Willingness to pay to avoid the consumption of pesticide residues in Uganda: An experimental auction approach

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Abstract

Experimental auctions were used to determine factors affecting the willingness to pay (WTP) of Ugandan rural and urban populations to avoid consuming pesticide residues. Information or type of proxy good did not affect WTP, while education had no effect in the urban population and had a negative effect in the rural population. Male respondents had a higher willingness to pay than female respondents in both samples. Free-riding behaviour was observed in both populations.

Key words: experimental auctions; willingness to pay; pesticide residues; Uganda

1. Introduction

The use of chemicals is prevalent in many agricultural systems, as is evident in the health and environmental risks associated with chemical exposure. There are a wide array of chemicals for use in agriculture, including fertilisers, insecticides, fungicides and herbicides. All of these are potentially are harmful if used incorrectly, and they can be linked to adverse human health conditions, including cancer, reproductive disorders and birth defects. The risk posed by extensive pesticide use has generated concern and, as a result, integrated pest management (IPM) is now being promoted in and incorporated into national agricultural policies in many countries. In addition, a heightened awareness of the need for a cleaner environment has triggered the establishment of a number of programmes promoting sustainable agricultural practices.

Studies on the economic impacts of reduced chemical use are relatively common, but there are not many on health and environmental impacts and, as such, the value of health and environmental benefits due to reduced pesticide use is still largely unknown. These impacts are unknown for a number of reason – their evaluation is difficult because of the complex and wide range of health and environmental variables involved, and the lack of markets for health and environmental services means that their monetary value cannot be observed readily. Nonetheless, difficulties in quantifying benefits that can be derived from reduced pesticide use should not be used as an excuse for abandoning attempts to do so. It is imperative to derive credible estimates of people's value in contexts where there are either no apparent markets or very imperfect or incomplete markets. Monetary expressions of value provide a generally acceptable method of comparing programmes, and act as a basis for policy formulation. This study examines the magnitude of the willingness to pay to avoid consumption of pesticide residues using non-market valuation techniques in a developing country setting, Uganda.

2. Problem statement

Major uses of pesticides are in agriculture (both crop production and animal husbandry), and in public health (disease vector control). In agricultural production, the increased need for food arising from an increase in population has lead to increased pesticide use. Pesticides account for an increasing share of farmers' production expenses. In Tanzania, for example, pesticides represent about 90% of the cost of purchased inputs for coffee (Ngowi 2002). In Uganda, pesticide imports amounted to UGX 18 199 million in 2001 (IFDC 2003).[1] Widespread pesticide use in Uganda is due to an equally widespread occurrence of insects and diseases on many crops and livestock, facilitated by a warm, humid climate throughout the year. In order to control these pests, many farmers use pesticides, as they are regarded as a fast-acting alternative to other pest control methods.

Unfortunately, many of the chemicals do not meet internationally accepted toxicity standards. The Food and Agricultural Organization (FAO 1999) estimated that over $300 million was spent annually by developing countries on pesticides that are highly toxic to humans and damaging to the environment. In the developed world, laws and regulations regarding pesticide use are relatively stringent, requiring adherence to strict guidelines of proper pesticide handling in order to reduce the risks associated with them. However, developing countries have limited resources in regulating pesticides imported to their area. In addition, pressing concerns of economic development and political stability in the developing world may take priority over health and the environment (Reynolds 1997). Because of this, laws and regulations regarding pesticide use are either non-existent or ignored, and the environmental and health problems associated with pesticide misuse continue unabated. Unregistered pesticides pose an even greater risk because they potentially are more dangerous, and since they are illegal, mixing instructions and labels are often deliberately removed. Even registered and approved chemicals may be subject to abuse and misuse, such as excessive application or using field pesticides during post-harvest storage. All these factors increase the potential risk of pesticides to human health and that of other living organisms.

Nonetheless, reducing pesticide use and employing other pest control methods often do not seem to be options for desperate farmers who can experience substantial crop loss due to pest damage. Another alternative, the judicious use of pesticides coupled with cultural methods and biological monitoring, is a practice being promoted by the IPM and Peanut Collaborative Research Support Programmes (CRSPs) to reduce pesticide misuse. In Uganda, these programmes have introduced pest management packages that reduce reliance on pesticides to control major pests on specific crops in collaboration with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and other international research organisations. Groundnuts are a focus of these programmes and are one of the proxy goods we use in the experiments. Because groundnuts are affected by a host of insect pests and diseases, frequent pesticide application occurs. The IPM CRSP developed several pest management packages for reducing pesticide use on groundnuts in Uganda. They consist of three integrated cultural practices to reduce pesticide use: altering planting time, altering planting density, and developing host resistance. The economic benefits of these packages, such as higher yields and farmer profits, have been documented (IPM CRSP 2002). However, benefits to human health and the environment to which these research programmes contribute are not quantified.

[1] 1 USD =1 725 UGX in 2001, and 1 550 UGX in 2013 (www.gocurrency.com).

To evaluate the impacts of a pesticide use-reducing programme, changes in the quality of health and the environment may be expressed in monetary terms. Non-market valuation methods can be used to translate such impacts into monetary terms. Expressing benefits in monetary terms is a convenient means of expressing the relative values that society places on the different uses of resources. However, the process of quantifying health and environmental improvements is complex.

The contingent valuation (CV) survey method has been suggested and applied as one means for valuing health and environmental benefits (Higley & Wintersteen 1992; Mullen *et al*. 1997; Brethour & Weersink 2001; Cuyno *et al*. 2001; Hanley *et al*. 2001). However, this method has been criticised due to several potential biases, including vehicle, strategic, hypothetical, starting point and information biases. Monetary-based measures that have been proposed, such as the Environmental Impact Level (EIL) and Cost of Illness (COI), have also been found to be inadequate (Berger *et al*. 1987). The EIL is limited by its field-based context and its focus on only environmental and not health parameters. Measures such as the COI are often not a viable option in developing countries, where many illnesses go unreported, and where health could be affected by many factors and cannot be traced directly to pesticide exposure or toxicity.

Developments in non-market goods valuation suggest that experiments can be an appropriate method for valuing improvements in the environment and health. Experimental auctions, where subjects place values on environmental improvements in a researcher-controlled setting and subjects actually pay these values, are recommended by experimental economists for non-market evaluation because its non-hypothetical nature produces more realistic responses. Using this method, a link is maintained between subject behaviour and outcomes (salience) (Freeman 2003). Experimental auction methods are also becoming accepted as a technique that can provide measures of economic choice-making that may be more accurate than those provided by surveys. Experiments are now commonplace in industrial organisation, game theory, public choice, finance, most microeconomic fields, and some aspects of macroeconomic theory, and their use is increasing (see review by Maupin 2006). With experimental methods, economists are no longer limited to merely observing. They can *control* important factors and *then* observe behaviour.

3. Justification

Reduced pesticide use may have both health and environmental benefits in Uganda, and quantifying these benefits is important for policy formulation. Moreover, because of the importance of groundnuts in the Ugandan economy, and the wide area on which the crop is grown, the benefits of reducing pesticide use on groundnuts may be large, as these benefits translate into reduced social costs for a large population over a wide geographical area.

In developed countries there is a heightened awareness of the benefits of a clean environment. Non-profit organisations that advocate environmental preservation are currently receiving increased recognition. Legislation for the allocation of more funding for activities aimed at enhancing natural resources is increasingly being passed in many developed countries. The developing world should not be left behind. Contrary to popular belief, poor populations may in fact value their environment, and their environmental interest could be increasing too. It is of interest to know how and to what extent these populations value their environment.

A credible concern is: How much do individuals value the environment? In January 2007, the Ugandan Ministry of Health endorsed the use of DDT for internal residual spraying (IRS) as a public health vector control mechanism against mosquitoes (The Daily Monitor 2007; The New Vision 2007). The use of this and other chemicals poses health and environmental risks due to the chemicals' persistence in the environment and accumulation in body tissues. While the international community and non-governmental organisations have raised concern over these chemicals, not much is heard from the local population on this issue. Questions of interest include: Do low income populations care about their environment? What value do they attach to an environmental amenity that is free from pesticide contamination? What is people's willingness to pay (WTP) to avoid environmentally degrading situations?

4. The pesticide situation in Uganda

The actual amount of pesticides used in Uganda is not known. Most pesticides have been classified as insecticides, acaricides, molluscides, nematicides, fungicides, rodenticides and herbicides. The common types include organophosphates (Bromophos, DDVP (*Dichloro dimethyl vinyl phosphate*), Diazinon, Dursban, Dimethoate, Malathion, Parathion), organochlorines (Aldrin, BHC, DDT, Dieldrin, Lindane, Thiodan, Toxaphene), carbamates (Dithane M45, Dithane M22, Furadan), pyrethrins/pyrethroids (Ambush CY (Permethrin), Ripcord (Cypermethrin, Decamethrin), phenoxy acetic acid (2-4-D (*Dichlorophenoxy acetic acid*), 2-4-5-T (*Trichlorophenoxy acetic acid*), MCPA (*Monochlorophenoxy acetic acid*), inorganic metals (shell copper (*copper oxide*), lead arsenate arsenic trioxide, phenylmercuric acetate) and bipyridyls (Grammoxone (*Paraquat*), Weedol and Diquat). Groundnut farmers use a variety of these pesticides to control a host of pests, ranging from pre-harvest termites to post-harvest storage pests. While many are contact pesticides, systemic pesticides, which are potentially more risky because they penetrate living tissue, are also used. With 80% of the country's population involved in agriculture, a modest estimate of 3% of all agricultural workers in developing countries who are affected by pesticide poisoning each year (Jeyaratnam 1990) would translate into well over 700 000 cases in Uganda annually. Moreover, because smallholder farmers often cannot afford the high prices of genuine agrochemicals, they resort to counterfeits, which possibly pose a greater danger to the health of consumers and farmers. A recent report shows that the country loses over Shs 13 billion (approx. $6m) annually in counterfeit agrochemicals (Kisitu 2012).

5. Objective

The objective of this paper was to examine the health benefits of reduced pesticide use by determining the willingness to pay to avoid pesticide exposure arising from the consumption of pesticide residues. In valuing the avoidance of pesticide exposure, the study is guided by several research questions: Is individual self-interest at odds with group/social interest? Do more informed economic agents make different decisions about the avoidance of pesticide exposure than less-informed agents? Does previous exposure to the harmful effects of pesticides make subjects more likely to bid higher values? Do more formally educated individuals have a higher willingness to pay to avoid pesticide exposure? Do rural and urban populations differ in their willingness to pay to avoid pesticide exposure? Will different proxy environmental goods result in different bids? Finally, do gender differences affect bidding behaviour to avoid pesticide exposure?

6. Sample selection

The participants in the study were selected from rural and urban areas. The rural group comprised semi-randomly selected groundnut producers from Iganga district. The study participants were drawn from one major groundnut-producing sub-county in each of the three major groundnut-producing counties in Iganga district: Waibuga, Buyanga and Nawandala. Within each of the selected sub-counties, the two largest parishes (in terms of population size) were identified. Two villages from each selected parish were randomly selected and village heads were contacted to provide lists of all groundnut farmers in the village. A random selection of 10 farmers from each village list was then done. A total of 121 participants formed the farmer group sample. The second group (the non-farmer group) was sampled from Kampala district. Respondent selection was semi-purposeful – targeting urban respondents by posting 35 "invitation-to-participate" notices in several strategic areas around Kampala. One hundred and fifty-six participants were recruited in Kampala.

Both Kampala and Iganga districts were important for this study because the former contains the biggest urban population in the country and is one of the leading consumers of groundnuts, while the latter is the leading producer of groundnuts in the country. In addition, while the farmer group may be concerned primarily with the profitability of pesticide use, the non-farmer group may be more concerned with the environmental and health impacts of pesticide use. This sample captures the views of a wide spectrum of respondents, providing a basis for comparison between different classes of people: farmers versus non-farmers that are rural dwellers versus urban dwellers and primary producers versus consumers.

7. Experimental auction procedures

Experimental auctions were run in which individuals were faced with various scenarios. They had the choice of consuming groundnuts or water (proxies for environmental good), each of which had pesticide-free samples and samples that were potentially contaminated with pesticides (proxy good variable). They were also either provided or not provided with information about the potential adverse impacts of pesticides (information variable). Finally, they were involved in either individual or group decision making (group variable).

In the group setting, the provision of a pesticide-free environment is viewed as the provision of a public good, which is both non-rival and non-excludable in nature. However, both these characteristics present a fundamental problem. Although it is reasonable to assume that everyone would prefer a pesticide-free environment, it is in the interest of each individual to free-ride and not to contribute towards its provision. Such behaviour is best modelled using an n-person Prisoners' Dilemma game, in which the individual rational action appears to lead to a social dilemma or "pareto inferior" outcome, with the dominant strategy for each individual being to act rationally (which is to be selfish – thinking about themselves individually). If they do not act selfishly, they would contribute more to the group and benefit more from the group as a whole than if they acted with selfish motives in the hope of benefiting from the contributions of those who contributed to the group, hence free-riding (Guala 2005), which would result in an outcome inferior to the social optimum.[2]

Individuals want to maximise utility (V_i). Assuming that individuals derive this utility from monetary payoffs and from the provision of a public good, thus:

$$V_i = f(\pi_i, G) \quad (1)$$

where π_i is the monetary payoff private good of player i, and G is the pesticide-free environment public good.[3] The monetary payoff function, π_i, is a linear function unlike ones considered in other studies (see Mestelman 2004), and may be specified in the following form:

$$\pi_i, = X_i - g_i \quad (2)$$

Therefore (1) becomes:

[2] Assuming individuals are uninterested in the choices of other people, that is, issues of altruism, fairness and equity are not considered.

[3] Note that the G is not indexed because it is not individual specific: consumption is in a collective provision situation – once provided, all individuals benefit, or if not provided, no one consumes.

$$V_i = f(X - g_i, G) \quad (3)$$

where X is the initial endowment and g_i , g_j are contributions to the public good by subject *i*, and other respondents in the group, *j*. The public good is either provided or not. Thus:

$$G = \begin{Bmatrix} 1 \; if \sum_j g_j > Y \\ 0 \; Otherwise \end{Bmatrix} \quad (4)$$

However, once provided, all individuals derive utility from it. Free-riding in this case is equivalent to having $g_i = 0$ but expecting $\sum_j g_j > Y$, such that G = 1 and V_i is maximised.[4] However, the socially optimum outcome is for all individuals to fully contribute, in which case $G = 1$. When all subjects contribute their total endowment ($g_i = g_j = X$), G = 1, and no subjects are subjected to consuming water/groundnuts of unknown quality (potentially pesticide contaminated). However, if all subjects free-ride, then $g_i = g_j = 0$, G = 0, and all subjects consume potentially pesticide-contaminated goods, regardless of the amount of π_i. Each individual, in making g_j contributions, makes a trade-off between π_i and G. The value Y is not known a priori. It is determined during the experimental sessions by determining the session binding average.

Each experimental session involved eight to nine subjects, no subject participated in more than one session, and the subjects were not informed beforehand in which treatment (proxy good, group or information) they would be participating. Each subject was endowed with Shs 500 in one hundred shilling coins, which represented one half of the per capita daily income. The use of an endowment serves as 'starting capital' and is based on the idea that control of subject behaviour can be achieved by using a reward structure to induce pre-specified monetary value actions (Friedman & Cassar 2004). Endowing subjects with cash allows actual statements of value with real economic commitments, since cash allocations are unbiased signals of preference (Smith 1976).

Bidding followed the *n*th price auction procedure, which was explained to the subjects before the experiment started.[5] Bids were ranked and the n^{th} highest price was recorded as the binding price. The *n*-1 highest bidders each paid the n^{th} highest price and consumed the good without pesticide residues, while the lower bidders had to consume the good that could contain residues.[6] A training period with no "real" payoffs was conducted before actual bidding started in order to familiarise the subjects with the auction procedure and to allow them to gain experience with the game used in the experiment. The experiments assume that subjects are motivated to truthfully place a value on the environmental situation as it relates to personal health, and these assumptions are validated by having subjects actually "consume" their purchase or, as Freeman (2003: 175) puts it: "to live with the consequences of their choices". In the information treatment, subjects were given a brief handout with information regarding the potential adverse health effects of exposure to pesticides. In the case of the farmer group, this information was first translated into the local language and read out to the subjects. Care was taken to make this information brief, free from bias and as simple as possible (see Cummings & Taylor 1999). In the group decision treatment, each individual in a

[4] This is a strict inequality because, for the efficient provision of a public good, the sum of WTP must exceed the cost of providing it.

[5] In the group treatment, group bids were ranked in descending order, and then a die was rolled to determine the binding rank (n). The bid amount in the position of the binding rank became the session binding average, which was multiplied by the number of group members to obtain Y.

[6] The actual good was regular tap water (in the WATER proxy good treatment) and conventionally grown groundnuts (for the GROUNDNUT proxy good treatment). Tap water is consumed widely in the country, although the normal practice is for households to boil it before drinking it. Groundnuts are often consumed roasted as a snack packaged in small polythene bags.

group was given an initial endowment, which they could deposit in a personal account or invest in a communal/group account for the purpose of contributing towards the public good. Individuals were informed that the total sum invested in the group account would benefit all group members equally, regardless of how individual members bid.

The amount of the endowment in this study imposed a restriction on the range of the dependent variable and, as such, a censored regression approach – the Tobit model – was used to obtain maximum likelihood estimates of WTP for both datasets:

$$y_i^* = \beta_0 + \beta_m \sum_{m=1}^{3} Treatment_{i,m} + \beta_k \sum_{k=1}^{7} Socio-economic_{i,k} + u_i \quad (5)$$

where m = 1…3 for PGood (proxy good), information, group treatments respectively; k = 1…7 for Age, Educ. (education), PExp (pesticide poisoning exposure), WaterExp (weekly water expenditure), Gender, Salaried, Hosp (whether ever been hospitalised in past) respectively; y_i^* is WTP; $\beta_0, \beta_m, \beta_k$ are coefficients to be estimated; and u_i is an error term.

Three models were estimated for each sample. Model 1, the full model, included all hypothesised socio-economic and treatment variables. Model 2 was developed using stepwise elimination of insignificant variables, focusing on retaining socio-economic variables. Stepwise elimination of variables was again used to develop Model (3), focusing on including treatment variables by following the procedure in Bonabana-Wabbi (2008).

8. Results

8.1 Characteristics of sample

On average, the rural sample had slightly more men than women. The sample's mean age was 40 years, with at least six of those years having been spent in school (Table 1). About equal numbers were involved in the three treatment types (proxy good, information, group). The WTP values for Iganga were distributed normally. The median category of WTP was also the mean category (Shs 201 to 300). The respondents were willing to pay 57% of their endowment to avoid an unfavourable environmental situation.

The urban sample consisted of relatively highly educated respondents, who had spent an average of sixteen years in school. A typical respondent was 35 years old and spent an average of Shs 1 890 weekly on safe drinking water. The distribution of WTP values in the Kampala sample was skewed to the right, with the mean willingness to pay to avoid an unfavourable environmental situation (Shs 343.97) higher than half the subjects' endowment. The sample in general had previously had little exposure to pesticide poisoning or hospitalisations from pesticide-related illness and consisted of slightly more men than women (Table 1).

Table 2 shows maximum likelihood estimates of three Tobit models for the Iganga sample. Model 1 (the full model) includes all the treatment variables and the available socio-economic variables for the sample that had a high response rate. In Model 1, three variables are significant at the 5% level, and the overall model is also significant at the same level based on the log likelihood ratio. Model 2 included only the socio-economic attributes of respondents, had a log likelihood ratio of 7.86 with three degrees of freedom (three independent variables), and was significant at the 5% level. Model 3 was more significant than either Model 1 or 2 and its log likelihood ratio was 13.21 with four degrees of freedom.

Table 1: Summary of sample characteristics

		Kampala			Iganga		
Variable	**Definition (Coding)**	**%**			**%**		
Gender	Male (1) Female (0)	56.12 43.88			57.85 42.15		
PGood	Groundnut (1) Water (0)	42.95 57.05			50.41 49.59		
Info	Information given (1) No information given (0)	43.59 56.41			51.24 48.76		
PExp	Poisoning exposure (1) No pesticide exposure (0)	11.54 88.46					
Group	Group decision making (1) Individual decision (0)	51.28 48.72			47.11 52.89		
Hosp	Hospitalised in past year (1) Not hospitalised in past year (0)	19.23 80.77			-		
Illever	Been ill in past year (1) Not ill in past year (0)	37.82 62.18			-		
Occupation	Salaried (1) Non-salaried (0)	40.14 59.86			-		
		Mean (std. dev.)	**Min**	**Max**	**Mean (std. dev.)**	**Min**	**Max**
Educ	Years completed in school	16.30 (2.41)	10	30	6.63 (3.05)	1	16
WaterExp	Money (Shs) spent weekly on safe-to-drink water	1 890.7 (2 297.9)	0	14 000	-	-	-
Age	Age of respondent (years)	35.54 (8.26)	20	59	40.02 (10.37)	20	70

Gender, education and the group treatment variables had a significant effect on the bidding behaviour of Iganga respondents. Men had higher WTP values than women (Table 2). Respondents with more formal education were willing to pay less to avoid bad environmental outcomes. Subjects who were involved in group treatments paid significantly less than those involved in 'self' treatments. Information, proxy good and age were not helpful in predicting WTP. Even after eliminating the information treatment variable that was found not to affect WTP, the gender, education and group variables continued to exert a strong effect on WTP (Model 3). The signs of the coefficients were consistent across models. The group, information and education variables retained the same negative sign, while the gender and age variables exerted positive effects on WTP across all models.

The general to specific approach was also adopted in the Kampala sample. Model 1, the full model, included all hypothesised socio-economic and treatment variables. The model was significant at the 1% level, with a log likelihood of -600.359 (Table 3). Model 2 retained three socio-economic variables and included one treatment variable, and was significant at the 10% level. Model 3 aimed to include all treatment variables. After dropping insignificant variables, the final model retained the group treatment and two socio-economic variables, and was significant at the 1% level.

All three models show that the grouping treatment variable (**Group**) was significant in predicting WTP values. In addition (at a lower significance level), previous exposure to pesticide poisoning and weekly water expenditure had an effect on WTP. The other variables and treatments did not show significant relationships with WTP values. All socio-economic variables (except gender) were unable to predict bidding behaviour.

Table 2: Maximum likelihood estimates of WTP – rural population (Iganga)

		Model 1		Model 2		Model 3	
Variable	**Beta**	**Coefficient**	**Std. dev.**	**Coefficient**	**Std. dev.**	**Coefficient**	**Std. dev.**
Age	β_8	.3219	1.377	.278	1.406	-	-
Gender	β_4	67.099[b]	29.485	74.245[b]	30.026	66.0094[b]	29.376
Educ	β_5	-10.406[b]	4.847	-9.866[b]	4.941	-10.041[b]	4.762
PGood	β_1	10.488	28.792	-	-	-	-
Info	β_2	-27.7462	28.359	-	-	-26.761	27.958
Group	β_3	-61.769[b]	28.711	-	-	-63.337[b]	28.234
Constant	β_0	351.293	67.186	307.479	63.039	367.833	41.192
Model statistics							
Log-likelihood		-672.476		-675.242		-672.569	
LR X^2 (df)		13.40 (6)		7.86 (3)		13.21 (4)	
Prob > X^2		0.0372		0.0489		0.0103	
Pseudo-R^2		0.0099		0.0058		0.0097	
N		121		121		121	

[a] Significant at 1%, [b] Significant at 5%, [c] Significant at 10%

Table 3: Maximum likelihood estimates of WTP – urban population (Kampala)

		Model 1		Model 2		Model 3	
Variable	**Beta**	**Coefficient**	**Std. dev.**	**Coefficient**	**Std. dev.**	**Coefficient**	**Std. dev.**
Age	β_8	-1.827	1.977	-.3870	1.966	-	-
Gender	β_4	42.899	33.677	-	-	47.460[c]	31.968
Educ	β_5	1.145	7.060	.6476	6.772	-	-
PGood	β_1	-69.821[b]	36.757	-	-	-	-
Info	β_2	-25.494	33.599	-	-	-	-
Group	β_3	-66.551[b]	35.346	-91.3303[a]	33.528	-100.738[a]	32.762
PExp	β_7	93.393[b]	53.005	-	-	-	-
WaterExp	β_9	.0147[b]	0.00743	0.01036[c]	0.0074	0.0108[c]	0.00737
Hosp	β_6	-52.012[c]	37.643	-	-	-	-
Salaried	β_{10}	123.115[a]	37.267	-	-	-	-
Constant	β_0	387.706	137.276	399.1323	126.476	376.4491	34.575
Model statistics							
Log-likelihood		-600.3599		-656.8267		-671.054	
LR X^2 (df)		27.69 (10)		9.24 (4)		13.38 (3)	
Prob > X^2		0.0020		0.0553		0.0039	
Pseudo-R^2		0.0225		0.0070		0.0099	
N		156		156		156	

[a] Significant at 1%, [b] Significant at 10%, [c] Significant at 20%

The negative sign on the **Group** variable implies that subjects who participated in the group treatment were more likely to have lower WTP values than those who participated in 'self' treatments. The (weak) positive signs on the **WaterExp** and **PExp** variables suggest that concern about exposure to pesticide poisoning influenced people to bid higher to avoid bad environmental outcomes. In Model 1, the expected WTP increased by Shs 0.0147 when water expenditure increased by Shs 1, holding all other variables in the model constant. That is, the more a person was willing to spend on safe drinking water, the more this person was also willing to pay to avoid a bad environmental situation in an experimental setting. In addition, a salaried person's expected WTP was Shs 123.11 (24.6% of subject endowment) higher than that of a non-salaried person. All else being equal, willingness to pay for reduced exposure to undesirable health and environmental outcomes was higher in the urban sample (Table 4).

Table 4: Mean and standard deviation of willingness to pay

	Rural WTP (Iganga)	Urban WTP (Kampala)
Number of subjects	121	156
Mean	286.86	343.97
Standard deviation	135.87	142.87

There was consistency in signs on coefficients of variables across the models. The coefficient on **Age** and **Group** variables was negative and that on the **Educ**, **WaterExp** and **Gender** variables was positive in all the models.

8.2 Tests of hypotheses

In this section, the more parsimonious and/or significant models from Tables 2 and 3 in the preceding section are used to conduct hypothesis tests one through five below and to discuss these treatment effects. In addition, the effects of two socio-economic variables (**Gender, Educ**) are examined in detail.

1. Does free-riding in health and environmental provision exist? Are there differences in free-riding behaviour between urban and rural populations? $H_0: \ \beta_3 = 0$ versus $H_1: \ \beta_3 < 0$, where β_3 is the coefficient on the group variable. In both Iganga (at the 5% level of significance) and Kampala (but only at the 10% level of significance), subjects bid significantly higher when involved in individual decision-making treatments. On average, subjects in groups were willing to pay less (by Shs 63 in Iganga and Shs 100 in Kampala) when they were involved in groups than when they were in individual settings (Model 3). This is an indication of free-riding behaviour. Thus, even when individuals would have preferred a pesticide-free environment (proxied by the goods presented to them), they would rather have another person 'pay' for it.

2. Does providing information matter? How does content information influence bidding behaviour? $H_0: \ \beta_2 = 0$ versus $H_1: \ \beta_2 \neq 0$, where β_2 is the coefficient on the information treatment variable. The coefficient β_2 was not statistically significant in any of the three models in Iganga or Kampala. The results of hypothesis testing for information provision do not support rejecting the null hypothesis. Information did not influence bidding behaviour in these two samples.

3. How do gender differences influence bidding for health improvements? Are women more sensitive to a better environment as it relates to their health than men? $H_0: \ \beta_4 = 0$ versus $H_1: \beta_4 < 0$, where β_4 is the coefficient on the gender variable. The coefficient on the gender variable is positive in both samples. The results of the one-sided hypothesis tests (with Model 3) are significant at 5% for the Iganga sample. In this rural sample, willingness-to-pay values were higher for men than for women. On average, male subjects bid Shs 66 higher than females in Iganga. In Kampala the null hypothesis was not rejected.

4. Which proxy environmental goods solicit the highest bids? Does it matter whether groundnuts or water are used as the environmental proxy? $H_0: \beta_1 = 0$ versus $H_1: \beta_1 \neq 0$, where β_1 is the coefficient on the proxy good variable. At the 5% level, the null hypothesis is accepted for both datasets (Model 1). The good does not matter.

5. Does formal education matter? How differently do educated individuals behave when bidding to preserve their environment? Do educated individuals bid higher than their less formally educated counterparts? $H_0: \beta_5 = 0$ versus $H_1: \beta_5 > 0$, where accepting the null hypothesis would imply that education (Model 1) does not matter – that educated and less educated individuals behave the same with regard to bidding for the environment. For the Kampala data, the null hypothesis cannot be rejected. In Kampala, the level of education did not affect bidding behaviour. However, the rural sample was different. More educated rural subjects were willing to bid significantly less (at 5% level, by Shs 10) to avoid consuming food with pesticide residues.

6. Do urban and rural populations differ in their valuation of health and the environment?

$$H_0: MWTP_{Iganga} = MWTP_{Kampala} \text{ versus } H_1: MWTP_{Iganga} \neq MWTP_{Kampala}$$

where MWTP is mean willingness to pay. The t statistic is 3.397, with a corresponding P value of 0.0008, thus urban subjects had a significantly higher mean willingness to pay to avoid consuming pesticide residues than rural subjects (Table 4).

7. Does previous exposure to the harmful effects of pesticides influence the way subjects bid to avoid pesticide exposure? Due to data limitations (see Bonabana-Wabbi 2008), the variable **PExp** was only included in Model 1 for Kampala as a proxy to measure people's risk aversion based on past experience with pesticide poisoning. For this urban sample, the variable was positively correlated with WTP, though only significant at the 20% level (Table 4).

9. Conclusions

Among the important results of this study is the manifestation of free-riding in public goods provision, differences in rural and urban sample bidding behaviour, and differences in bidding behaviour due to income differences. The existence of free-riding suggests government intervention may be necessary if there is to be improvement in both health and environmental provision. If the problems associated with pesticides in the environment and their potential effects on humans are to be addressed, reliance on the individuals directly concerned to act will not be sufficient and a concerted effort of a 'third party' may be necessary – a typical public goods problem.

Differences in willingness-to-pay values between urban and rural populations suggest that any health and environmental improvement programmes may require different interventions for the different regions. Rural populations are less willing to pay to avoid ill-health outcomes, and also, since their line of work exposes them more to pesticides than the urban population, rural populations are more prone to potential contamination. Perhaps the rural population feels that it is their obligation to be provided with a clean environment, or they generally do not care as much about their health and environment, or they perceive the concentration levels of the pesticides to be too low to cause them any damage, or indeed, as one rural respondent stated: "I have been subjected to these chemicals for a long time. But look at me, I am still healthy." Such reasoning, if widespread in the rural population, is an indication that rural people may be discounting the future heavily: what matters to them is their immediate survival. In addition, that there is some WTP suggests that at least some individuals may be willing to pay a premium for residue-free food.

Perhaps the most important explanation for differences in bidding behaviour for health and environmental improvement can best be attributed to differences in income, rather than differences in non-economic factors (recall that information, proxy good treatments and education had no significant positive effect on WTP). The high willingness to pay to avoid contamination of higher income urban subjects is an indication that increased incomes induce health and environmental awareness. As economic development increases and people's incomes increase, the demand for environmental quality by Ugandans can be expected to rise. People may devote some of their increased income to improving their health and their environment, and to the protection of natural resources.

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