$$

The estimation of Equation (2) requires that the assumptions over the distributions of the error terms to be made. For MNL model, the errors are assumed to be independently and identically distributed (iid) with a Type 1 extreme value (Weibull) distribution (McFadden, 1974). This suggests that the probability of choosing alternative j by respondent i is:

$$Prob_i(j|C_i) = \exp\{\mu V_{ij}\}/\sum_{k\in C_i}\exp\{\mu V_{ik}\} \quad (3)$$

where μ is a scale parameter that is inversely proportional to the variance of the error term. This parameter is not separately identified and thus, it is generally assumed to be equal to one, which implies constant error variance (e.g. Ben-Akiva and Lerman, 1985). As such, the log-likelihood function takes the form:

$$ln\ LL = \sum_{i=1}^{N}\sum_{j=1}^{3}\{Y_{ij} * \ln[\,Prob_i(j|C_i)]\} \quad (4)$$

where the value of Y_{ij} is one if the i^{th} respondent chooses alternative j and zero otherwise. Equation (4) is estimated by maximum likelihood procedure (e.g. Hensher *et al*., 2015). Given the important restrictions in the MNL formulation because of the rigidity of its error structure, other formulations have been developed with flexible error term distribution structures such as the mixed logit (MXL), scaled-multinomial logit (S-MNL), generalized-multinomial logit (G-MNL) and the generalized-mixed logit (GMXL) models.

5.3.2 The mixed logit model (MXL)

Nowadays, the MXL model has largely replaced the MNL model in analyzing discrete choice data. The model was developed to account for the intuitive fact that decision agents differ from each

other. Thus, it is able to account for random taste variation, unrestricted substitution patterns and correlation in unobserved preference factors of individuals (e.g. Hensher *et al*., 2015). Therefore, the utility respondent i receives from a choice alternative j is algebraically formulated as:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{5}$$

where V_{ij} is the deterministic component of the utility function observable to the researcher while ε_{ij} is the random component of the utility function known only by the individual respondent. The deterministic component V_{ij} is a linear function of the policy attributes in vector x_{ij} and the vector (β) of utility weights for each attribute, hence:

$$U_{ij} = \beta_i' x_{ij} + \varepsilon_{ij} \tag{6}$$

However, β_i is partitioned into a mean part $(\bar{\beta})$ and individual i^{th} deviation (η_i), thus:

$$U_{ij} = \beta_i' x_{ij} + \varepsilon_{ij} = (\bar{\beta}' + \eta_i')x_{ij} + \varepsilon_{ij} \tag{7}$$

Following Train (2009), the probability of choosing alternative j by respondent i expressed by a vector of policy attributes x is obtained by integrating the distribution density over the range of parameter values, thus:

$$Prob(j|x_i, b, w) = \int \exp\left(\bar{\beta}_i' x_{ij}\right) / \sum_{j \in k} exp\left(\bar{\beta}_{i\,ij}'\right),\ \Omega(\bar{\beta}|b, w) d\beta \tag{8}$$

The utility function of each consumer therefore has some random taste parameters $\bar{\beta}_i'$ with values that depend on the values of the parameters b and w of an underlying distribution $\Omega(\bar{\beta}|b, w)$. As

Hensher and Green (2003) note, the choice of distribution strongly affects the properties of the model. As such, random taste parameters $\bar{\beta}_i$ induce correlation across choices made by the same respondent but, maintains the advantageous logit probability. In effect, ε_{ij} is iid Gumbel and therefore, the choice probability remains logit conditional on the parameter draw. The MXL formula is thus a weighted average of the MNL probability calculated at different values of β. The weight is the probability density (Ω) of β over respondents with mean b and variance-covariance matrix w. Since Equation (8) does not have a closed form solution, it is estimated by simulated maximum likelihood method (e.g. McFadden and Train, 2000). For the reason that the MXL formulation still maintains the MNL model assumption that the idiosyncratic error term is iid, it is unable to account for scale heterogeneity. To account for the potential effects of scale heterogeneity, S-MNL model that relaxes the iid assumption was developed (e.g. Fiebig *et al*., 2010).

5.3.3 The scaled multinomial logit (S-MNL)

The MXL model only accounts for the unobserved taste heterogeneity in the deterministic component of utility. As such, the scale factor μ, which is inversely associated with the error variance σ_ε^2 is normalized to one to allow the estimation of the model. Past research (e.g. Louviere and Eagle, 2006) suggests that such a constant scale of error distribution may not be appropriate in explaining individual choice behaviour. Thus, Fiebig *et al*. (2009) developed other modelling methods that could accommodate variance across respondents in the random component of utility, namely, the S-MNL and G-MNL. For S-MNL model, the error variance σ_ε^2 is allowed to be heterogeneous in the population so that the utility U_{ij} that respondent i derives from alternative j is:

$$U_{ij} = (\beta\sigma_i)'x_{ij} + \varepsilon_{ij} \quad (9)$$

where β denotes a vector of averaged attribute parameters of the population, σ_i refers to the individual's specific standard deviation of the idiosyncratic error term that captures scale heterogeneity; x_{ij} denotes a vector of the observed explanatory variables; and ε_{ij} is a stochastic error that is iid over the alternatives and the individuals (Fiebig *et al*., 2009). The individuals scaling factor has to be restricted to be positive and this is attained through the use of the exponential transformation (e.g. Fiebig *et al*., 2009; Greene and Hensher 2010), that is:

$$\sigma_i = exp(\bar{\sigma} + \tau w_i) \quad (10)$$

where, $\bar{\sigma}$ denotes the mean parameter related to the error variance; τ is the coefficient associated with the unobserved scale heterogeneity; and w_i refers to the unobserved individual heterogeneity related to the scale that is standard normally distributed. Since $\bar{\sigma}$ is unidentified separately from τ, σ_i is normalized as $\bar{\sigma} = \tau^2/2$. Thus, larger parameter values for τ show a greater degree of scale heterogeneity (Fiebig *et al.*, 2009). The S-MNL model is estimated by way of simulated maximum likelihood procedure. The need to account for both taste and scale heterogeneity in one and the same model led to the development of the G-MNL model (e.g. Keane *et al.*, 2006; Fiebig *et al.*, 2010; Greene and Hensher , 2010).

5.3.4 The generalized multinomial logit model (G-MNL)

The G-MNL model nests both MXL and S-MNL. First operationalized by Fiebig *et al.* (2010) and subsequently by Greene and Hensher (2010), the marginal utility for attribute *j* for the G-MNL model is represented as:

$$U_{ij} = \sigma_i \bar{\beta}_j + \gamma\theta_{ij} + (1-\gamma)\sigma_i\theta_{ij} \quad (11)$$

where γ takes any value between 0 and 1 and where:

$$\sigma_i = e^{\bar{\sigma}+\tau v_i} \quad (12)$$

In Equation (12), $\bar{\sigma}$ denotes a mean parameter of scale variance, τ is a parameter of unobserved scale heterogeneity and v_i is a standard normal distribution representing the unobserved scale heterogeneity. Ignoring σ_i and in the extreme case where γ takes the value 0, Equation (11) collapses to:

$$U_{ij} = \sigma_i(\bar{\beta}_j + \theta_{ij}) \quad (13)$$

suggesting that scale impacts equally upon both the mean and standard deviation parameters. Fiebig *et al.* (2010) refer to this model as G-MNL II. On the other extreme, when γ equals 1, Equation (11) collapses to:

$$U_{ij} = \sigma_i \bar{\beta}_j + \theta_{ij} \quad (14)$$

suggesting that scale impacts only upon the mean parameter. Fiebig *et al.* (2010) refer to this model as G-MNL I. Values of γ between 0 and 1 suggest that scale impacts both the mean and standard deviation parameters but, to different extents. Returning to σ_i, if $\sigma_i = 1$ and all $\theta_{ij} = 0$, then the model collapses to the standard MNL model. If σ_i is estimated to take the value 1, then the marginal utilities obtained from the model would collapse to the MXL model estimates. Similarly, if all θ_{ij} simultaneously equal 0, then the model collapses to the scaled version of MNL

model or S-MNL model (Fiebig *et al.*, 2010) such that the marginal utilities obtained from the model would algebraically be given as:

$$U_{ij} = \sigma_i \bar{\beta}_j \tag{15}$$

3.3.5 The generalized mixed logit model (G-MXL)

Finally, a more flexible G-MXL modelling approach accommodating individual taste as well as individual scale heterogeneity was proposed by Fiebig *et al.* (2009). The G-MXL model specification thus accounts for the unobserved heterogeneity both in the deterministic and in the random components of the individual utility function. In this model, utility, U_{ij}, is defined by:

$$U_{ij} = \{\sigma_i \beta + \gamma \eta_i + (1-\gamma)\sigma_i \eta_i\}' x_{ij} + \varepsilon_{ij} \tag{16}$$

where σ_i denotes the respondent specific standard deviation of the idiosyncratic error term that captures the scale variance, η_i is respondent specific deviations from the mean, capturing individual heterogeneity in taste; and γ is a weighting parameter between 0 and 1, that captures how the variance of the individual taste varies with scale. While estimating the G-MXL model, several normalizations are however required. σ_i is again normalized as $\bar{\sigma} = -\tau^2/2$ to enable identification of $\bar{\sigma}$ so that $E[\sigma_i] = 1$. In addition, to ensure that $\tau \geq 0$, the model is fit in terms of λ, where $\tau = \exp(\lambda)$ and l is unrestricted (e.g. Hensher *et al.*, 2011). τ is the parameter that captures scale variance. If τ approaches 0, then the G-MXL model approaches the MNL model (Fiebig *et al.*, 2009).

5.4 The discrete choice experiment

5.4.1 Experimental design

Notably, DCEs have become increasingly common in environmental economics and across many other social science disciplines in eliciting individual preferences for both market goods and non-market goods that have a set of attributes to be considered (e.g. Kragt and Bennet, 2011). The increasing popularity of DCEs is partially in response to problems recognized in the use of contingent valuation (Hausman, 1993) and also partly because it is able to identify easily the individuals' preference trade-offs for different policy attributes compared to other available approaches. One crucial aspect of the DCE methodology is that it allows the estimation of marginal rates of substitution (MRS) between the policy attributes in question. The marginal rates of substitution offer an implicit ranking of the policy attributes that could then be compared with other ranking mechanisms.

In a typical DCE, a policy intervention, usually hypothetical in nature, is described through its specific attributes or characteristics with every attribute being exemplified by a defined number of dimensions termed as attribute levels (e.g. Louviere *et al*., 2011). A set of hypothetical choice options are experimentally constructed using the defined attributes and attribute levels (e.g. Hensher *et al*., 2005; Louviere *et al*., 2011). Respondents are thereafter presented with two or more of the defined choice options from which they are asked to state their most preferred alternative (e.g. Kragt, 2013). Respondents' choices are thereafter used to indicate individuals' preference that is attached to the policy intervention and its attributes (Lancsar and Louviere, 2008). In this paper, a widely recommended and systematic process by Hensher *et al*. (2005) and Louviere *et al*. (2010) was followed to construct and implement the experimental design.

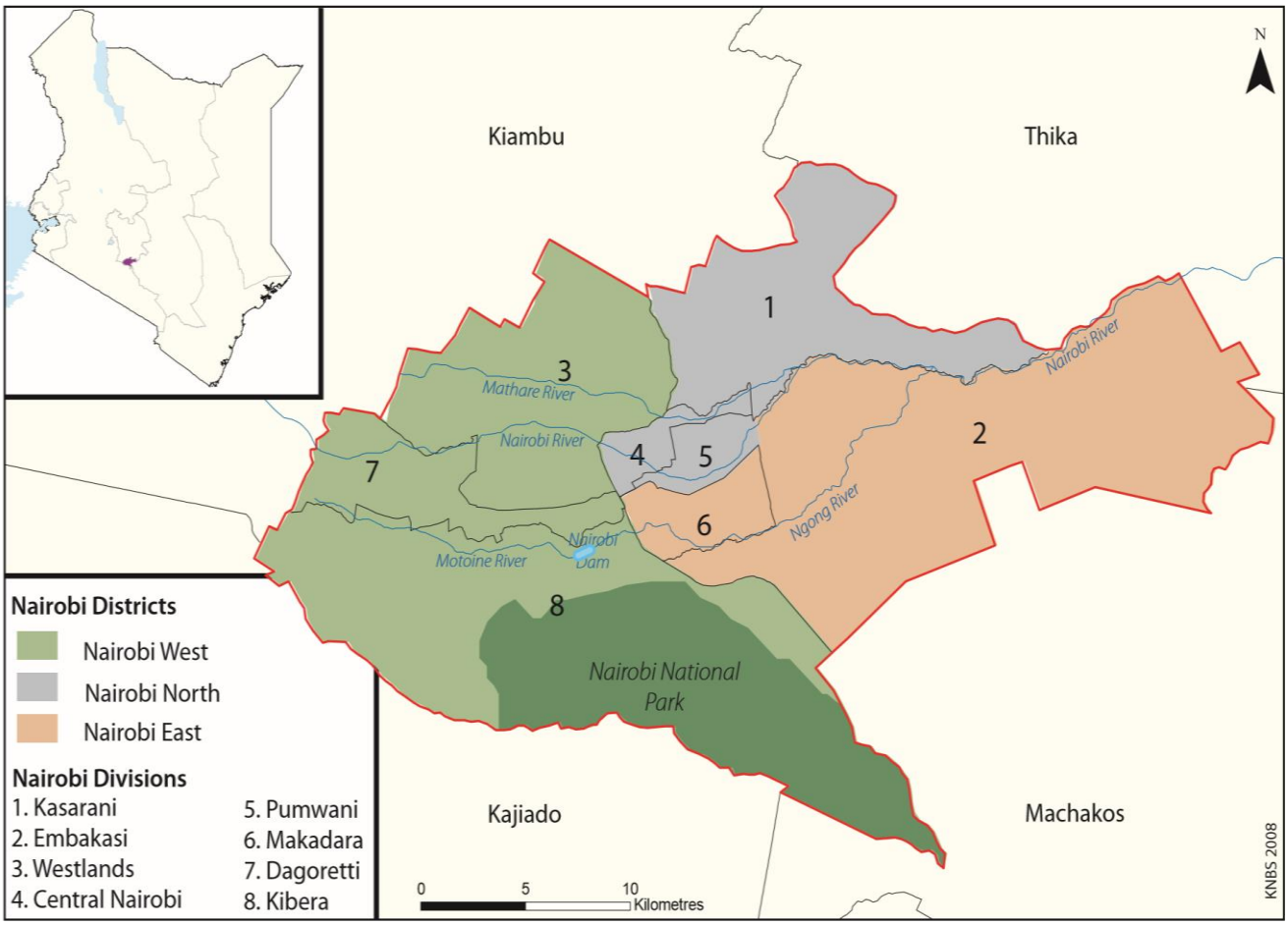
5.4.2 The study area – the city of Nairobi

This study was conducted in Kenya's capital city, Nairobi, which is situated on the south-eastern end of the country's agricultural land, at about 1° 9'S, 1° 28'S and 36° 4'E, 37° 10'E. The area covered by the city is about 696 Km^2 with an altitude that varies between 1,600-1,850 metres above the sea level (CBS, 2009). There are eight administrative divisions in the city that include Westlands Central, Embakasi, Dagoreti, Kibera, Kasarani, Makadara and Pumwani and each is connected to some major road to the Central Business District (CBD). The city is resident to about 8 per cent of the nation's total population and about 25 per cent of country's urban population (CBS, 2009). The city's population is estimated to have increased from 343,500 people in 1962 to about 3.1 million in 2009 and by 2015, it was expected to reach the 3.8 million mark (CBS, 2009; NEMA, 2010).

Due to high growth of the population, the demand for urban transport in the city has also increased leading to enhanced motorization and thus, greater levels of vehicular emissions (Odhiambo *et al*., 2010). With more toxic gases such as the oxides of sulphur, carbon monoxide, oxides of nitrogen, hydrocarbons and the particulate matter in the ambient air (Kinney *et al.*, 2011), many city residents are therefore exposed to problems associated with vehicular emissions (Odhiambo *et al.*, 2010; Kinney *et al.*, 2011) that potentially pose serious long-term implications for health and to the environment (Vliet and Kinney, 2007; Odhiambo *et al.*, 2010; Kinney *et al.*, 2011). The map and the figures shown below indicate the 8 divisions, which constitute the city of Nairobi, the major routes in the city and the approximated inbound and outbound number of vehicles during peak hours of the morning and evening. As shown, the city's road network mainly consists of radial routes that connect the surrounding neighbourhoods to the CBD. Notably, lack of circumferential roads tends to force numerous peripheral trips through the city center. Regarding

the aggregated morning and evening peak traffic flows, the direction of traffic in the morning is predominantly towards the city center while in the evening, huge traffic flows in both directions, but with more exiting the city centre.

Figure 5.1. Nairobi's three districts and eight divisions



Source: Kenya National Bureau of Statistics, 2008.

Figure 5.2. Nairobi Road Network

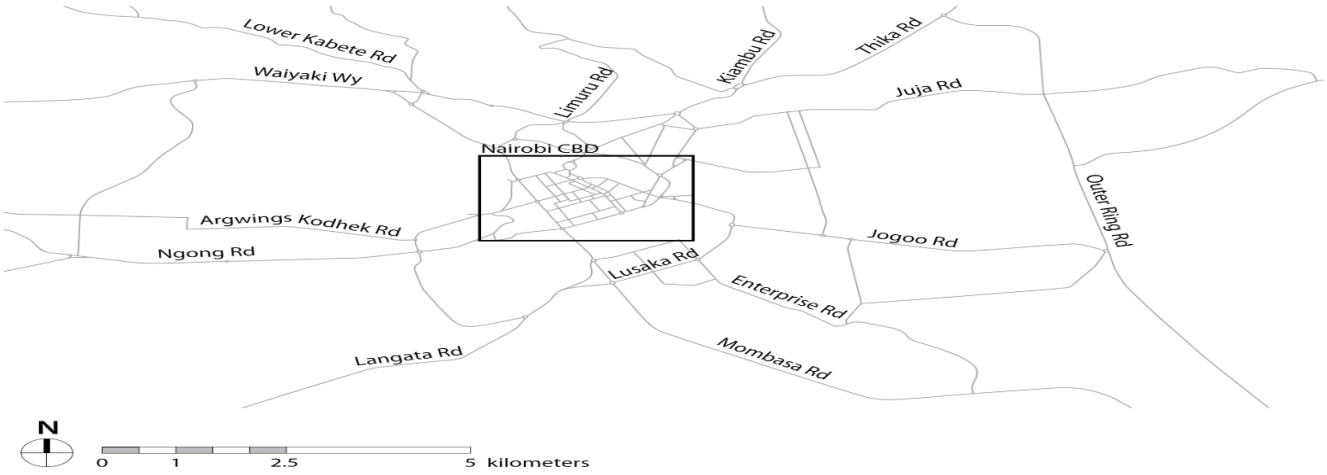


Figure 5.3. Peak hour flows in the morning– vehicles to and from the city centre

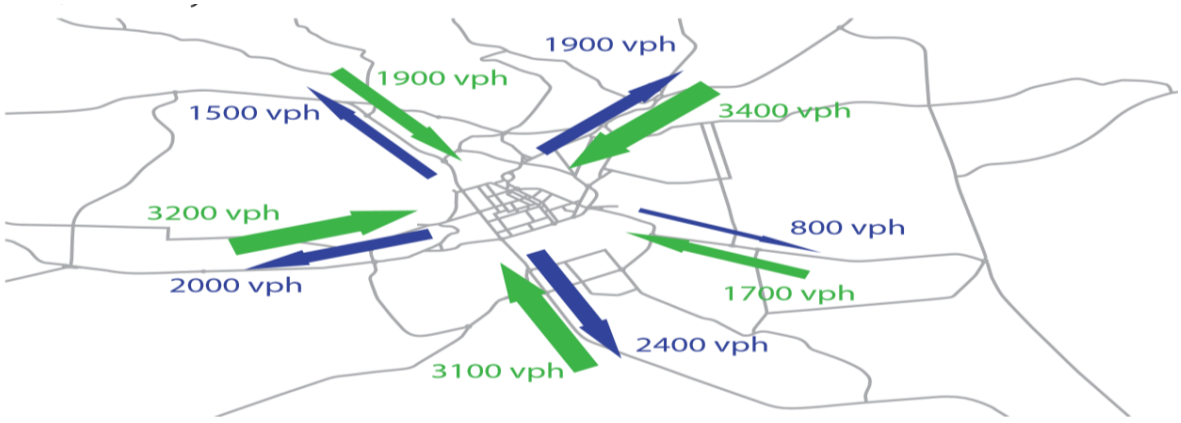
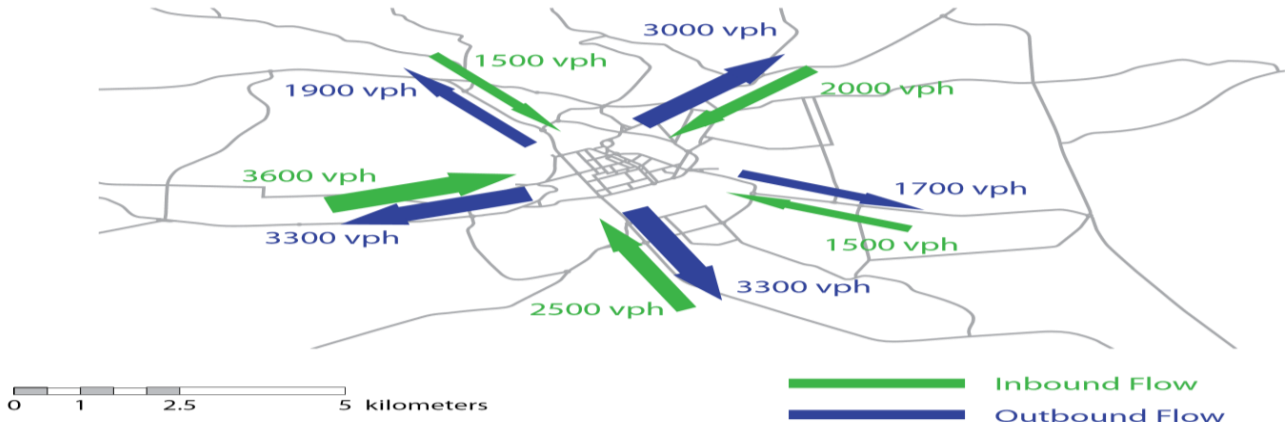


Figure 5.4. Peak hour flows in the evening– vehicles to and from the city centre



Source: Gonzales et al., 2009.

5.4.3 Policy intervention, choice sets and the attributes

The need for a policy that would improve the quality of air in the city of Nairobi through motorized emission control comprised the public good of interest, which was considered in the study. A hypothetical policy scenario composed of attributes and levels that would address the policy problem of motor vehicle emissions in the city was assumed so as to draw preferences from car owners. To identify the essential attributes for motorized emission reductions, an initial set of attributes was derived through widespread literature reviews. These attributes were thereafter revised through extensive interviews with researchers and policy analysts in the motor vehicle industry. This led to the identification of three attributes, namely, namely, *fuel use* measured in how many litres of fuel (fossil or biofuel) a motor vehicle could drive per 100 kilometres, the exhaust gas *emission level*, measured in milligrams of carbon dioxide emitted per kilometer driven, and the *extra fuel price* paid for each litre of fuel towards improved efficiency in motor vehicle fuel use and emission reduction. These attributes and their levels are shown in Table 5.1.

Table 5.1: Descriptions and levels of the chosen attributes

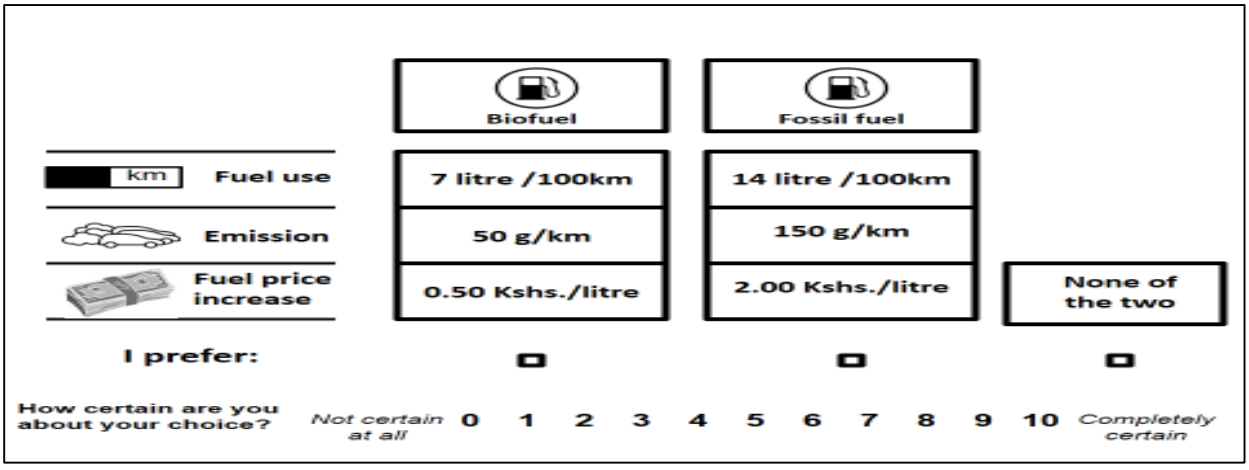
Attribute	**Description**	**Levels**
Fuel use	The number of litres of fuel (fossil and biofuel) a vehicle can drive on per 100 kilometres.	Level 1: 7litre/100km Level 2: 14litre/100km Level 3: 21litre/100km
Emission level	The amount of carbon dioxide measured in milligrams per kilometer driven that is emitted from the vehicle.	Level 1: 50g/km Level 2: 100g/km Level 3: 150g/km
Fuel price increase	The extra fuel price one is asked to pay for each litre of fuel to improve fuel efficiency and at the same time reduce exhaust gas emissions from vehicle.	Level 1: Kshs. 0.50/litre Level 2: Kshs. 1.00/litre Level 3: Kshs. 1.50/litre Level 4: Kshs. 2.00/litre

5.4.4 Choice sets

From the number of attributes and their levels shown in Table 5.1, it is clear that there would have been numerous possibilities and combinations for use in the survey. However, the DCE was

designed in a way that it only included a few of these combinations. Thus, with a sample size of 107 respondents per administrative division and the chosen attributes and levels, the Bayesian efficient design containing 10 choice sets with 3 alternatives each was obtained through the *Ngene* software (Institute of Transport and Logistics Studies, 2007) and using priors that were assumed after expert consultation at the time of designing the experiment. Of the three alternatives used in the study, two represented fuel alternatives (fossil fuel and biofuel) and the third one represented the fixed status quo. For those respondents who persistently chose the status quo alternative in all the 10 choice tasks, they were asked a follow-up question to provide the underlying reasons for choosing the status quo. Figure 5.5. presents the kind of the choice card employed in the study.

Figure 5.5: Choice card employed in the study



5.4.5 Questionnaire design and survey method

A questionnaire was prepared with the help of professionals in the motor vehicle industry and then pretested with an open ended interview ($N = 50$) to assess to what extent respondents understood the survey questions. Thus, the final version of the questionnaire employed in the study was a reflection of the inputs from the pretest as well as the guidance provided by the professionals. This

final version of the survey questionnaire had three sections. The first section measured respondents' general knowledge on fuel types and fuel use efficiency characteristics of their motor vehicles so as to acquaint them with the policy attributes of interest that were being addressed. The second section comprised questions for DCE analysis designed to elicit respondents preferences for motorized emission reductions by analyzing trade-offs between price and the other attributes. The final part involved questions about the socio-demographic characteristics of the respondents, such as age, gender and income. Since exposure to environmental and human health problems may encompass a certain level of uncertainty, respondents' uncertainties were also captured in the choice tasks. As such, respondents were probed to rate their level of uncertainty regarding their choices on a scale of 0 to 10. The number 0 indicated completely uncertain while 10 indicated that respondents were completely certain.

The survey was implemented between November 2015 and January 2016 through 960 person-to-person interviews with respondents above the age of 18 and owned a motor vehicle. Moreover, interviews were conducted by eight trained local interviewers who had strict instructions to limit all explanations to facts so as to minimize the introduction of any interviewer bias. Both text and pictograms were also used to represent information in the choice cards so as to enhance the understanding of people with low literacy about the attributes before they chose their most preferred policy alternative. The interviews involved random selection of respondents at their homes along the major roads, shown in the map, that connect the 8 administrative divisions to the city centre. Once data screening was done, 958 of the 960 interviews were found useful for further analysis. The response rate was notably 99.8%, which is not unusual for this kind of stated preference research in a developing country context (Whittington, 1998).

5.5 Results and discussions

5.5.1 Socio-demographic characteristics of the sample

The socio-demographic characteristics of the respondents are presented in Table 5.2. From a sample of 958 respondents, the share of male respondents constituted 63% of the respondents where the average age was 38.4 years with a range of between 18 and 65 years. The household size of the respondents was about 4 people with 2 children below the age of 18 years. As for the literacy, the share of respondents with primary, secondary and post-secondary education was 3%, 7% and 90%, respectively. The share of respondents deriving their livelihood from formal employment was 40% while from self-employment was 56% and from casual labour was 4.9%. The average monthly income of the respondents was Kshs. 119,415 ($1,194.15). In addition, majority of respondents resided about 3.5kms away from the nearest highway. With regard to motor vehicle characteristics, the study found that the mean age of the car driven by respondents was 8.7 years. While the share of respondents using a car every day was 54.7%, the share using a car almost every day was 30.4% and that using a car 1-2 times a week was 9.5%. The share using a car to drive to work was 85.4% and that using a car to shop was 49.7%. As for the average kilometre driven per month, respondents in the sample had an average monthly mileage of about 300kms. Moreover, 59% of the respondents had an exhaust filter fitted in their car. The share of respondents whose cars used petrol was 83.6% while that for diesel was 16.4%. The average costs of fuel per month was Kshs 12,798 ($1,278.80) while the average fuel efficiency of a car was 10.3km/litre of fuel. The share of respondents who had ever had heard about biofuel before was 76.4%. The share concerned about air pollution was 90.1% while that believing air pollution was bad for health was 87.7%. Furthermore, 69.4% of respondents had the perception that they could easily die from air pollution. As such, the share concerned about CO_2 emissions was 93% with 89.5% finding the need to control car exhaust emissions.

Table 5.2: Socio-demographic and motor vehicle characteristics of the sample

Characteristics	Mean	Std error	Minimum	Maximum
Share of male (%)	63.1	0.5	0.0	1.0
Average age (years)	38.4	9.1	18.0	65.0
Average household size (persons)	4.3	1.8	1.0	11.0
Average number of children	1.5	1.1	0.0	6.0
Share completed primary school (%)	2.9	0.2	0.0	1.0
Share completed secondary school (%)	7.3	0.3	0.0	1.0
Share completed post-secondary school education (%)	89.8	0.3	0.0	1.0
Share employed (%)	39.6	0.5	0.0	1.0
Share self-employed (%)	55.5	0.5	0.0	1.0
Share day/casual labourer (%)	4.9	0.2	0.0	1.0
Average distance from nearest highway (km)	3.5	4.6	0.01	47.0
Average household income (Kenya Shillings)	119,415	105,542	50,000	625,000
Average age of the car (years)	8.7	4.3	1.0	40.0
Average years driving current car	3.5	2.2	0.5	18.0
Share whose car has exhaust filter (%)	59.0	0.5	0.0	1.0
Share using car every day (%)	54.7	0.5	0.0	1.0
Share using car almost every day (%)	30.4	0.5	0.0	1.0
Share using car 1-2 times per week (%)	9.5	0.3	0.0	1.0
Share using car to drive to work (%)	85.4	0.4	0.0	1.0
Share using car to shop (%)	49.7	0.5	0.0	1.0
Average kilometre driven per month (kms)	6.6	2.4	1.0	9.0
Share using petrol (%)	83.6	0.4	0.0	1.0
Share using diesel (%)	16.4	0.4	0.0	1.0
Average fuel costs per month (kshs)	12,798	12,802	1,000	120,000
Average car fuel efficiency (km/liter)	10.3	4.2	2.0	25.0
Share who heard about biofuel before (%)	76.4	0.4	0.0	1.0
Share concerned about air pollution in Nairobi (%)	90.1	0.3	0.0	1.0
Share who believe air pollution is bad for their health (%)	87.7	0.3	0.0	1.0
Share who believe one can die from air pollution (%)	69.4	0.5	0.0	1.0
Share concerned about CO_2 emissions (%)	93.0	0.3	0.0	1.0
Share who believe there is a need to control car exhaust emissions (%)	89.5	0.3	0.0	1.0

Explanatory notes: N=958 respondents.

5.5.2 Results of the estimated utility models

As mentioned earlier, five behavioural models, namely, MNL, MXL, S-MNL, G-MNL and the G-MXL were estimated not only to derive the implicit prices and explore their relative performance but, also evaluate how best they were able to account for individual heterogeneity inherent in the choice data. For the MNL model, researchers use the interaction terms to capture taste heterogeneity. In the MXL model, taste heterogeneity is captured in the systematic component of utility and accounted for by specifying the choice attributes as random parameters. For S-MNL model, scale heterogeneity is implicitly accounted for in the random component of utility. In regard to G-MNL and G-MXL models, both taste and scale heterogeneity are accounted for in both the systematic and the random components of utility.

In this paper, all the five models (MNL, MXL, S-MNL, G-MNL and G-MXL) were estimated as attributes only models where the utility functions were specified only as linear functions of the attributes. In addition, some two alternative specific constants (ASCs) were also included in the utility functions to represent the difference in utility between respondents' choice of the provided choice alternatives (fossil fuel or biofuel) and the status quo option assuming all attributes are equal. The ASCs were included in the model as dummy variables with the provided choice alternatives being coded as one and the status quo option as zero (Tarfesa and Brouwer, 2012). In addition, following Greene *et al*. (2006), the random price parameter was assumed to follow a constrained triangular distribution to ensure a negative sign on the price parameter while a normal distribution was defined for the other random parameters. The relative performance of the models was discussed based on the log likelihood and some three information criteria, namely, the Akaike (AIC), Bayes (BIC) and consistent Akaike (CAIC) information criteria. Table 5.3 presents the estimation results.

As shown, the coefficient signs in all the models were consistent with a priori and theoretical expectations. The coefficient sign of the ASCs for fossil fuel and biofuel use were positive and significant, which means that car owners would derive higher utility from the two fuel alternatives as opposed to the status quo option. Of interest is that the utility that car owners would derive from fossil fuel (ASC for fossil fuel) was higher compared to that of biofuel (ASC for biofuel). Though the opposite outcome would have been expected, the current result might be explained by the prevailing constraints associated with production, availability and use of biofuels in Kenya as opposed to fossil fuels. The coefficients for fuel use, level of emission and fuel price increase are however negative and significant, which means that an increase in the level of any of the attributes would lead to lower utility for the car owners. The significant standard deviations of the random parameters in the MXL, G-MNL and G-MXL models provide evidence that there was significant consumer heterogeneity (e.g. Christie and Gibbons, 2011; Fiebig *et al.*, 2010) in the choice behaviour of the car owners regarding motorized emission reduction attributes in Nairobi, Kenya.

5.5.3 Performance of the estimated choice models

Table 5.3 also presents the results regarding the relative performance of the estimated choice models. Based on the log likelihood (LL) information, the results indicate that the G-MXL model (LL = -6002.59) performed better than G-MNL (LL = -6011.01), S-MNL (LL = -6093.19), MXL (LL = -6169.82) and MNL (LL = -6324.02) models. Besides, results from the Akaike Information Criteria also show that the G-MXL model with AIC = 12039.20, BIC = 6080.51 and CAIC = 12178.03 dominated G-MNL (AIC = 12054.01; BIC = 6084.34; CAIC = 12184.74) and S-MNL (AIC = 12204.40; BIC = 6134.44; CAIC = 12277.89) models.

Table 5.3: Results of the estimated choice models – attributes only models

Characteristics	MNL		MXL		S-MNL		G-MNL		G-MXL	
	Coef.	Std error	Coef.	Std error	Coef.	Std error	Coef.	Std error	Coef.	Std error
Mean estimate random parameters										
ASC for fossil fuel	6.681***	0.242	6.846***	0.254	21.699***	3.257	24.316***	3.648	20.667***	3.584
ASC for biofuel	6.248***	0.236	6.279***	0.247	21.179***	3.243	23.436***	3.657	19.846***	3.586
Fuel use	-0.032***	0.006	-0.032***	0.007	-0.064***	0.008	-0.055***	0.009	-0.053***	0.009
Emission level	-0.004***	0.001	-0.005***	0.001	-0.005***	0.001	-0.006***	0.001	-0.006***	0.001
Fuel price increase	-0.270***	0.046	-0.299***	0.052	-0.396***	0.046	-0.422***	0.056	-0.445***	0.060
Standard deviation random parameters										
ASC for fossil fuel			0.003	0.071			0.025	0.355	0.050	0.290
ASC for biofuel			0.019	0.071			0.018	0.461	0.060	0.369
Fuel use			0.006	0.007			0.003	0.019	0.007	0.015
Emission level			0.004***	0.001			0.002***	0.002	0.004***	0.001
Fuel price increase			0.801***	0.088			1.084***	0.095	1.080***	0.113
Model summary statistics										
LR chi-square	934.44		8709.78		8863.02		9027.40		9044.24	
Prob > chi square	0.0000		0.0000		0.0000		0.0000		0.0000	
McFadden Pseudo R^2	0.0680		0.4138		0.4211		0.4289		0.4297	
Number of observations	9580		9580		9580		9580		9580	
Parameters	8		15		9		16		17	
Log-likelihood.	-6324.02		-6169.82		-6093.19		-6011.01		-6002.59	
Scale parameter $\boldsymbol{\tau}$	-		-		0.907***		0.893***		0.862***	
Weighting parameter $\boldsymbol{\gamma}$	-		-		fixed		fixed		0.002	
Sample mean $\boldsymbol{\sigma_i}$	-		-		0.987		0.988		0.989	
Sample standard deviation $\boldsymbol{\sigma_i}$	-		-		1.041		1.021		0.977	
Akaike Information Criterion (AIC)	12664.00		12369.60		12204.40		12054.01		12039.20	
Bayesian Information Criterion (BIC)	6360.69		6238.58		6134.44		6084.34		6080.51	
Consistent Akaike Information Criterion (CAIC)	12729.38		12492.15		12277.89		12184.74		12178.03	

Explanatory notes: ASC_fossil fuel and ASC_biofuel refer to alternative-specific constants, which represent dummies for the respondent's choosing the alternatives, A and B, respectively. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; 95% confidence intervals in parentheses.

There was also substantial improvement in all the three information criteria for the S-MNL model (AIC = 12204.40; BIC = 6134.44; CAIC = 12277.89) over the MNL model (AIC =12664.00; BIC =6360.69; CAIC =12729.38). The S-MNL model also performed better than the MXL model with AIC = 12369.60, BIC = 6238.58 and CAIC = 12492.15. Nevertheless, the MXL model outperformed the MNL model based on both the log likelihood and all the three information criteria.

5.5.4 Accounting for taste and scale heterogeneity

On individual heterogeneity, it is important to note that the MNL model does not implicitly account for either taste or scale heterogeneity and as such, researchers in the past accounted for taste heterogeneity using interaction terms between the attributes and relevant socio-demographics. Nowadays, researchers use other model formulations (MXL, S-MNL, G-MNL and G-MXL) to address this problem inherent in the MNL model. With the attributes-only model specification, the study results in Table 5.3 futher show that accounting for taste heterogeneity in the MXL model improved the LL by 154.20 points or 2.44% over the standard MNL values, and this would represent the amount of taste variation in the data not captured by the MNL model. Similarly, accounting for scale heterogeneity in the S-MNL model improved the LL by 230.83 points or 3.65% over the MNL values. Apparently, the S-MNL model outperformed the MXL model based on the LL by 76.63 points or 1.24%, which represents the amount of scale variation in the choice data not accounted for in the MXL model. It also means that scale heterogeneity was more important than taste heterogeneity (Scarpa *et al*., 2011) in our choice data. The G-MNL model, which nests both MXL and the S-MNL models and hence, accounts for both taste and scale variation in the choice data, improved the LL by 313.01 points or 4.95% over the MNL model. The G-MXL model specification, which also accounts for both taste and scale variation, had the largest LL improvement over the MNL model by 321.43 points or 5.08%. This implies that economic

valuation studies should account for both taste and scale heterogeneity for better model performance and precise evaluation of policy interventions (e.g. Fiebig *et al.*, 2010; Kragt, 2013). As such, the G-MXL model seems to hold most promise as it dominates its closest counterpart, the G-MNL model.

Besides, the statistically significant scale parameter, τ, in the S-MNL, G-MNL and G-MXL models means that there was considerable degree of scale heterogeneity in the choice data. That is, the choice behaviour of the respondents could have been characterized by a greater degree of randomness or uncertainty or near lexicographic preferences. Thus, the DCE in this study may have presented a difficult choice situation to the car owners since according to Fiebig *et al*. (2010) and Christie and Gibbons (2011), a significant scale factor is usually, but not always, a case of difficult choice contexts presented to respondents. The weighting parameter, γ, was also found very close to zero ($\gamma = 0.002$) meaning that the variance of the random taste heterogeneity increased with scale. Remarkably, the individual taste and scale factors jointly captured in either the G-MNL or G-MXL models cannot be disentangled, which suggests that their individual importance in the choice data could best be approximated through the MXL model (for taste factors) and S-MNL (for scale factors).

5.6 WTP of the estimated choice models

WTP values were also estimated from models involving the attributes only. The values were derived from the four attributes, namely, ASC_fossil fuel, ASC_biofuel, fuel use and emission level. The estimates from all the models are presented in Table 5.4. As shown, it is evident that the WTP estimates in all the models are statistically significant at $\alpha = 0.01$. Moreover, car owners' WTP for fossil fuel option was generally higher than that of biofuel. Although the opposite outcome would have been expected, the current result might be explained by the prevailing constraints associated with production, availability and use of

biofuels in Kenya as opposed to fossil fuels. In addition, MXL and G-MNL models provided the most conservative WTP estimates for fossil fuel and biofuel options as opposed to S-MNL, G-MNL and G-MXL models. Conservative WTP estimates were also associated with fuel use and emission level attributes across the five models. The S-MNL and G-MXL models generally provided higher WTP estimates in comparison to all the other models. Notably, the magnitude of WTP estimates were very similar for MXL and G-MNL models, on one hand, and for S-MNL and G-MXL models, on the other. The WTP estimates were also similar for all the models regarding the attribute on exhaust emission level reduction. Except for the attribute on emission level, a t-test confirmed that there were significant differences in the WTP estimates between MNL, MXL/G-MNL and S-MNL/G-MXL models. This means that welfare estimates were sensitive to model specifications, notwithstanding the significant heterogeneity in taste and scale across the individuals.

Table 5.4: WTP and confidence intervals of the estimated Attributes-only choice models

Descriptions	**MNL**	**MXL**	**S-MNL**	**G-MNL**	**G-MXL**
	WTP (CI)	WTP (CI)	WTP (CI)	WTP (CI)	WTP (CI)
ASC_fossil fuel use	24.27*** (16.71 - 31.83)	21.95*** (15.10 - 28.80)	61.85*** (38.41 - 85.28)	21.95*** (15.10 - 28.80)	61.85*** (38.41 - 85.28)
ASC_biofuel use	23.56*** (15.85 - 31.28)	21.95*** (14.32 - 29.58)	47.97*** (31.03 - 64.90)	21.95*** (14.32 - 29.58)	47.97*** (31.03 - 64.90)
Fuel use efficiency	0.12*** (0.06 - 0.18)	0.10*** (0.047 - 0.161)	0.17*** (0.11 - 0.22)	0.10*** (0.047 - 0.161)	0.17*** (0.11 - 0.22)
Emission level	0.01*** (0.01 - 0.02)	0.02*** (0.01 - 0.02)	0.01*** (0.01 - 0.02)	0.02*** (0.01 - 0.02)	0.01*** (0.01 - 0.02)

Explanatory notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; 95% confidence intervals in parentheses.
ASC_fossil fuel and ASC_biofuel refer to alternative-specific constants, which represent dummies for the respondent's choosing the alternatives, A and B, respectively.

5.7. Conclusion and recommendations

This paper purposed to assess car owners' preferences for motorized emission reduction attributes in Nairobi, Kenya with an account for both taste and scale heterogeneity. Consequently, five models (MNL, MXL, S-MNL, G-MNL and G-MXL) with only attributes as random parameters were estimated to unveil the implicit prices, compare model

performance and assess how best the models are able to account for taste and scale variation in the choice data. Car owners were thus presented with attributes on fuel use measured in how many litres of fuel (fossil or biofuel) a motor vehicle could drive per 100 kilometres, exhaust gas emission level measured in milligrams of carbon dioxide discharged per kilometer driven, and the extra fuel price paid for each litre of fuel burnt to improve fuel use efficiency and at the same time reduce exhaust gas emissions. Both log likelihood and three information criteria (AIC, BIC and CAIC) were used to evaluate model performance and the way models accounted for taste and scale heterogeneity.

The results have shown that the coefficient signs in all the models were consistent with a priori and theoretical expectations. The coefficient signs of the ASCs for fossil fuel and biofuel use were positive and significant meaning that car owners were likely to derive greater utility from the two fuel alternatives as opposed to the status quo option. The coefficients for fuel use, level of exhaust gas emission and fuel price increase were however negative and significant meaning that an increase in the level of any of the attributes would lead to lesser utility for the car owners.

Findings from the study have also shown that G-MXL model outperformed the G-MNL, S-MNL, MXL and MNL models using both the log likelihood and the three information criteria, namely, AIC, BIC and CAIC. The G-MXL model is therefore recommended in this paper as most appropriate behavioural model in stated choice analysis even though this may also be dictated by the data under consideration. The study findings also show that the MXL model all along outperformed the MNL model, which advises about the importance of accounting for taste heterogeneity in model estimation. The S-MNL model also outperformed the MXL meaning that scale heterogeneity was also more important than taste heterogeneity in this case. The G-MNL and G-MXL model specifications further improved model performance

compared to S-MNL, MXL and MNL formulations meaning that there was significant taste and scale heterogeneity across respondents that together needed to be accounted for.

As for the welfare estimates, it is evident that estimates of the WTP in all the models were statistically significant with reasonable confidence intervals. In addition, the S-MNL and G-MXL models generally provided higher WTP estimates in comparison to all the other models. The magnitudes of WTP estimates were also very similar for all the models on emission level attribute. Apart from for the attribute on emission level, there were significant differences in the WTP estimates among the models, which means that welfare estimates were sensitive to model specifications, notwithstanding the significant heterogeneity in taste and scale across individuals studied in this paper.

On the whole, the kind of evidence presented in this paper strongly suggests that future stated choice studies should further endeavour to provide more comparative empirical studies about various modelling approaches to individual heterogeneity especially with choice data valuing less familiar environmental goods and services in the developing world. This would contribute to building more consensus on the preferred approach to modelling choice data and individual heterogeneity.

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CHAPTER SIX

Summary, Conclusions and Recommendations

6.1 Introduction

The goal of this study was to carry out an economic valuation of air quality improvements in the city of Nairobi, Kenya based on two non market valuation approaches, namely, CV and DCEs. The aim was to provide relevant policy and methodological valuation information that could be used by the research community to inform decisions on air quality management especially in the urban areas. Thus, in this final section of the study, a summary, conclusions and recommendations derived from the study findings are presented.

6.2 Summary and conclusions

The study had five objectives based on the information gaps identified in the literature. In the first objective, the study analyzed the stated preferences for improved air quality management in the city of Nairobi, Kenya based on responses from the conventional payment card elicitation format. The research was inspired by the need to estimate the policy value of implementing a motorized emission control plan in the city since air quality problems to human health and to the environment were reaching unprecedented levels.

The preliminary findings have shown that people in Nairobi were well aware of air pollution problems in the city. They also identified motor vehicles as the primary cause of low air quality problems due to their emission of toxic gases and dust particles into the atmosphere. The city residents were also familiar with the adverse effects of motorized emissions to human health and the environment and as a result, majority of them were willing to pay positive amounts towards emission reductions in the city. While there were few people willing to pay true zero amounts towards the same course citing ‘overwhelming household

financial commitments,' a few others protested against the motorized emissions control plan. They said that either the government or the motor vehicle owners needed bear all the responsibilities associated with the costs of air clean-up plans. In fiscal terms, interval regression results showed that individuals in the city were, on average, willing to pay Kshs. 396.57 ($4.67) to reduce vehicular emissions. The median willingness to pay was Kshs. 244.94, which is equivalent to $2.88. This amounted to about 2.04% and 1.26% of respondents' average income, respectively. As for the determinants of respondents' willingness to pay, study findings indicate that respondents' age, gender, income, motor vehicle ownership, certainty about future income and the area of residence had significant effect on peoples' willingness to pay decision for motorized emission reductions.

In the second objective, the study purposed to estimate and compare welfare estimates of individuals across stated preference and uncertainty elicitation formats for air quality improvements in the city of Nairobi. The motivation was to test the hypothesis that respondent uncertainty had no significant effect on the underlying welfare estimates of individuals for motorized emission reductions in the city that were elicited through the conventional PC, SPC and the PPC. The results showed that the way WTP values are elicited, with and without ability to express preference uncertainty, had significant effect on the underlying welfare estimates of individuals. That is, allowing respondents to express their experienced uncertainty when stating WTP values yielded more conservative, but less accurate WTP values for inclusion in policy analysis. Never the less, PPC format was seen to hold most promise since it was easier to understand and imposed less cognitive burden on survey participants than the SPC especially in a developing country context. The study also found that age, gender and income of the respondents, distance respondents resided from nearby roads, motor vehicle ownership and individuals' certainty about future incomes had statistically significant effects on individuals' WTP decision. Significant determinants of

individuals' preference uncertainty were bid levels, age, gender and income of the respondent, distance from nearby roads, motor vehicle ownership and individuals' certainty about future incomes.

In the third objective, the survey evaluated the scope effects of respondent uncertainty in CV method with evidence from motorized emission reductions in the city of Nairobi. The study applied the convention PC, SPC and PPC formats to elicit individuals WTP for the bottom-up (25% then 50%) and top-down (50% then 25%) motorized emission reductions based on advance disclosure approach. This enabled testing of various hypotheses on 'within' and 'between' respondents WTP in order to ascertain whether respondents were internally and externally sensitive to scope. While the PC format conventionally assumes that respondents are certain about their WTP, SPC and the PPC formats assume that respondents are uncertain and therefore, allow them to express their level of uncertainty. Hence, the use of SPC and PPC formats, based on the findings of the PC format, enabled the testing of whether or not respondent uncertainty had influence on individuals' sensitivity to scope.

The study findings showed that individual responses for motorized emission reductions in the city were both internally and externally scope sensitive except for the findings under the PPC format in the latter case. These findings were generally consistent with economic theory, which supposes that welfare estimates should be sensitive to changes in the magnitudes of the good under valuation. The results also made a novel contribution to CV literature regarding scope tests under conditions of respondent uncertainty. It was established that when individuals are given the opportunity to express their uncertainty, as in SPC and PPC formats, it was likely that they would be less sensitive to scope than in the case where they are assumed to be certain, as in PC format. Therefore, accounting for respondent uncertainty had the potential to lower the scope sensitivity of individuals in CV.

In regard to the determinants of individuals' sensitivity to scope, the study findings show that age and gender of the respondent, respondents' income, distance respondents dwell from nearby roads, motor vehicle ownership and the area of residence have statistically significant influence on the sensitivity of individuals' WTP for emission reductions. The '*scope'* variable, which is both positive and significant implies that respondents in the survey were willing to pay larger amounts for larger emission reductions than for smaller reductions hence, sensitive to scope. The '*format'* variable, which is negative and significant means that allowing respondents to express their uncertainty would yield significantly lower payments for motorized emission reductions than when respondents are assumed to be certain about their preferences. On the whole, this study initiated a better understanding of the relationship between respondent uncertainty and scope sensitivity in CV. The results suggest that city planners and policy makers in Nairobi and beyond ought to take respondent uncertainty into account while analyzing increamental benefits from air quality management programmes as this would yield precise estimates of welfare change.

In the fourth objective, the survey evaluated the implicit prices that car owners in Nairobi were willing to pay for motorized emission reduction attributes. This was motivated by the need to test the hypothesis that the underlying implicit prices for motorized emission reduction attributes among car owners in the city of Nairobi were positive and thus, would support policy decisions regarding the introduction of low emission and fuel efficient vehicles. The study found that the WTP estimates in all the models were statistically significant and that car owners' WTP for fossil fuels was higher than that of biofuel. Furthermore, MXL and G-MNL models provided conservative WTP estimates as opposed to MNL, S-MNL and G-MXL models. Conservative WTP estimates were also obtained for fuel use and emission level attributes across the five models. By and large, the G-MXL and S-MNL models, yielded higher WTP estimates compared to all the other models. With the

exception of the attribute on emission level, a t-test analysis established that there were infact significant differences in the WTP estimates between the models meaning that the estimates may have been sensitive to model specifications, notwithstanding significant taste and scale heterogeneity across the individuals.

In the fifth objective, the survey purposed to look at the relative performance of five behavioural models, the MNL, MXL, S-MNL, G-MNL and G-MXL in addition to finding out how best the models were able to account for preference variation in the choice data. The aim was to conduct a test that would further our understanding as to whether the G-MXL model specification generally performs better than the other choice models and whether it it would account for preference variation better than the other models. Study findings show that the G-MXL model performed better than all the other models based on the log likelihood information. In addition, results from the Akaike Information Criteria also show that the G-MXL model dominated all the other models. There was also substantial improvement in all the three information criteria for the S-MNL model over the MNL model with the S-MNL model also performing better than the MXL model. Nevertheless, the MXL model outperformed the MNL model based on both the log likelihood and all the three information criteria. On individual heterogeneity, accounting for taste variation in the MXL model enhanced its log likelihood over the standard MNL values. Equally, accounting for scale variation in the S-MNL model was also seen to enhance its log likelihood over the MNL values. Apparently, the S-MNL model was found to perform better than the MXL model based on the log likelihood, which represents the amount of scale variation in the choice data was not accounted for in the MXL model. It also means that scale variation was more important than taste heterogeneity (Scarpa *et al*., 2011) in our choice data. The G-MNL model, which accounts for both taste and scale variation in the choice data had a higher log likelihood than the MNL model. The G-MXL model specification, which also accounts for

both taste and scale variation, had the largest log likelihood improvement over the MNL values. The scale parameter, τ, was found to be statistically significant in the S-MNL, G-MNL and G-MXL models, which means that there was considerable degree of scale heterogeneity in the choice data. The weighting parameter, γ, was also found very close to zero and this implies that the variance of the random taste heterogeneity increased with scale.

Several implications arise from the findings of this study. First, since air quality problems in the city are continuously deteriorating owing to increased motorization, the concerned authorities could now use the WTP estimates to formulate their budget estimates and policy proposals for emission reduction plans. Secondly, the city authorities could also use the findings of the study to adjust their budgetary and policy proposals for the socio-demographic characteristics of individuals as they have been found to have significant effects of the amounts people are willing to pay to reduce motorized emissions. Thirdly, researchers involved in choice analysis ought to use the G-MXL model since it has been found to perform better than G-MNL, S-MNL, MXL and MNL models. Lastly, the use of the G-MXL model is further recommended in choice analysis since it is found to acoount for both taste and scale variation better than the G-MNL model though this may also depend on choice data in question.

6.3 Recommendations

Firstly, despite the foregoing findings of the study, more CV surveys are still required in order to understand specific policy values of tackling environmental and/or human health related problems (e.g. respiratory diseases, damage to city buildings and contamination of water dams) due to motorized emissions. These surveys would help in providing wide-ranging policy information to the decision makers on how to deal with the different problems that from motor vehicle emissions. Secondly, even though the study has provided additional

evidence that accounting for response uncertainty has a downward effect on the underlying welfare estimates of individuals in CV, there is need for more studies on the effects that respondent uncertainty has on individuals' welfare estimates from different countries and with different case studies and models in order to corroborate the results of this study. Thirdly, even though the study has also initiated a better understanding of the relationship between respondent uncertainty and scope sensitivity in CV and therefore, appear to support the use of the CV method in studying the increamental benefits and costs of environmental policies, more research is however, recommended on this subject using different environmental goods and services in order to better our understanding about the already established relationship between respondent uncertainty and scope sensitivity. Fourthly, the kind of evidence presented about DCE strongly suggests that future stated choice studies should further endeavour to provide more comparative empirical studies about other modelling approaches to individual heterogeneity especially with choice data valuing less familiar environmental goods and services from the developing world. This would contribute to building more consensus on the preferred approach to modelling choice data and individual heterogeneity.

Appendices

The conventional payment card (PC)

	Value
□	KSh. 0
□	KSh. 25
□	KSh. 50
□	KSh. 75
□	KSh. 100
□	KSh. 150
□	KSh. 200
□	KSh. 250
□	KSh. 300
□	KSh. 400
□	KSh. 500
□	KSh. 800
□	KSh. 1000
□	KSh. 1500
□	KSh. 2000

The stochastic payment card (SPC)

Value	Definitely Yes	Probably Yes				Not Sure	Probably No				Definitely No
KSh. 0	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
KSh. 25	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
KSh. 50	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
KSh. 75	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
KSh. 100	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
KSh. 150	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
KSh. 200	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
KSh. 250	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
KSh. 300	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
KSh. 400	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
KSh. 500	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
KSh. 800	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
KSh. 1000	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
KSh. 1500	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
KSh. 2000	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0

The polychotomous payment card (PPC)

Value	Definitely Yes	Probably Yes	Not Sure	Probably No	Definitely No
KSh. 0	□	□	□	□	□
KSh. 25	□	□	□	□	□
KSh. 50	□	□	□	□	□
KSh. 75	□	□	□	□	□
KSh. 100	□	□	□	□	□
KSh. 150	□	□	□	□	□
KSh. 200	□	□	□	□	□
KSh. 250	□	□	□	□	□
KSh. 300	□	□	□	□	□
KSh. 400	□	□	□	□	□
KSh. 500	□	□	□	□	□
KSh. 800	□	□	□	□	□
KSh. 1000	□	□	□	□	□
KSh. 1500	□	□	□	□	□
KSh. 2000	□	□	□	□	□

Questionnaires:

This study employed 14 different versions of the questionnaire based on the objectives of the study. The table below summarizes the different versions of questionnaires used in the study.

No	Study objective	Questionnaire type	Questionnaire description
1	1,2,3	PC - Survey Questionnaire - 25% - 50%	Payment card BU
2	1,2,3	PC - Survey Questionnaire - 50% - 25%	Payment card TD
3	1,2,3	SPC - Survey Questionnaire - 25% - 50%	Stochastic Payment card BU
4	1,2,3	SPC - Survey Questionnaire - 50% - 25%	Stochastic Payment card TD
5	1,2,3	PPC - Survey Questionnaire - 25% - 50%	Polychotomous Payment card BU
6	1,2,3	PPC - Survey Questionnaire - 50% - 25%	Polychotomous Payment card TD
7	4,5	DCE – Survey Questionnaire Version 1	WTP Before CE Kshs. 0.50
8	4,5	DCE – Survey Questionnaire Version 2	WTP Before CE Kshs. 1.00
9	4,5	DCE – Survey Questionnaire Version 3	WTP Before CE Kshs. 1.50
10	4,5	DCE – Survey Questionnaire Version 4	WTP Before CE Kshs. 2.00
11	4,5	DCE – Survey Questionnaire Version 5	WTP After CE Kshs. 0.50
12	4,5	DCE – Survey Questionnaire Version 6	WTP After CE Kshs. 1.00
13	4,5	DCE – Survey Questionnaire Version 7	WTP After CE Kshs. 1.50
14	4,5	DCE – Survey Questionnaire Version 8	WTP After CE Kshs. 2.00

All these questionnaires are available from the author on request. However, for the purpose of this thesis, four different general versions of the questionnaire are appended here below. Notably, it is from these general versions that the 14 specific versions were derived.

Economic Valuation of Air Quality in Kenya

The Payment Card Survey Questionnaire

Name of the administrative area:…...……..……..
Interviewer's name: ……...……..……
Date:……..……

Preamble

I am a PhD student in Environmental Economics at the University of Pretoria in South Africa conducting academic research towards my thesis on ***"Economic Valuation of Air Quality in Kenya."*** The study is all about knowing the value you would pay for air quality improvement in the city of Nairobi. As such, you have been selected, through a random sampling procedure, as one of the persons to participate in this survey. Your answers are voluntary and will be kept strictly confidential. To begin with, I would like to ask you the following few questions:

a) Have you ever heard about air pollution?
1. YES 2. NO

If **YES,** continue with the interview. If **NO,** discontinue the interview and move on to the next respondent.

b) What is it (air pollution)?
……
……
……

d) What are the **MAIN** problems associated with air pollution?
……
……
……
……

c) According to you, what is the **MAIN** source of air pollution?
1) Factories/industries
2) Farming activities e.g. burning of farm waste.
3) Motor vehicles.
4) Household activities e.g. burning of waste.

e) Do you think Nairobi suffers from air quality problems?
1. YES 2. NO

f) If the answer is yes, what is the **MAIN** air quality problem in Nairobi?
……
……
……
……

Purpose of the survey

Generally, the consumer demand for most goods is generally regulated through the market price of the goods we trade. Most environmental goods such as the quality of the air we breathe cannot however be regulated through the market because these goods have no market prices and hence cannot be traded. Setting a price on these goods is also complex because it might be hard to exclude people from enjoying benefits of the goods (e.g. improved air quality) that they may not have paid for. This leads to misuse and/or overuse and eventual deterioration of the environmental goods. To repair this deterioration requires policy measures to be undertaken by the relevant stakeholders. The application of these policy measures, inevitably, gives rise to a cost, which directly or indirectly has to be paid by all of us. The contamination of air by motor vehicle emissions in Nairobi indirectly excludes many persons from the essential right to breathe clean air. In order to compare the social costs of air contamination and the required costs to improve air quality together with the benefits that clean air gives us, it is necessary to know individuals willingness to pay for air quality improvements. Therefore, this survey intends to know how much, you as an individual, would be willingness to pay for a new policy proposal on air quality improvement through motorized emission reductions in the city of Nairobi, Kenya.

The Questionnaire

The questionnaire is divided into three sections, namely: A B and C. Questions belonging to section A are directly related to the problem of motor vehicle emissions. Section B contains the hypothetical scenario and the valuation questions and section C has questions related to personal data such as age, income and so on.

Section A (Questions on motor vehicle emissions)

g) From your own understanding, how would you categorize motor vehicle emission problem? (one answer).
   1) as a political problem.
   2) as an economic problem.
   3) as a social problem.
   4) as an environmental problem.

h) According to you, motor vehicle emission problems are issues that concern who?
   1) Government agencies e.g. NEMA, local authorities, the police.
   2) Non-governmental organizations e.g. owners associations.
   3) Business community.
   4) Every citizen in Kenya.

i) What degree of seriousness would you place on the problem of motor vehicle emissions?
   1) Very serious.
   2) Serious.
   3) Less serious.

j) What do you think of the concerned authorities with regard to vehicular emissions reduction in Nairobi?
   1) They have given a lot of attention to the problem.
   2) Only some attention to the problem.
   3) Not too much attention to the problem.
   4) No attention at all.

k) Which **ONE** of the following measures should be applied in Nairobi to cut motor vehicle emissions?
   1) A fuel tax. 2) Regulation of traffic. 3) Improvement in road infrastructure.
   4) A road toll for entering Nairobi. 5) Building bicycle lanes to enhance the use of bicycles.
   6) Use of quality fuel (e.g. biofuel) 7) use of low emission and fuel efficient vehicles

Section B

Description of air quality problem in Nairobi

The increase in the number of motor vehicles over the last ten years in the city of Nairobi has resulted in a substantial deterioration of air quality. It has also made the city to be one of the most polluted urban areas in Kenya. High concentrations of toxic gases such as carbon dioxide, nitrogen oxide, sulphur dioxide among others are emitted from both public and private motorized vehicles like cars, motors and buses. High concentrations of these gases affect human health and can lead to respiratory diseases like asthma. To reduce these harmful emissions from motor vehicles, extra measures are required and would come at a cost to you. For instance, the formulation and implementation of a policy proposal on the use of low-emission and fuel-efficient vehicles is a promising measure to reduce emissions from vehicles but, can only be formulated and implemented at a cost to you. In the next part, I am interested in your preferences for the policy proposal to cut motorized emissions in the city of Nairobi. I will therefore present a situation that would help formulate and implement this policy proposal.

The hypothetical scenario

Consider the following hypothetical situation. Suppose relevant stakeholders comprising of environmental groups, county planners, natural resource managers and interested citizens introduce a “special vehicular emission control trust fund" into which individuals are to make a one-off payment to restore air quality in Nairobi. The restoration fund is to ensure appropriate policy measures are undertaken to guarantee motor vehicle emissions are reduced to the minimum standards prescribed by National Environment Management Authority (NEMA) and the World Health Organization (WHO). The contribution to the fund would be exclusively used to help the stakeholders formulate and implement the relevant policy measures to cut automobile emissions. This would ensure that air quality in the city is restored to avoid unnecessary side-effects of vehicle emissions to the natural and built environment and also to human health. If you make the payment into this special trust fund towards motor vehicle emissions control, you will avoid the side effects of motor vehicle emissions such as diseases and dark colouration of natural and the built environment. In the part that is following, I am interested to know how much you would be willing to pay for motorized emission reductions in Nairobi. I will therefore ask you two questions about your willingness to pay towards the new policy proposal for reducing motor vehicle emissions by 25% and 50%.

l) ***What would you be willing to pay and with what level of certainty for the new policy to reduce motor vehicle emissions by x% in Nairobi (show picture to respondents) if it meant that you will contribute Kshs. X into the special fund? (Please circle or tick one amount).***

Kshs. 0	Kshs 150	Kshs 500
Kshs. 25	Kshs 200	Kshs 800
Kshs. 50	Kshs 250	Kshs 1000
Kshs. 70	Kshs 300	Kshs 1500
Kshs. 100	Kshs 400	Kshs 2000

m) ***What would you be willing to pay and with what level of certainty for the new policy to reduce motor vehicle emissions by x% in Nairobi (show picture to respondents) if it meant that you will contribute Kshs. X into the special fund? (Please circle or tick one amount).***

Kshs. 0	Kshs 150	Kshs 500
Kshs. 25	Kshs 200	Kshs 800
Kshs. 50	Kshs 250	Kshs 1000
Kshs. 70	Kshs 300	Kshs 1500
Kshs. 100	Kshs 400	Kshs 2000

n) If the answer to questions (I &m) is Kshs. 0 (zero), which of the following reasons best describes why you would "not" be willing to pay anything to the special trust fund to control motor vehicle emissions?

1) Because air quality improvement has no value to me.
2) Because it is the responsibility of the Government.
3) Because I have many other basic financial commitments.
4) Other.....

o) Which one of the following payment methods would you prefer to use in making your contribution towards motor vehicle emissions control policy in Nairobi?

a) Donations e.g. labour.
b) Special fund e.g. an account managed by trustees.
c) Amenity bills e.g. amount to be paid added to water bills, electricity bills.
d) Some environmental tax deducted straight from one's income.

Section C

This section concerns personal data of the respondents as related to the study. Indicate the responses in the response box shown as 0, 1,2,3,4 etc.

Variable	Description	Measurement	Response
a) Age of the house hold head.	What is the age of the household head?	1=below 20 years 2 = 20-30 years 3 = 31-40 years 4 = 41-50 years 5 = 51-60 years 6= above 60 years	
b) Gender of the household head.	What is the gender of the head of the household?	1= male 0 = otherwise	
c) Education of the household head.	What is the level of formal schooling attained by the head of the household?	1= No education 2= Primary 3= Secondary 4= Tertiary 5= University	
d) Income level of the household	What is the monthly income level of the head of the household?	1=below Kshs. 10, 000 2 = Kshs. 10,001-20,000 3 = Kshs. 20,001-30,000 4 = Kshs. 30,001-40,000 5 = Kshs. 40,001-50,000 6= Kshs. 50,001-60,000 7= Above Kshs. 60,000	
e) Household size.	What is the number of family members in the household?	1= 1 people 2= 2 people 3= 3 people 4= 4 people 5= 5 people 6 = above 5 people	
f) Distance household head resides from the nearest road.	What is the distance to the nearest road that the household resides?	1= below 50 metres 2= 51-100 metres 3= 101-150 metres 4= 151-200 metres 5= 201-250 metres 6 = above 250 metres	

g) Special trust fund.	Is the household head confident about the hypothetical trust fund used as the payment vehicle for the WTP amount?	1= yes 0 = otherwise	
h) Knowledge.	Does the household head know the effects of vehicular emissions such as the respiratory effects?	1= yes 0 = otherwise	
i) Necessity.	Does the household head find it necessary to control vehicular emissions?	1= yes 0 = otherwise	
j) Vehicle ownership.	Does the household head own a motor vehicle?	1= yes 0 = otherwise	
k) Certainty of future income.	Is the household head certain about her future income?	1= yes 0 = otherwise	
l) Name of the urban area the household lives	Does the household live in the CBD or in the outskirts (i.e. Embakasi, Kawangware or Kitengela)?	1= CBD 0= otherwise	

THANK YOU FOR YOUR COOPERATION

Economic Valuation of Air Quality in Kenya

The Stochastic Payment Card Survey Questionnaire

Name of the administrative area:…..……..……..
Interviewer's name: ……..……..……
Date:……..…….

Preamble

I am a PhD student in Environmental Economics at the University of Pretoria in South Africa conducting academic research towards my thesis ***"Economic Valuation of Air Quality in Kenya."*** The study is all about knowing the value you would pay for air quality improvement in the city of Nairobi. As such, you have been selected, through a random sampling procedure, as one of the persons to participate in this survey. Your answers are voluntary and will be kept strictly confidential. To begin with, I would like to ask you the following few questions:

a) Have you ever heard about air pollution?
1. YES **2. NO**

If **YES,** continue with the interview. If **NO,** discontinue the interview and move on to the next respondent.

b) What is it (air pollution)?
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d) What are the **MAIN** problems associated with air pollution?
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c) According to you, what is the **MAIN** source of air pollution?
1) Factories/industries
2) Farming activities e.g. burning of farm waste.
3) Motor vehicles.
4) Household activities e.g. burning of waste.

e) Do you think Nairobi suffers from air quality problems?
1. YES **2. NO**

f) If the answer is yes, what is the **MAIN** air quality problem in Nairobi?
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Purpose of the survey

Generally, the consumer demand for most goods is generally regulated through the market price of the goods we trade. Most environmental goods such as the quality of the air we breathe cannot however be regulated through the market because these goods have no market prices and hence cannot be traded. Setting a price on these goods is also complex because it might be hard to exclude people from enjoying benefits of the goods (e.g. improved air quality) that they may not have paid for. This leads to misuse and/or overuse and eventual deterioration of the environmental goods. To repair this deterioration requires policy measures to be undertaken by the relevant stakeholders. The application of these policy measures, inevitably, gives rise to a cost, which directly or indirectly has to be paid by all of us. The contamination of air by motor vehicle emissions in Nairobi indirectly excludes many persons from the essential right to breathe clean air. In order to compare the social costs of air contamination and the required costs to improve air quality together with the benefits that clean air gives us, it is necessary to know individuals willingness to pay for air quality improvements. Therefore, this survey intends to know how much, you as an individual, would be willingness to pay for a new policy proposal on air quality improvement through motorized emission reductions in the city of Nairobi, Kenya.

The Questionnaire

The questionnaire is divided into three sections, namely: A B and C. Questions belonging to section A are directly related to the problem of motor vehicle emissions. Section B contains the hypothetical scenario and the valuation questions and section C has questions related to personal data such as age, income and so on.

Section A (Questions on motor vehicle emissions)

g) From your own understanding, how would you categorize motor vehicle emission problem? (one answer).
   1) as a political problem.
   2) as an economic problem.
   3) as a social problem.
   4) as an environmental problem.

h) According to you, motor vehicle emission problems are issues that concern who?
   1) Government agencies e.g. NEMA, local authorities, the police.
   2) Non-governmental organizations e.g. owners associations.
   3) Business community.
   4) Every citizen in Kenya.

i) What degree of seriousness would you place on the problem of motor vehicle emissions?
   1) Very serious.
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   3) Less serious.

j) What do you think of the concerned authorities with regard to vehicular emissions reduction in Nairobi?
   1) They have given a lot of attention to the problem.
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   4) No attention at all.

k) Which **ONE** of the following measures should be applied in Nairobi to cut motor vehicle emissions?
   1) A fuel tax. 2) Regulation of traffic. 3) Improvement in road infrastructure.
   4) A road toll for entering Nairobi. 5) Building bicycle lanes to enhance the use of bicycles.
   6) Use of quality fuel (e.g. biofuel) 7) use of low emission and fuel efficient vehicles

Section B

Description of air quality problem in Nairobi

The increase in the number of motor vehicles over the last ten years in the city of Nairobi has resulted in a substantial deterioration of air quality. It has also made the city to be one of the most polluted urban areas in Kenya. High concentrations of toxic gases such as carbon dioxide, nitrogen oxide, sulphur dioxide among others are emitted from both public and private motorized vehicles like cars, motors and buses. High concentrations of these gases affect human health and can lead to respiratory diseases like asthma. To reduce these harmful emissions from motor vehicles, extra measures are required and would come at a cost to you. For instance, the formulation and implementation of a policy proposal on the use of low-emission and fuel-efficient vehicles is a promising measure to reduce emissions from vehicles but, can only be formulated and implemented at a cost to you. In the next part, I am interested in your preferences for the policy proposal to cut motorized emissions in the city of Nairobi. I will therefore present a situation that would help formulate and implement this policy proposal.

The hypothetical scenario

Consider the following hypothetical situation. Suppose relevant stakeholders comprising of environmental groups, county planners, natural resource managers and interested citizens introduce a “special vehicular emission control trust fund" into which individuals are to make a one-off payment to restore air quality in Nairobi. The restoration fund is to ensure appropriate policy measures are undertaken to guarantee motor vehicle emissions are reduced to the minimum standards prescribed by National Environment Management Authority (NEMA) and the World Health Organization (WHO). The contribution to the fund would be exclusively used to help the stakeholders formulate and implement the relevant policy measures to cut automobile emissions. This would ensure that air quality in the city is restored to avoid unnecessary side-effects of vehicle emissions to the natural and built environment and also to human health. If you make the payment into this special trust fund towards motor vehicle emissions control, you will avoid the side effects of motor vehicle emissions such as diseases and dark colouration of natural and the built environment. In the part that is following, I am interested to know how much you would be willing to pay for motorized emission reductions in Nairobi. I will therefore ask you two questions about your willingness to pay towards the new policy proposal for reducing motor vehicle emissions by 25% and 50%.

I) ***What would you be willing to pay and with what level of certainty for the new policy to reduce motor vehicle emissions by x% in Nairobi (show picture to respondents) if it meant that you will contribute Kshs. X into the special fund? (Please indicate the level of certainty by circling the probability to pay each one of the amounts shown in the table below).***

Bid	Definitely yes	Probably yes				Not sure	Probably no				Definitely no
Kshs. 0	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
Kshs. 25	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
Kshs. 50	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
Kshs. 70	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
Kshs. 100	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
Kshs. 150	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
Kshs. 200	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
Kshs. 250	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
Kshs. 300	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
Kshs. 400	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
Kshs. 500	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
Kshs. 800	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
Kshs. 1000	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
Kshs. 1500	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
Kshs. 2000	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0

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n) If the answer to questions (l &m) is Kshs. 0 (zero), which of the following reasons best describes why you would "not" be willing to pay anything to the special trust fund to control motor vehicle emissions?

1) Because air quality improvement has no value to me.
2) Because it is the responsibility of the Government.
3) Because I have many other basic financial commitments.
4) Other.....

o) Which one of the following payment methods would you prefer to use in making your contribution towards motor vehicle emissions control policy in Nairobi?

a) Donations e.g. labour.
b) Special fund e.g. an account managed by trustees.
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THANK YOU FOR YOUR COOPERATION

Economic Valuation of Air Quality in Kenya

The Polychotomous Payment Card Survey Questionnaire

Name of the administrative area:…....………….………………………………………………..
Interviewer's name: ……………..……………………………….……………………………
Date:…………………………………………………………..…………………………………..

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Kshs. 50											
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THANK YOU FOR YOUR COOPERATION

THE DCE SURVEY

****

This survey aims to assess public perception of motor vehicle emission levels in Nairobi, Kenya.

0. Do you currently own a vehicle?

0 No, I don't own a vehicle (STOP THE INTERVIEW).

1 Yes, I am a vehicle owner (CONTINUE THE INTERVIEW).

The questionnaire will take no more than 15 minutes. You do not need to know much about motor vehicle emissions and there are no right or wrong answers. We are simply interested in your opinion.

Your answers will be treated strictly confidential. Your answers will not be shared with anyone else and only used for this independent study carried out by Moi University. Your anonymity will be guaranteed. **Your opinion is highly valued and your time is greatly appreciated!**

****

1. What type of motorized vehicle do you have (brand and type)?

1 Car, namely ……..……
2 Motor, namely ……
3 Other, namely ……

2. How old is the vehicle? ……..….... years

3. How many years do you have the vehicle? …….... years

4. How often do you use your vehicle?

1 Not very often, at most once every fortnight (2 weeks)
2 Regularly, at least 1-2 times per week
3 Often, almost every day
4 Every day
5 Other, namely …….

5. What do you use your vehicle for?
(multiple answers possible)

1 To drive to work
2 To pick up groceries/go shopping
3 To tour around
4 Other, namely …….

6. How many kilometers do you drive on average every month in your vehicle?

1	<50 km	6	201-300 km
2	50-75	7	301-400
3	76-100	8	401-500
4	101-150	9	501-750
5	151-200	10	More than 750 km per month, namely ……

7. How much do you currently spend on average on fuel costs per month?

Kshs.……..……..……. per month

8. What fuel type do you use?

1 Petrol
2 Diesel
3 Biofuel
4 Other, namely …….....

9. How many kilometers does your vehicle drive on average on one liter of fuel?…… km

10. What was the most important reason why you bought this particular vehicle?
(please state at most 3 reasons, starting with the most important one (=1), followed by the second most important one (=2) and finally the third most important reason (=3))

... Brand/type
... Price/affordability
... Fuel type (gas/ petrol/diesel)
... Engine power
... Size/number of doors
... Colour
… Petrol/diesel use efficiency (liters/km)
... Other, namely …….

11. Does your vehicle have an exhaust filter?

0 No
1 Yes
2 I don't know

12. How much exhaust gases does your vehicle emit in your view?

1 Not a lot
2 Somewhat
3 A lot
4 I don't know

13. How much exhaust gases does your vehicle emit compared to other vehicles?

1 Less
2 The same
3 More
4 I don't know

14. Did environmental concerns play a role in your decision whether or not to buy your current vehicle, such as fuel use efficiency or exhaust gases?

0 No
1 Yes, fuel use efficiency
2 Yes, exhaust gases
3 Yes, both fuel use and exhaust gases
4 Yes, other environmental concerns, namely ……..

15. How concerned are you about air pollution in Nairobi?

0 Not concerned at all
1 Somewhat concerned
2 Very concerned

16. What are in your view the most important sources of air pollution in Nairobi?

(please state at most 3 sources, starting with the most important one (=1), followed by the second most important one (=2) and finally the third most important pollution source (=3))

... Smoke/emissions from factories/industry
... Smoke from waste burning by residential households
,,. Dust particles from wind
... Bad odour from uncollected waste in the city
... Exhaust gases from buses
... Exhaust gases from motors
… Exhaust gases from cars
... Other, namely ……

17. How far do you live from the nearest highway? ……..…….....Km

18. Do you believe air pollution is bad for your health?

0 No
1 Yes
2 I don't know

19. If so, how do you rate the health risk from air pollution compared to for example the health risk from drinking polluted water?

1 I rate the health risk from air pollution lower
2 I rate the health risk from air pollution equally high as drinking polluted water
3 I rate the health risk from air pollution higher
4 I don't know

20. Do you believe you can die from air pollution?

0 No
1 Yes
2 I don't know

21. Do you believe air pollution is bad for the environment?

0 No
1 Yes
2 I don't know

22. How familiar are you with carbon dioxide emissions?

0 Not familiar at all (I never heard of it / I don't know what these are) >> GO TO QUESTION 24
1 Somewhat familiar
2 Very familiar

23. If you are somewhat or very familiar with carbon dioxide emissions, can you explain what these are?

……

24. How concerned are you about carbon dioxide emissions from motor vehicles in Nairobi?

0 Not concerned at all
1 Somewhat concerned
2 Very concerned

25. Do you believe there is a need to control car exhaust emissions in Nairobi?

0 No
1 Yes
2 I don't know

[CHOICE EXPERIMENT]

I will now briefly read out some information, followed by some cards. The increase in the number of motor vehicles in the last 10 years in Nairobi has resulted in a substantial deterioration of air quality. High concentrations of toxic gases such as carbon dioxide are emitted from public and private motorized vehicles like cars, motors and buses. High concentrations of these gases affect human health and can lead to respiratory diseases like asthma. To reduce these harmful emissions from motor vehicles, extra measures are required. The use of low-emission fuels and fuel-efficient vehicles are considered promising measures to reduce emissions from vehicles. In the next part, I'm interested in your opinion and your preferences for renewable, low emission fuels like biofuel. Biofuel is made of biological ingredients such as plant material, vegetable oils and treated municipal and industrial waste. It can be added to existing petroleum based fuels or used in a pure form as ethanol, biodiesel or biogas. The advantage of using biofuel is twofold: it reduces the dependence on fossil fuels and generates no or much less emission.

26. Have you ever heard of biofuel before?

0 No
1 Yes

27. Are you willing to pay <u>0.50</u> Kshs per liter extra for biofuel over and above the current fuel price to reduce the emission of exhaust gases from your vehicle by 50% and improve air quality in Nairobi?

0 No
1 Yes
2 I don't know

28. On a scale from 0 (completely uncertain) to 10 (completely certain), how certain are you that you would actually pay this amount of money?

Payment certainty 0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10

I will show you 10 cards which describe the characteristics of 2 fuel types, that is, the conventional fossil fuel you currently use (petrol or diesel) and biofuel, which is a new type of fuel based on biological material like plants and vegetable oils. The characteristics of the fuel types relate to the fuel use efficiency, that is, how many kilometers a vehicle can drive on one litre of fuel, the exhaust gas emission level of each fuel type, measured in milligrams of carbon dioxide per kilometer driven, and the extra fuel price you are being asked to pay for each litre of fuel to improve the efficiency of the fuel and at the same time reduce the emission level of exhaust gases from your vehicle. You only have to say which of the two fuel types you prefer. I will first show you an example card.

INTERVIEWER INSTRUCTION: SHOW THE EXAMPLE CARD

This is the example card. You see the two fuel types, the ordinary fossil fuel you and others currently used for your cars, that is either petrol or diesel, and biofuel. In this example card, we assume that biofuel can drive you twice as far on one liter of fuel than fossil fuels like petrol or diesel and emits a third of the amount of carbon dioxide compared to petrol or diesel. You need 7 liter biofuel in this example to drive 100 km and twice as much fossil fuel (14 liter) to drive the same distance of 100 km. Fossil fuels at the same time emit 3 times as much carbon dioxide as biofuel in this example. Or the other way around: biofuels emit only a third of the fossil fuel. Most vehicles in Nairobi emit about 150g of CO_2 per km. This most probably includes your own vehicle too. So, an emission level of 50g for biofuel is a reduction of 67% compared to the emission level of most vehicles, whereas an emission level of 150g for the conventional fuel is the same as what most vehicles currently emit. In both cases the increase in fuel efficiency and lower emission level comes at an extra cost in fuel price. The question therefore is, in this card and the cards that will follow after this, how important fuel efficiency and lower emission levels are to you personally and to what extent you are willing to pay a higher fuel price to improve fuel efficiency and reduce emission levels. As said, you only have to say which of the two fuel types you prefer most. You can also choose none of the two. In that case you do not pay anything extra for your current fuel use and you stay with the characteristics of your current fuel type. Is this clear? Can you tell me which fuel type you prefer in this example card?

INTERVIEWER INSTRUCTION:

- AFTER THE RESPONDENT CHOOSES BETWEEN THE TWO ALTERNATIVES, ASK HIM/HER HOW CERTAIN HE/SHE IS ABOUT HIS/HER CHOICE ON A SCALE OF 0 TO 10 (0=NOT CERTAIN AT ALL, 10=COMPLETELY CERTAIN)

- IF THE RESPONDENT CONSISTENTLY CHOOSES NONE OF THE TWO, ASK HIM/HER WHY (SEE QUESTION 32); IF THE RESPONDENT DOES NOT UNDERSTAND THE ASSIGNMENT OF CHOOSING BETWEEN THE 2 FUEL TYPES, TRY TO EXPLAIN IT ONCE AGAIN UNTIL HE/SHE UNDERSTANDS

I will now show you 10 new cards, which I want you to evaluate separately and independently from each other. Each card gives you a completely new choice occasion between two types of fuels with different fuel characteristics. After each card you are also asked to state how certain you are about your choice on a scale from 0 – 10, where 0 means completely uncertain and 10 means completely certain.

INTERVIEWER INSTRUCTION: IMPORTANT BEFORE YOU FILL IN QUESTION 26: CIRCLE CLEARLY THE CHOICE SET NUMBER YOU USE (RANDOMLY CHOOSE ONE OF THE CHOICE SETS BETWEEN 1 AND 12):

1 2 3 4 5 6 7 8 9 10 11 12

29. Which fuel alternative do you prefer?

	Alternative 1	Alternative 2	None of the two
CARD 1	☐	☐	☐
Choice certainty	0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10		
CARD 2	☐	☐	☐
Choice certainty	0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10		
CARD 3	☐	☐	☐
Choice certainty	0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10		
CARD 4	☐	☐	☐
Choice certainty	0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10		
CARD 5	☐	☐	☐
Choice certainty	0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10		
CARD 6	☐	☐	☐
Choice certainty	0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10		
CARD 7	☐	☐	☐
Choice certainty	0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10		
CARD 8	☐	☐	☐
Choice certainty	0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10		
CARD 9	☐	☐	☐
Choice certainty	0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10		
CARD 10	☐	☐	☐
Choice certainty	0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10		

30. When making your choices, can you indicate about which fuel characteristic you were each time most uncertain? *(please tick only one option, namely the one you are most uncertain about)*

1 I was most uncertain about the choice between the two fuel types
2 I was most uncertain about the different fuel use efficiencies
3 I was most uncertain about the different emission levels
4 I was most uncertain about the fuel price increase and whether I was willing to pay higher price
5 I was equally uncertain about all characteristics

31. When making your choices, can you indicate which characteristic was most important?
please rank the characteristics, starting with the most important one (=1), followed by the second most important one (=2), the third most important one (=3) and finally the fourth most important one (=4); ***NOTE****: if you ignored a characteristic, please give this characteristic a zero (=0)*

... Fuel type
... Fuel use efficiency
... Emission level
... Fuel price increase
... All attributes were equally important

32. If the respondent consistently chooses none of the two, please explain why.

1 I don't care about any of the fuel type characteristics.
2 I don't care about the impacts of carbon dioxide emission on the environment or human health.
3 I don't believe the fuels are causing air pollution problems in Nairobi.
4 I don't believe the fuel characteristics can be changed as displayed in the cards.
5 I don't have enough money/income to pay extra for fuel.
6 I already pay enough for my current fuel use.
7 The polluter should pay for the air pollution in Nairobi, I'm not a polluter.
8 Other, namely ……..

Finally, some questions about yourself concerning your own personal situation for statistical purposes only, to make sure we have a representative sample of respondents.

Please note that all information provided will be treated strictly confidential!

33. Is the respondent a man or a woman?

0 Man
1 Woman

34. What is your age? ……..……years.

35. How many people are in your household <u>including yourself</u>? ..... persons

36. How many children younger than 18 years of age are in your household? . …….children

37. What is your highest <u>completed</u> education level?

0=I did not go to school or complete any school
1 = Primary/elementary school
2 = Secondary school
3 = High school
4 = College
5 = University
6 = Other, namely .....

38. Which of the categories below applies to you?

1 = Independent employer/entrepreneur
2 = Full time/part time employee
3 = day labourer
3 = Currently/temporary unemployed
4 = Housewife/houseman
5 = Student
6 = Retired
7 = Other, namely …….....

39. What is your total net (after tax) household income per month? Kshs. ……..

Remember: All your answers are treated as strictly confidential and will not be used for any other purpose.

Alternatively, if you feel uncomfortable telling me how much you earn exactly, please tick one of the categories below in which your current household income falls

1= less than Kshs. 100,000	7= Kshs. 350,001-400,000
2 = Kshs. 100,001-150,000	8= Kshs. 400,001-450,000
3 = Kshs.150,001-200,000	9 = Kshs. 450,001-500,000
4 = Kshs. 200,001-250,000	10 = Kshs. 500,001-550,000
5 = Kshs. 250,001-300,000	11 = Kshs.550,001-600,000
6 = Kshs. 300,001-350,000	12 = More than Kshs. 600,000

40. Are you a member of or a donor to any environmental protection organization?

0 No

1 Yes ➔ If so, which organisation and how much do you donate every year?

Name organization:.....

Annual donation/contribution: Kshs. .....
[*Note: ask for an approximation if respondent does not know the exact amount*]

THIS IS THE END OF THE INTERVIEW

THANK YOU VERY MUCH FOR YOUR TIME

DO YOU HAVE ANY COMMENTS OR SUGGESTIONS TO IMPROVE THE QUESTIONS IN THIS QUESTIONNAIRE?

……

……