WATER RESOURCES RESEARCH, VOL. 29, NO. 6, PAGES 1539–1560, JUNE 1993

Household Demand for Improved Sanitation Services in Kumasi, Ghana: A Contingent Valuation Study

DALE WHITTINGTON,[1,2] DONALD T. LAURIA,[1] ALBERT M. WRIGHT,[3] KYEONGAE CHOE,[2] JEFFREY A. HUGHES,[1] AND VENKATESWARLU SWARNA[1]

A contingent valuation survey was conducted in Kumasi, Ghana, to estimate households' willingness to pay for two types of improved sanitation services: improved ventilated pit latrines and water closets connected to a sewer system. Over 1200 randomly selected households throughout the city were interviewed. Most households were willing to pay more for improved sanitation service than they were currently paying for their existing sanitation system (mostly public and bucket latrines), but in absolute terms the potential revenues from households are not large, of the order of US$1.40 per household per month (about 1–2% of household income). The results of the study confirm the conventional wisdom that conventional sewerage is not affordable to the vast majority of households without massive government subsidies. On the other hand, it appears that only modest subsidies are required to achieve relatively high levels of coverage with on-site sanitation (improved ventilated pit latrines). This is because improved ventilated pit latrines are much cheaper than conventional sewerage and because most households are willing to pay about as much for a ventilated pit latrine as for a water closet connected to a sewer. Several tests were conducted to check the accuracy of respondents' answers to contingent valuation questions. The findings indicate that contingent valuation surveys can be successfully carried out in cities in developing countries for public services such as sanitation and that reasonably reliable information can be obtained on household demand for different sanitation technologies.

1. INTRODUCTION

In most cities in industrialized countries, households do not have a choice about whether or not to connect the sanitary facilities in their house to a sewer. Every household may be required by law to connect if access is provided. This regulatory approach can only work, however, when the vast majority of households clearly have sufficient financial resources to pay for the sewerage system and the connection. In many developing countries, this is not the case; issues of affordability and households' willingness to pay for improved sanitation services are often much less clear. If households in a city of a developing country are required by law to connect to a sewerage system but the costs of the system including connections are much higher than the majority of households are able and willing to pay, then subsidies from some level of government will be required to cover the deficit. If subsidies are not available, such a regulation typically cannot be enforced.

This situation is now commonplace in many cities in developing countries. Many sewerage systems have been built that people cannot afford to connect to and are thus not being used. Households are often unwilling to pay for even the operation and maintenance of sewerage systems. Because large subsidies for the construction of sewerage systems are increasingly difficult to obtain, user charges in the form of sewer connection fees and monthly tariffs must be relied upon to an increasing extent to finance sanitation improvements. However, the process of establishing a tariff structure requires detailed information on how specific groups of households will respond to various combinations of monthly tariffs and connection fees. Such information on household demand for improved sanitation services is rarely available; it must be collected by the government agencies and donors involved before sanitation planning in developing countries can be improved.

One approach to gathering such information is simply to ask a random sample of households in a city whether they would choose to use a new sanitation system if it were available at a specified price. This direct survey approach to estimating household demand is termed the "contingent valuation method" (CVM), and it is being increasingly used by environmental and resource economists in industrialized countries to estimate the benefits of environmental improvements and other public goods [*Cummings et al.*, 1986*a*; *Mitchell and Carson*, 1989]. This method of estimating demand has two obvious drawbacks: (1) the individual may not know how he would respond if faced with such a hypothetical choice, and (2) he may know but not tell the truth. When the contingent valuation method is used to estimate the use value of goods and services with which individuals are familiar, experience from industrialized countries has shown that these threats to the reliability and validity of contingent valuation results are often not as serious as many economists originally feared, and that contingent valuation surveys that are carefully designed and administered can yield accurate and useful information on households' preferences [*Cummings et al.*, 1986*b*; *Dickie et al.*, 1987].

Evidence on the accuracy of the CVM in developing countries is much more limited, but the few available studies suggest that contingent valuation (CV) surveys can be successfully implemented in this context as well [*Whittington et al.*, 1990*a*, *b*, 1991, 1992; *Briscoe et al.*, 1990; *Singh et al.*, 1993; *Bohm et al.*, 1993; *Altaf et al.*, 1993]. This paper

[1]Department of Environmental Sciences and Engineering, University of North Carolina at Chapel Hill.
[2]Department of City and Regional Planning, University of North Carolina at Chapel Hill.
[3]Infrastructure and Urban Development Department, World Bank, Washington, D. C.

Paper number 93WR00184.
0043-1397/93/93WR-00184$05.00

presents the first application of the contingent valuation method designed to estimate household demand for improved sanitation in a developing country. A survey of over 1200 households was conducted in fall 1989 in Kumasi, Ghana, to determine how much households would be willing to pay for two types of improved sanitation systems: Kumasi ventilated improved pit latrines (KVIPs) and water closets (WC) connected to a piped sewerage system. In another paper we describe the existing housing, water, and sanitation situation in Kumasi, and household attitudes and perceptions of the present sanitation system [*Whittington et al.*, 1993]. Here we discuss the results of the contingent valuation survey.

In section 2 of the paper, we describe the research design and the contingent valuation questions. Section 3 analyzes the determinants of the responses to the contingent valuation questions and offers some evidence about the reliability and validity of the willingness-to-pay bids. In this paper we use the term "reliability" to mean the extent of the variance of an observed variable, e.g., reported household willingness to pay, due to random sources. By "validity" we mean the degree to which a data collection method or instrument, e.g., a survey questionnaire, measures a given concept. An "accurate" method is both reliable and valid. In section 4 we illustrate how the information obtained from the contingent valuation survey can be used to assist sanitation planning in Kumasi. Section 5 of the paper summarizes our findings and conclusions.

2. Research Design

Field Procedures

The field work for this research was carried out over a 5-month period from July to November 1989. An initial version of the household questionnaire was developed over a 3-week period of intensive experimentation in July 1989. Approximately 50 household interviews and open-ended discussions were conducted with respondents throughout Kumasi. The household questionnaire was then pretested with 100 households.

The final survey questionnaire had four parts. The first consisted of several questions about demographic characteristics of the respondent and his or her household (such as the number of family members and whether the respondent was head of the household). The second part included questions about the household's existing water and sanitation situation: type of facilities used, monthly expenditures, and household satisfaction with its existing sanitation facility, including perceptions of its cleanliness, privacy, and convenience. The third contained questions (described below) about the household's willingness to pay for improved sanitation facilities. The final part of the questionnaire contained questions about the socioeconomic characteristics of the household, including such items as education, income, ownership of assets, weekly expenditures, occupation, religion, and housing characteristics.

A two-stage stratified sampling procedure was utilized to select a random sample of 1633 households. Twenty enumerators (16 men and four women) were each given 1 week of intensive training in the administration of the questionnaire. Enumerators were instructed in the precise translation of the questionnaires into the predominant local language (Twi) and were trained in how to ask questions and elicit answers. This training included extensive use of role playing. Each enumerator was observed in practice interviews and was tested on his or her ability to administer the questionnaires. Field supervisors returned to selected respondents after the enumerator reportedly completed the interview in order to verify that the enumerator had, in fact, interviewed the correct household and that the interview had taken place as reported. Each completed questionnaire was checked by a supervisor for omissions and errors, and where problems were found, the interviewer was instructed to return to the household in order to rectify them.

Out of the 1633 households in the sample frame, usable interviews were completed with 1224 respondents. The overall response rate for those households that could be located was very high: only 4% refused to be interviewed (3% of the total number of households). Two percent of the completed interviews were discarded because of inconsistencies in the respondent's answers.

Contingent Valuation Questions Asked

Respondents were asked about their willingness to pay for five different types of services: KVIPs, WCs with sewer connections, sewer connections for households already with WCs and septic tanks, private water connections, and both a private water connection and a WC with a sewer connection for households currently without water. Each household was not asked its willingness to pay (WTP) for all five levels of service but only for those relevant to its particular circumstances. For example, if a household had a water connection but did not have a WC, it was possible to ask the respondent about its willingness to pay for both a WC with a connection to a sewer and a KVIP. If a household already had water and a WC, it was not relevant to ask how much they would pay for a KVIP; rather, we asked how much the household would be willing to pay to connect the WC to a sewer.

On the other hand, if the household did not have a private water connection, it would not make sense to ask how much the household would be willing to pay for a WC with a sewer connection because first the household would have to obtain a water connection. It would be possible, however, to have a KVIP without a water connection. In this case, the enumerator first asked how much the household would be willing to pay for a water connection. Next, he or she asked how much the household would be willing to pay for both a water connection and a WC with a sewer connection. Finally the enumerator asked how much the household would be willing to pay for a KVIP. (Another reason respondents were not asked willingness-to-pay questions about all five levels of service separately was that this would simply be too many contingent valuation questions for one interview; respondents could become impatient or distracted, and their answers might well depend on the order in which the questions were asked.) Table 1 summarizes the types of willingness-to-pay questions asked of respondents with different water and sanitation situations.

The enumerators described each of the relevant options by reading from a prepared text, and, for some of the options, by showing diagrams and pictures to the respondents. A combination of "yes/no" questions and a direct, open-ended question was used to elicit the respondent's maximum willingness to pay (this question format is termed an "ab-

TABLE 1. Different Types of Respondents and WTP Questions

Category	Number of Respondents	WTP Questions Asked
Households with water and without a WC	406	WTP for KVIP WTP for WC and sewer
Households with water and with a WC	295	WTP for a connection to a sewer
Households without water	523	WTP for KVIP WTP for water WTP for water, WC, and sewer

breviated bidding procedure with follow-up"). The respondent was first asked whether or not he would choose to pay a stated monthly fee for one of the specified technologies. In order to test whether respondents' answers were sensitive to the questionnaire design, the starting value of this initial fee was varied among respondents: some received a high starting value and others received a low value. Only two starting values were used in order to ensure that the responses of everyone interviewed would fall into the same three categories (see (1) below). A respondent who received a high starting value for one level of service or technology also received a high value for all subsequent levels of service in the interview.

The iterative bidding procedure had the following three steps, depending on whether the respondent received a high or low initial value: For a low starting value, (1) ask initial starting value; if "no" go to step 3, if "yes" go to step 2; (2) increase the initial value to the high starting value, and ask if respondent is willing to pay; then go to step 3; and (3) ask respondent for the maximum amount he is willing to pay for the service described. For a high starting value, (1) ask initial starting value; if "no" go to step 2, if "yes" go to step 3; (2) decrease the initial value to the low starting value, and ask if the respondent is willing to pay; then go to step 3; and (3) ask respondent for the maximum amount he is willing to pay for the service described. Let L and H denote the low and high starting values for a given technology. The first two steps in this question format allow us to classify each respondent's willingness-to-pay (WTP) bids into one of the following three categories:

Category 1

$$\text{WTP} < L \tag{1a}$$

Category 2

$$L \leq \text{WTP} < H \tag{1b}$$

Category 3

$$H \leq \text{WTP} \tag{1c}$$

This question format was used for each of the five services. The order of the questions about different services was the same for all respondents. An example of an opening statement and the contingent valuation questions used is presented in Appendix A.

This elicitation procedure yields two types of information on respondents' willingness to pay for improved services. First, a respondent's answer(s) to the "yes/no" questions place him in one of the three categories above. We can thus discriminate among respondents willing to pay "high," "medium," and "low" amounts based on their answers to the "yes/no" questions. The open-ended, follow-up question provides us with a point estimate of the maximum amount a respondent is willing to pay.

Both renters and landlords were interviewed, and somewhat different introductory statements were required for each. In addition to the different versions for landlords and renters, for households with and without water, and for high and low starting points, the questionnaire was also designed to test whether one subset of respondents (renters with water) bid differently if they were given 1 day to reflect before giving their answers to the willingness-to-pay questions. In total, 10 different versions of the household questionnaire were administered in the field. Which version a specific household in the sample received was randomly assigned; the enumerators had no control over it.

The questionnaires asked how much households were willing to pay for particular sanitation technologies given their existing sanitation situation, but households were not asked which service level they would choose if different fees were charged for each. It seems reasonable to assume that if a household bid more for a WC with a sewer connection than for a KVIP, then the household would choose the WC if the fees were the same for both. We do not know, however, which technology the household would choose if the fee for the KVIP was, say, half the fee of the WC.

3. Households' Willingness-to-Pay Bids for Improved Sanitation

How Much Respondents Said They Were Willing to Pay

Table 2 presents means and standard deviations of households' willingness-to-pay bids (based on the follow-up open-ended question) for the five types of service for groups of households with different existing water and sanitation conditions. As shown, households without a WC on average said that they were willing to pay about the same amount per month for a WC as for a KVIP (US$1.40 versus US$1.45). Households with a WC said they were willing to pay slightly less than this for a connection to a sewer (US$1.30). On average, households without water connections said that they were willing to pay US$1.52 for a water connection and US$2.57 per month for both a water connection and a WC. This result suggests that the demand for water and sanitation is largely additive, i.e., that expenditures for one do not substitute for the other.

Households with private water connections but without a WC were asked their willingness to pay for both a KVIP and a WC with a sewer connection. On average, they were willing to pay about 7% more for a WC and sewer than for a KVIP. There were large differences in the mean willingness-to-pay bids for KVIPs between households with water using public latrines and households with water using other sanitation systems. For example, households using public latrines were willing to pay about 37% more for a KVIP than households with bucket latrines, which makes sense because households using public latrines are the most dissatisfied with their existing sanitation system and are currently spending the most for sanitation [*Whittington et al.*, 1993].

Determinants of the Willingness-to-Pay Bids

Models for the willingness-to-pay responses. We use the following conceptual framework to describe a household's

TABLE 2. Average Household WTP Based on Existing Sanitation

Existing Sanitation	Willingness to Pay (US $/month) for KVIP	WC and Sewer	Sewer Connection	Water	WC and Water
Households With Water					
Bucket latrine	1.13 (0.92)	1.24 (1.01)	...	...	...
Public latrine	1.55 (1.13)	1.66 (1.16)	...	...	...
Pit latrine	1.23 (0.92)	1.26 (0.90)	...	...	...
WC	...	...	1.31 (1.06)	...	...
Other	1.34 (0.62)	1.19 (0.62)	...	...	...
Households Without Water					
Bucket latrine	1.49 (1.03)	...	...	1.71 (1.73)	2.60 (1.59)
Public latrine	1.72 (0.98)	...	...	1.61 (1.20)	2.72 (1.74)
Pit latrine	1.15 (0.82)	...	...	1.13 (0.76)	1.78 (1.16)
Other	1.33 (1.02)	...	...	1.32 (0.91)	2.07 (1.30)
Overall mean	1.45 (0.92)	1.40 (0.95)	1.30 (0.98)	1.52 (1.01)	2.57 (1.42)

Values in parentheses show the standard deviations.

decision on whether or not to agree to pay for an improved sanitation system. Let $V(\ )$ be an individual's indirect utility function, the arguments of which are attributes of the sanitation system including its monthly cost (**Q**), income (Y), the prices of other goods and services (**P**), and other socioeconomic characteristics and attitudes of the household which may affect (or serve as proxies for) tastes (**SE**). Consider a change in an individual's sanitation system from $\mathbf{Q}_0$ to $\mathbf{Q}_1$. The individual's willingness to pay (WTP) for this change is derived from his indifference between the following two indirect utility functions:

$$V(Y_0 - \text{WTP}, \mathbf{P}, \mathbf{Q}_1, \mathbf{SE}) = V(Y_0, \mathbf{P}, \mathbf{Q}_0, \mathbf{SE}) \quad (2)$$

This implies that an individual's WTP for an improvement in sanitation service will be a function of the proposed change in **Q** and of all the other factors which influence the individual's valuation of a change in **Q**:

$$\text{WTP} = f(\mathbf{Q}_0, \mathbf{Q}_1, Y_0, \mathbf{P}, \mathbf{SE}) \quad (3)$$

Three different types of multivariate models were used to analyze this relationship that describes the determinants of the willingness-to-pay bids. Ordinary least squares (OLS) was used to explain the willingness-to-pay bids obtained in response to the follow-up direct question. The OLS model is

$$\text{WTP}^{\text{open-ended}} = f(\mathbf{Q}_0, \mathbf{Q}_1, Y_0, \mathbf{P}, \mathbf{SE}) + \varepsilon \quad (4)$$

where $\text{WTP}^{\text{open-ended}}$ is the respondent's answer to the open-ended willingness-to-pay question and is a point estimate, and the stochastic component ε describes the unexplained variances of the deterministic variables in $f(\ )$.

The information on willingness to pay obtained from respondents' answers to the "yes/no" questions was analyzed in two ways. First, a respondent's answer(s) were interpreted as defining interval estimates for his willingness to pay. In other words, the respondent's willingness to pay was assumed to fall into one of the categories defined by the high and low starting points in (1). This analysis was based on the following relationship:

$$\text{WTP}^{\text{lower}} < f(\mathbf{Q}_0, \mathbf{Q}_1, Y_0, \mathbf{P}, \mathbf{SE}) + \varepsilon_0 < \text{WTP}^{\text{upper}} \quad (5)$$

where the endpoints of each group ($\text{WTP}^{\text{lower}}$ and $\text{WTP}^{\text{upper}}$) are defined by the values suggested in the abbreviated bidding game (L and H in (1)). No attempt is made to characterize or compare the relative magnitude of the willingness to pay of respondents within a given category. This formulation is estimated using *Stewart*'s [1983] maximum likelihood estimator for grouped data. (Software for the Stewart maximum likelihood estimation was based on a FORTRAN algorithm written by David Guilkey of the University of North Carolina at Chapel Hill and solved with the DFP search method).

The second method used to analyze the responses to the "yes/no" questions was an ordered probit model. This approach assumes that the responses to the questions only provide an ordering of the preferences of respondents. In other words, if one respondent answered the willingness-to-pay questions with a low bid and another respondent answered with a high bid, the only information that is assumed to be obtained from these responses is that the first respondent was willing to pay less for the improved sanitation service than the second respondent. In contrast to the Stewart estimator, this model does not use the endpoints of classes defined by the abbreviated bidding game. In the ordered probit model, the endpoints of the intervals defining willingness to pay (u^{lower} and u^{upper}) are treated as parameters to be estimated:

$$u^{\text{lower}} < g(\mathbf{Q}_0, \mathbf{Q}_1, Y_0, \mathbf{P}, \mathbf{SE}) + \varepsilon_1 < u^{\text{upper}} \quad (6)$$

TABLE 3. Descriptions of Variables

Variable Name	Mean (Standard Deviation)	Variable Description	Expected Sign
		Questionnaire Design	
Starting value of iterative bidding	0.51 (0.50)	1, bidding game used high point; 0, low starting point	+
Time to think	0.24 (0.43)	1, respondent was given time to think about willingness to pay; 0, no time to think	?
		Respondent's Characteristics	
Sex	0.59 (0.49)	1, respondent was male; 0, female	?
Age	39.30 (12.25)	age of respondent	?
Household head	0.15 (0.36)	1, respondent was spouse of household head; 0, otherwise	−
Owner of house	0.11 (0.31)	1, respondent was owner of house; 0, renters	+
Religion	0.22 (0.41)	1, respondent was Moslem; 0, otherwise	?
Knowledge	···*	1, respondent knows about the corresponding technology; 0, otherwise	+
		Household Characteristics	
Household income	2.42 (1.91)	monthly household income in 10,000 cedis†	+
Wealth	33.19 (90.37)	value in 10,000 cedis for assets of the household	+
Number of years of education	8.31 (5.39)	Years of education of respondent	+
Trader	0.34 (0.48)	1, primary worker's occupation is trader; 0, otherwise	−
Office worker	0.23 (0.42)	1, primary worker's occupation is office worker or professional; 0, otherwise	?
		Housing Characteristics	
Multistory housing	0.27 (0.44)	1, house is multistory building; 0, single-story building	−
Landlord living in the house	0.55 (0.50)	1, landlord lives in the house; 0, otherwise	+
Number of households	11.1 (6.89)	number of households living in a building	−
		Water Use Practices	
Private water connection	0.43 (0.49)	1, private water tap is primary water source; 0, otherwise	+
Expenditure on water	4.42 (6.69)	monthly water expenditure in 100 cedis per household	+
		Sanitation Practices	
Expenditure on sanitation	2.15 (3.53)	monthly sanitation expenditure in 100 cedis per household	+
Satisfaction level	0.13 (0.34)	1, respondent was very satisfied with current sanitation system; 0, otherwise	−
		Quality of Interview	
Other people listening	0.28 (0.45)	1, other people were listening during the interview; 0, otherwise	?

*Thirty-four percent of respondents answered they knew about KVIP, while 16% of respondents answered they knew about a sewer system.
†In 1989, 350 cedis equaled US$1.00.

Each of these three approaches to the multivariate analysis progressively relaxes the assumptions about the precision of willingness-to-pay information that can be obtained from the contingent valuation survey for improved sanitation services (see *Whittington et al.* [1992] for a more detailed discussion of these three modeling frameworks).

All three multivariate modeling approaches use the same four types of variables for explaining variation in willingness-to-pay bids for a given sanitation technology: (1) characteristics of the questionnaire (e.g., whether a respondent was given a high or low starting point, or time to think); (2) characteristics of the respondent (e.g., sex, education); (3) socioeconomic characteristics of the household (e.g., income); and (4) household's existing water and sanitation situation. The names and definitions of the independent variables used in the models of the determinants of the willingness-to-pay bids are presented in Table 3, which also shows the expected signs of the parameters based on consumer demand theory. In some cases, the expected signs are unknown, which is indicated by question marks.

Results of the analysis. Tables 4–8 present the results of the multivariate models of willingness-to-pay bids for KVIPs, WCs with sewer connections, sewer connections (for houses with WCs), water, and water and WC with sewer connections (for houses without water), respectively. Each table includes the results for six different models. For the specific level of service (e.g., KVIPs in Table 4), results are presented for the three estimators (namely, OLS, Stewart maximum likelihood, and ordered probit). For each of the three estimators, two versions of the model are reported: (1) one which uses the complete list of independent variables (designated "C") as potential determinants of WTP and (2) one which uses a more restricted list of independent variables (designated "R"). This approach was used to see how sensitive the model results were to changes in model specification.

Overall, the multivariate results from all three modeling strategies are remarkably robust and consistently show the same independent variables as being statistically significant. The results presented in Tables 4–8 show conclusively that the willingness-to-pay information obtained from the contingent valuation survey for all five levels of improved service is systematically related to the socioeconomic characteristics of the household and the respondent in ways suggested by consumer demand theory and prior expectations. This is true regardless of the source of willingness-to-pay information (i.e., answers to the "yes/no" questions in the bidding game or the open-ended final question), the estimation method used, or the exact model specification.

The four explanatory variables with the consistently largest effects on willingness to pay have clear economic interpretations: household income, whether the respondent owns the house or is a tenant, how much the respondent's household was spending on its existing sanitation system, and how satisfied the respondent was with his household's existing sanitation system. Households with higher incomes bid significantly more for all types of improved services than households with lower incomes. Owners bid much more for improved service than tenants, indicating a greater willingness to invest in their own property. Respondents who were paying more for and who were dissatisfied with their existing sanitation service bid more for improved sanitation services (both KVIPs and WCs with sewer connections) than respondents who were paying less and were more satisfied.

Two other explanatory variables that consistently have statistically significant effects on willingness to pay for improved sanitation services are (1) whether the resident has access to a private water connection in his house or apartment, and (2) whether the respondent lives in a multistory building. Respondents with access to a private connection bid more for a KVIP than respondents without a private connection. We interpret this result to mean that respondents who have essentially solved their water problem are now ready to pay to improve another basic service (namely, sanitation). (If the per unit price of water increased, we would expect that households would be willing to pay more for a KVIP than for a WC because a WC uses water and a KVIP does not.)

Households living in multistory buildings are willing to pay less for a KVIP than households living in single-story buildings. This makes sense because KVIPs are less convenient for individuals living in a multistory building than in a single-story building because a KVIP will always be located at ground level (unlike a WC). On the other hand, respondents living in multistory buildings with WCs were willing to pay more for a sewer connection than respondents with WCs living in single-story buildings. This may be because the holding tanks for the effluent from WCs were more likely to overflow in densely crowded areas with multistory buildings where they were more heavily used.

"Traders" generally bid less for improved services (except for sewer connections) than respondents with other occupations (although this effect is often not statistically significant). We hypothesize that this is due to the greater variability (and uncertainty) of their income, and thus a reluctance to make a long-term commitment for the purchase of improved services such as water and sanitation. Another possible reason may be because many traders work at the large central market area in Kumasi that is well-served by public water taps and public latrines. They may thus feel less need for service improvements at their home.

Perhaps the most surprising finding of these multivariate analyses is how little effect any of the social or cultural variables had on individuals' willingness to pay for improved sanitation or water services. More educated respondents generally bid more than less educated respondents, but this effect is statistically significant in only a few of the models and its magnitude is always small. The sex of the respondent and whether the respondent is the head of household are almost never statistically significant, and the direction of these effects is mixed. The only case in which the age of the respondent influences willingness to pay is for WCs with sewer connections: older respondents bid less for this type of sanitation improvement than younger individuals.

The results for the variables denoting the religion of the respondent are difficult to interpret. Whether the respondent was Moslem or non-Moslem had no effect on willingness to pay for a KVIP or for a sewer connection. However, Moslems bid more for a WC with a sewer connection than non-Moslems; the magnitude of the effect was large and statistically significant. On the other hand, Moslems bid less for water than non-Moslems; in this case the effect was of moderate size and was also statistically significant.

Prior knowledge of the KVIP technology had no effect on the willingness-to-pay bids for this sanitation service. However, respondents who had WCs and knew about sewers bid considerably more than respondents who did not know about this technology.

Tests of Reliability and Validity of the Willingness-to-Pay Bids

An obvious and important issue is whether the responses to the contingent valuation questions are accurate reflections of households' true preferences for improved sanitation services. It is impossible to know with complete certainty whether households' answers would be accurate predictors of behavior if respondents were actually confronted with the choices posed in the questionnaire, but different tests were carried out to check the reliability and validity of the willingness-to-pay bids. These tests or checks (described below) provide little basis for believing that respondents gave implausible or hypothetical answers, or that they acted strategically. In general, the models of the determinants of the willingness-to-pay responses appear quite robust, and the bids are systematically related to the variables that would be expected to explain demand based on economic theory.

TABLE 4. Alternative Models for WTP Bids for KVIPs

Independent Variables	Maximum WTP Bids (OLS)		Known WTP Intervals (Stewart Maximum Likelihood)		Ordering of Alternatives (Ordered Probit)	
	C	R	C	R	C	R
Intercept	255.6	200.1	294.7	218.7	−0.552	−0.736
	(4.672)***	(6.388)***	(4.985)***	(3.756)***	(−2.299)**	(−4.474)***
Questionnaire Design						
Starting value of iterative bidding	48.8	47.2	54.9	56.0	0.146	0.151
	(2.604)***	(2.589)***	(3.038)***	(4.207)***	(1.739)*	(1.815)*
Time to think	−6.0	−15.0	−8.0	−1.9	−0.021	0.002
	(−0.220)	(−0.562)	(−0.240)	(−0.042)	(−0.161)	(0.016)
Respondent's Characteristics						
Sex	−4.4	...	17.6	...	−0.047	...
	(−0.175)	...	(−0.584)	...	(−0.408)	...
Age	−0.9	...	−1.7	...	−0.005	...
	(−1.101)	...	(−1.461)	...	(−1.247)	...
Household head	14.5	...	0.4	...	0.002	...
	(0.473)	...	(0.015)	...	(0.013)	...
Owner of house	238.8	232.2	310.3	300.3	0.826	0.805
	(6.854)***	(6.991)***	(7.116)***	(10.099)***	(5.074)***	(5.169)***
Religion	16.8	...	39.9	...	0.107	...
	(0.745)	...	(1.182)	...	(1.032)	...
Knowledge	−5.5	...	−3.0	...	−0.010	...
	(−0.261)	...	(−0.214)	...	(−0.107)	...
Household Characteristics						
Household income, 10,000 cedis	42.6	42.7	54.1	55.5	0.144	0.147
	(7.624)***	(8.135)***	(5.960)***	(6.304)***	(5.336)***	(5.981)***
Wealth, 10,000 cedis	0.1	...	0.2	...	0.001	...
	(0.388)	...	(1.064)	...	(1.099)	...
Number of years of education	4.8	5.3	8.5	8.3	0.023	0.021
	(2.228)**	(2.847)***	(2.496)**	(2.604)***	(2.341)**	(2.426)**
Trader	−38.3	−25.1	−64.8	51.0	−0.175	−0.140
	(−1.664)*	(−1.291)	(2.583)***	(−1.802)*	(−1.712)*	(−1.577)
Office worker	−11.5	...	−38.5	...	−0.102	...
	(−0.425)	...	(−1.344)	...	(−0.823)	...
Housing Characteristics						
Multistory housing	−60.7	−83.8	−50.5	−50.3	−0.134	...
	(−2.094)**	(−3.183)***	(−2.051)**	(−3.487)***	(−0.956)	...
Landlord living in the house	40.5	44.2	60.7	60.8	0.162	0.158
	(2.029)**	(2.289)***	(4.909)***	(2.352)**	(1.815)*	(1.805)*
Number of households	−2.0	...	−4.4	−4.6	−0.012	−0.014
	(−1.334)	...	(−1.842)*	(−1.910)*	(−1.817)*	(−2.338)**
Water Use Practices						
Private water connection	102.4	89.6	184.4	189.3	0.493	0.527
	(4.587)***	(4.179)***	(5.959)***	(5.444)***	(4.749)***	(5.379)***
Expenditure on water, 100 cedis	NA	NA	NA	NA	NA	NA
	...	...	...	...	...	...
Sanitation Practices						
Expenditure on sanitation, 100 cedis	28.2	28.0	28.8	28.4	0.077	0.075
	(9.826)***	(9.978)***	(5.932)***	(5.870)***	(6.046)***	(6.075)***
Satisfaction level	−134.8	−146.5	−325.2	−322.7	−0.863	−0.824
	(−2.808)***	(−3.186)***	(−4.369)***	(−3.604)***	(−3.315)***	(−3.171)***
Quality of Interview						
Other people listening to interview	−3.6	...	23.3	20.5	0.062	...
	(−0.169)	...	(1.771)*	(1.130)	(0.656)	...
Statistics						
Number of observations	813	852	813	813	813	813
R^2	0.339	0.330	...	...	...	...
Adjusted R^2	0.322	0.321	...	...	...	...
F value	20.323	37.599	...	...	...	...
Prob ($>F$)	0.000	0.000	...	...	...	...
Percent predicted correctly	...	...	...	...	56	55

Columns headed C denote model with complete set of explanatory variables; columns headed R denote model with restricted set of explanatory variables. Values in parentheses indicate calculated t statistics for coefficients. Two-tailed tests were used. Three asterisks, two asterisks, and one asterisk indicate 1, 5, and 10% significance level, respectively. NA denotes not applicable.

TABLE 5. Alternative Models for WTP Bids for WCs With Sewers

Independent Variables	Maximum WTP Bids (OLS)		Known WTP Intervals (Stewart Maximum Likelihood)		Ordering of Alternatives (Ordered Probit)	
	C	R	C	R	C	R
Intercept	452.2	474.5	575.9	556.5	0.214	0.135
	(6.387)***	(8.393)***	(20.241)***	(21.951)***	(0.572)	(0.513)
			Questionnaire Design			
Starting value of iterative bidding	59.8	61.4	88.4	86.7	0.234	0.220
	(2.295)**	(2.371)**	(2.463)**	(2.086)**	(1.830)*	(1.774)*
Time to think	−24.0	−13.9	−29.3	−10.5	−0.080	−0.024
	(−0.849)	(−0.499)	(−1.022)	(−0.336)	(−0.565)	(−0.179)
			Respondent's Characteristics			
Sex	−14.1	···	−26.9	···	−0.072	···
	(−0.418)	···	(−0.752)	···	(−0.398)	···
Age	−3.7	−3.6	−6.2	−5.6	−0.016	−0.128
	(−3.007)***	(−3.181)***	(−4.006)***	(−3.854)***	(−2.551)**	(−2.329)**
Household head	−34.2	···	−64.4	···	−0.175	···
	(−0.836)	···	(−1.542)	···	(−0.817)	···
Owner of house	303.1	330.0	499.6	252.1	1.264	1.293
	(6.119)***	(6.969)***	(7.050)***	(6.606)***	(4.725)***	(5.204)***
Religion	97.4	89.1	166.3	153.9	0.439	0.368
	(3.051)***	(2.860)***	(4.228)***	(3.941)***	(2.783)***	(2.478)**
Knowledge	56.7	···	103.6	112.2	0.26	···
	(1.398)	···	(3.362)***	(3.120)***	(1.250)	···
			Household Characteristics			
Household income, 10,000 cedis	47.4	50.9	70.8	75.4	0.186	0.189
	(6.085)***	(6.736)***	(4.732)***	(5.220)***	(4.063)***	(4.669)***
Wealth, 10,000 cedis	(0.5	···	0.9	···	0.002	···
	(2.904)***	···	(2.561)**	···	(2.553)**	···
Number of years of education	0.5	···	0.3	···	0.001	···
	(0.186)	···	(0.062)	···	(0.048)	···
Trader	−72.8	−79.6	−118.1	−117.3	−0.316	−0.281
	(−2.274)**	(−2.688)***	(−4.289)***	(−3.140)***	(−1.796)*	(−2.083)**
Office worker	−85.6	−67.7	−85.2	−54.5	−0.230	···
	(−2.272)**	(−1.859)*	(−2.433)**	(−1.341)	(−1.136)	
			Housing Characteristics			
Multistory housing	−45.7	···	−27.8	−25.0	−0.081	···
	(−1.385)	···	(−2.122)**	(−0.605)	(−0.486)	···
Landlord living in the house	25.7	···	−5.7	···	−0.015	···
	(0.921)	···	(−0.223)	···	(−0.113)	···
Number of households	−4.1	−5.7	−9.2	−10.4	−0.024	−0.028
	(−1.978)**	(−3.013)***	(−2.686)***	(−3.072)***	(−2.535)**	(−3.292)***
			Water Use Practices			
Private water connection	NA	NA	NA.	NA	NA	NA
	···	···	···	···	···	···
Expenditure on water, 100 cedis	0.9	···	5.0	···	0.013	···
	(0.291)	···	(0.860)	···	(0.284)	···
			Sanitation Practices			
Expenditure on sanitation, 100 cedis	26.5	25.6	32.3	31.9	0.084	0.079
	(7.527)***	(7.360)***	(4.335)***	(4.291)***	(4.661)***	(4.939)***
Satisfaction level	−170.0	−132.7	−400.7	−408.4	−1.086	−0.921
	(−2.984)***	(−2.470)**	(−3.545)***	(−3.588)***	(−2.624)***	(−2.239)**
			Interview Context			
Other people listening to interview	9.3	···	47.4	46.0	0.125	···
	(0.319)	···	(4.269)***	(2.781)***	(0.897)	···
			Statistics			
Number of observations	401	401	402	402	402	402
R^2	0.448	0.427	···	···	···	···
Adjusted R^2	0.419	0.410	···	···	···	···
F value	15.433	26.376	···	···	···	···
Prob (>F)	0-.000	0.000	···	···	···	···
Percent predicted correctly	···	···	···	···	62	59

Columns headed C denote model with complete set of explanatory variables; columns headed R denote model with restricted set of explanatory variables. Values in parentheses indicate calculated t statistics for coefficients. Two-tailed tests were used. Three asterisks, two asterisks, and one asterisk indicate 1, 5, and 10% significance level, respectively. NA denotes not applicable.

TABLE 6. Alternative Models for WTP Bids for Sewers

Independent Variables	Maximum WTP Bids (OLS) C	Maximum WTP Bids (OLS) R	Known WTP Intervals (Stewart Maximum Likelihood) C	Known WTP Intervals (Stewart Maximum Likelihood) R	Ordering of Alternatives (Ordered Probit) C	Ordering of Alternatives (Ordered Probit) R
Intercept	249.4	288.2	270.2	300.2	−0.567	−0.292
	(2.496)**	(5.322)***	(2.113)**	(2.962)***	(−1.312)	(−1.244)
Questionnaire Design						
Starting value of iterative bidding	88.4	83.2	129.0	113.0	0.301	0.231
	(2.395)**	(2.328)**	(2.682)***	(2.759)***	(1.808)*	(1.456)
Time of think	−72.7	−95.0	−111.5	−117.2	−0.253	0.292
	(−1.910)*	(−2.661)***	(−1.882)*	(−2.154)**	(−1.555)	(−1.821)*
Respondent's Characteristics						
Sex	31.5	···	63.2	53.2	0.147	···
	(0.731)	···	(1.688)*	(1.130)	(0.783)	···
Age	−1.1	···	1.5	···	−0.003	···
	(−0.628)	···	(−0.670)	···	(−0.366)	···
Household head	77.2	···	167.2	166.0	0.391	0.337
	(1.285)	···	(3.798)***	(3.996)***	(1.726)*	(1.707)*
Owner of house	119.7	···	336.2	273.4	0.759	0.501
	(1.538)	···	(3.564)***	(3.885)***	(2.203)**	(1.867)*
Religion	−3.9	···	43.7	···	0.081	···
	(−0.049)	···	(0.833)	···	(0.236)	···
Knowledge	99.6	103.8	141.0	172.3	0.33	0.429
	(2.326)**	(2.588)***	(3.396)***	(4.155)***	(1.807)*	(2.578)***
Household Characteristics						
Household income, 10,000 cedis	52.8	58.8	48.1	57.2	0.111	0.135
	(4.886)***	(6.713)***	(2.558)**	(3.308)***	(2.085)**	(2.959)***
Wealth, 10,000 cedis	−0.1	···	−0.2	···	0.000	···
	(−0.300)	···	(−0.682)	···	(−0.564)	···
Number of years of education	2.2	···	3.5	···	0.009	···
	(0.533)	···	(0.551)	···	(0.416)	···
Trader	47.4	···	45.1	···	0.106	···
	(1.029)	···	(1.144)	···	(0.499)	···
Office worker	89.8	73.6	128.2	98.4	0.291	···
	(1.907)*	(1.986)**	(3.968)***	(3.623)***	(1.349)	···
Housing Characteristics						
Multistory housing	117.4	114.3	117.2	···	0.273	···
	(2.331)**	(2.402)**	(1.935)*	···	(1.283)	···
Landlord living in the house	−43.1	···	−77.3	−43.5	−0.167	···
	(−1.074)	···	(−2.098)**	(−3.588)***	(−0.944)	···
Number of households	−10.7	−11.6	−17.2	−12.8	−0.0396	−0.032
	(−3.073)***	(−3.513)***	(−2.830)***	(−2.863)***	(−2.585)***	(−2.767)***
Water Use Practices						
Private water connection	NA	NA	NA	NA	NA	NA
	···	···	···	···	···	···
Expenditure on water, 100 cedis	2.1	···	8.2	···	0.019	···
	(0.722)	···	(1.577)	···	(1.385)	···
Sanitation Practices						
Expenditure on sanitation, 100 cedis	81.6	91.2	170.4	202.7	0.393	0.452
	(2.922)***	(3.422)***	(3.636)***	(3.698)***	(2.207)**	(2.761)***
Satisfaction level	−82.4	−73.8	−172.3	−162.6	−0.400	−0.337
	(−2.037)**	(−1.888)*	(4.025)***	(−4.426)***	(−2.156)**	(−1.900)*
Interview Context						
Other people listening to interview	46.3	···	82.9	64.4	0.191	···
	(1.082)	···	(5.245)***	(4.811)***	(1.051)	···
Statistics						
Number of observations	274	274	275	275	275	275
R^2	0.342	0.323	···	···	···	···
Adjusted R^2	0.290	0.300	···	···	···	···
F Value	6.606	14.073	···	···	···	···
Prob (>F)	0.000	0.000	···	···	···	···
Percent predicted correctly	···	···	···	···	59	57

Columns headed C denote model with complete set of explanatory variables; columns headed R denote model with restricted set of explanatory variables. Values in parentheses indicate calculated t statistics for coefficients. Two-tailed tests were used. Three asterisks, two asterisks, and one asterisk indicate 1, 5, and 10% significance level, respectively. NA denotes not applicable.

TABLE 7. Alternative Models for WTP Bids for Water

Independent Variables	Maximum WTP Bids (OLS) C	Maximum WTP Bids (OLS) R	Known WTP Intervals (Stewart Maximum Likelihood) C	Known WTP Intervals (Stewart Maximum Likelihood) R	Ordering of Alternatives (Ordered Probit) C	Ordering of Alternatives (Ordered Probit) R
Intercept	296.4	243.1	431.1	320.5	−0.182	−0.534
	(4.124)***	(7.581)***	(5.343)***	(5.587)***	(−0.585)	(−3.394)***
Questionnaire Design						
Starting value of iterative bidding	−9.9	−1.8	−27.3	−25.2	−0.071	−0.068
	(−0.370)	(−0.070)	(−0.758)	(−0.598)	(−0.578)	(−0.575)
Respondent's Characteristics						
Sex	−17.2	...	−22.4	...	−0.059	...
	(−0.475)	...	(−0.533)	...	(−0.364)	...
Age	−0.5	...	−2.0	...	−0.005	...
	(−0.398)	...	(−1.278)	...	(−0.979)	...
Household head	32.3	...	45.1	...	0.115	...
	(0.709)	...	(1.159)	...	(0.553)	...
Owner of house	228.1	229.0	306.6	295.1	0.784	0.741
	(4.751)***	(5.178)***	(5.045)***	(6.669)***	(3.676)***	(3.895)***
Religion	−63.5	−62.5	−92.1	−89.8	−0.237	...
	(−2.079)***	(−2.221)**	(−2.211)**	(−4.414)***	(−1.609)	...
Household Characteristics						
Household income, 10,000 cedis	34.7	38.5	43.6	51.3	0.113	0.128
	(4.183)***	(5.173)***	(3.185)***	(3.084)***	(2.860)***	(3.516)***
Wealth, 10,000 cedis	0.4	...	0.9	...	0.002	...
	(1.971)**	...	(2.225)**	...	(1.924)*	...
Number of years of education	7.4	7.4	10.4	11.0	0.027	0.029
	(2.393)**	(2.831)***	(2.162)**	(2.335)**	(1.904)*	(2.292)**
Trader	−52.2	...	−111.5	−81.6	−0.290	−0.286
	(−1.602)	...	(−2.534)**	(−1.963)**	(−2.029)**	(−1.491)
Office worker	−1.6	...	−31.7	...	−0.090	...
	(−0.041)	...	(−0.712)	...	(−0.514)	...
Housing Characteristics						
Multistory housing	−96.5	−119.3	−228.8	−227.2	−0.571	−0.606
	(−1.760)*	(−2.396)**	(−4.575)***	(−8.044)***	(−2.413)**	(−2.531)**
Landlord living in the house	−12.8	...	−1.8	...	−0.003	...
	(−0.462)	...	(−0.0.73)	...	(−0.022)	...
Number of households	0.7	...	0.1	...	0.0003	...
	(0.330)	...	(0.036)	...	(0.034)	...
Water Use Practices						
Private water connection	NA	NA	NA	NA	NA	NA
	...	...	...	...	...	...
Expenditure on water, 100 cedis	33.5	32.3	34.2	34.1	0.088	0.087
	(12.498)***	(12.483)***	(5.249)***	(5.265)***	(5.092)***	(5.112)***
Sanitation Practices						
Expenditure on sanitation, 100 cedis	12.9	13.9	13.7	13.8	0.035	0.034
	(3.166)***	(3.560)***	(1.993)**	(2.047)**	(2.017)**	(2.062)**
Satisfaction level	−102.6	...	−230.5	−177.0	−0.636	...
	(−1.126)	...	(−2.930)***	(−14.055)***	(−1.562)	...
Interview Context						
Other people listening to interview	−15.6	...	−15.6	...	−0.041	...
	(−0.518)	...	(−0.839)	...	(−0.283)	...
Statistics						
Number of observations	407	426	407	407	407	407
R^2	0.488	0.475	...	...	...	...
Adjusted R^2	0.464	0.465			...	...
F Value	20.596	47.211	...	...	...	...
Prob (>F)	0.000	0.000	...	...	...	...
Percent predicted correctly	...	...	...	...	53	54

Columns headed C denote model with complete set of explanatory variables; columns headed R denote model with restricted set of explanatory variables. Values in parentheses indicate calculated t statistics for coefficients. Two-tailed tests were used. Three asterisks, two asterisks, and one asterisk indicate 1, 5, and 10% significance level, respectively. NA denotes not applicable.

TABLE 8. Alternative Models for WTP Bids for Water and WC

	Maximum WTP Bids (OLS)		Known WTP Intervals (Stewart Maximum Likelihood)		Ordering of Alternatives (Ordered Probit)	
Independent Variables	C	R	C	R	C	R
Intercept	471.8 (4.585)***	478.1 (11.222)***	456.0 (4.062)***	344.7 (4.245)***	−0.582 (−1.835)*	−0.571 (−4.356)***
Questionnaire Design						
Starting value of iterative bidding	62.6 (1.638)	55.3 (1.516)	59.8 (1.965)**	78.9 (1.309)	0.129 (1.020)	0.098 (0.833)
Respondent's Characteristics						
Sex	−38.9 (−0.740)	... ...	17.8 (0.365)	... ...	0.044 (0.258)	... ...
Age	−0.3 (−0.186)	... ...	−1.3 (−0.598)	... ...	−0.002 (−0.353)	... ...
Household head	32.6 (0.504)	... ...	140.2 (2.609)***	131.5 (3.524)***	0.271 (1.311)	... ...
Owner of house	423.9 (6.354)***	407.6 (6.505)***	577.0 (5.357)***	539.5 (6.784)***	1.047 (5.097)***	0.976 (5.441)***
Religion	−77.5 (−1.766)*	−87.3 (−2.153)**	−75.2 (−1.952)*	−77.9 (−2.699)***	−0.158 (−1.045)	... ...
Knowledge	53.5 (0.856)	... ...	96.3 (4.157)***	99.3 (4.452)***	0.182 (0.184)	... ...
Household Characteristics						
Household income, 10,0000 cedis	56.1 (4.628)***	61.1 (5.728)***	81.9 (4.208)***	83.8 (4.631)***	0.152 (3.567)***	0.173 (4.617)***
Wealth, 10,000 cedis	0.0 (−0.078)	... ...	0.2 (0.436)	... ...	0.000 (0.462)	... ...
Number of years education	5.0 (1.154)	... ...	12.7 (1.852)*	14.0 (2.161)**	0.023 (1.606)	... ...
Trader	−25.1 (−0.538)	... ...	−60.0 (−1.399)	... ...	−0.105 (−0.705)	... ...
Office worker	82.9 (1.530)	... ...	70.6 (2.146)**	95.8 (6.168)***	0.133 (0.739)	... ...
Housing Characteristics						
Multistory housing	−126.5 (−1.596)	... ...	−290.9 (−6.860)***	−303.0 (−8.888)***	−0.532 (−2.116)**	−0.556 (−2.128)**
Landlord living in the house	−26.5 (−0.666)	... ...	−40.6 (−1.629)	... ...	−0.074 (−0.528)	... ...
Number of households	1.6 (0.520)	... ...	−1.0 (−0.201)	... ...	−0.002 (−0.209)	... ...
Water Use Practices						
Private water connection	NA ...	NA ...	NA ...	NA ...	NA ...	NA ...
Expenditure on water, 100 cedis	51.7 (11.025)***	50.8 (11.218)***	63.6 (6.666)***	62.2 (6.600)***	0.117 (7.514)***	0.116 (8.317)***
Sanitation Practices						
Expenditure on sanitation	31.6 (5.558)***	32.8 (5.982)***	35.6 (3.543)***	37.1 (3.756)***	0.066 (3.498)***	0.064 (3.726)***
Satisfaction level	−3.5 (−0.026)	... ...	−311.8 (−3.772)***	−265.2 (−10.072)***	−0.702 (−1.294)	... ...
Interview Context						
Other people listening to interview	−106.0 (−2.427)**	−103.0 (−2.477)**	−90.8 (−1.738)*	−86.5 (−1.614)	−0.165 (−1.100)	... ...
Statistics						
Number of observations	404	423	404	404	404	404
R^2	0.467	0.448	...	...	...	...
Adjusted R^2	0.442	0.438			...	...
F Value	17.808	48.166	...	...	...	...
Prob (>F)	0.000	0.000	...	...	...	...
Percent predicted correctly	...	...	...	...	59	57

Columns headed C denote model with complete set of explanatory variables; columns headed R denote model with restricted set of explanatory variables. Values in parentheses indicate calculated t statistics for coefficients. Two-tailed tests were used. Three asterisks, two asterisks, and one asterisk indicate 1, 5, and 10% significance level, respectively. NA denotes not applicable.

TABLE 9. Comparison of WTP With Present Expenditures

	Percent of Households	Average Present Expenditure, US$/month	Average WTP Bid Less Average Present Expenditure, US$/month
Households With Water and Without a WC			
WTP for KVIP greater than current expenditure	75	0.47	1.00
WTP for KVIP equal to current expenditure	12	0.73	0.00
WTP for KVIP less than current expenditure	13	2.43	−1.43
WTP for WC and sewer greater than current expenditure	75	0.50	1.06
WTP for WC and sewer equal to current expenditure	11	0.65	0.00
WTP for WC and sewer less than current expenditure	14	2.25	−1.29
Households with a WC			
WTP for sewer greater than current expenditure	97	0.08	1.26
WTP for sewer equal to current expenditure	2	0.00	0.00
WTP for sewer less than current expenditure	1	0.31	−0.16
Households Without Water and Without a WC			
WTP for water greater than current expenditure on water	67	0.62	1.10
WTP for water equal to current expenditure on water	15	1.13	0.00
WTP for water less than current expenditure on water	18	2.43	−1.11
WTP for KVIP greater than current expenditure on sanitation	74	0.57	1.16
WTP for KVIP equal to current expenditure on sanitation	12	1.18	0.00
WTP for KVIP less than current expenditure on sanitation	14	1.89	−0.84
WTP for water and WC with sewer greater than current expenditure on water and sanitation	89	0.73	2.00
WTP for water and WC with sewer equal to current expenditure on water and sanitation	4	0.35	0.00
WTP for water and WC with sewer less than current expenditure on water and sanitation	7	2.16	−0.86

Plausibility of the willingness-to-pay bids. One possible result of a contingent valuation study is that the respondents could give wildly unrealistic answers or simply refuse to answer the willingness-to-pay questions. As an initial step in assessing the validity of the willingness-to-pay bids, it is important to note that this did not happen in Kumasi. Very few people refused to be interviewed, and of those who were interviewed, almost no one indicated an unwillingness to pay for improved sanitation services (i.e., bid zero). If substantial numbers of respondents gave "much higher" bids than the mean, this too would raise questions about whether their bids accurately reflected real budget constraints or whether they might be answering strategically. This did not happen either. Very few respondents gave willingness-to-pay bids more than twice as much as the mean bid.

Most respondents bid more for improved sanitation than they presently paid for their existing sanitation service. A simple consistency check of the data was made to compare each household's willingness-to-pay bid with its current expenditure on sanitation (and, for some households, on water) to see which was greater (Table 9). Consider households which have water but not a WC. Seventy-five percent of these respondents gave bids for KVIPs that exceed their present sanitation expenditures. On the average, their present expenditures are US$0.47/month, and their average bids exceeded this amount by about US$1.00/month. A similar pattern exists for all the proposed services. About 88% of all households said they were willing to pay at least as much for improved sanitation as the amounts they were currently spending.

About 12% of all respondents gave bids below their present expenditures; the majority of these used public latrines. These respondents were asked an open-ended question about why they were willing to pay an amount less than their current expenditure. About 60% cited problems with cash flow. At present, since they pay for sanitation on a daily basis, these households are never confronted with a large bill for this service. However, with an improved system, the need to make a single monthly payment would pose problems. These results suggest that even the willingness-to-pay bids of respondents who bid less than their current expenditure may be plausible [*Whittington et al.*, 1990*b*].

Explanatory power of the models of the determinants of the willingness-to-pay bids. The adjusted R^2 values for the restricted OLS models in Tables 4–8 range from 0.32 for sewer to 0.47 for water. Although these R^2 values indicate that much of the variation in the willingness-to-pay bids cannot be explained by the models, these values are quite high for cross-section data from contingent valuation surveys and compare very favorably with the results of contingent valuation studies carried out in the United States and western Europe. For example, *Mitchell and Carson* [1989, p. 213] suggest that "the reliability of a CV study which fails to show an R^2 of at least 0.15, using only a few key variables, is open to question." These results from Kumasi clearly pass Mitchell and Carson's proposed standard.

Test for starting point bias. If a respondent's willingness-to-pay bid reflects his or her "true" value of the good or service, then it should not matter what initial amount (or "starting point") the enumerator uses to begin the bidding game. Figure 1 suggests that the starting point does indeed affect respondents' final bids for all five types of service, but that the magnitude of the effect is not large. For example, a high starting point raises the average respondent's willingness-to-pay bid for KVIPs by about US$0.19 (67 cedis per month), which is about 13% of the mean bid. Figure 2 presents the frequency distribution of responses to the open-ended willingness-to-pay question for KVIPs. Forty-one percent of the respondents' willingness-to-pay bids fall into the two ranges, 451–500 cedis/month and 951–1000 cedis/month (US$1.29–1.43 and US$2.72–2.86), which include the two starting points (namely, 500 cedis and 1000 cedis per month). For example, for bids in the range 451–500 cedis/month, substantial numbers of households gave responses which were as follows: For the low starting point, (1) "If the price were 500 cedis per month, would you want to have access to a KVIP latrine?" "Yes"; (2) "What is the most you would be willing to pay per month?" "500 cedis." For the high starting point, (1) "If the price were 1000 cedis per month, would you want to have access to a KVIP latrine?" "No"; (2) "If the price were 500 cedis per month, would you want to have access to a KVIP latrine?" "Yes"; (3) "What is the most you would be willing to pay per month?" "500 cedis."

The frequency distributions for WCs with sewer connections, sewer connections, and water, show similar patterns. Respondents' answers tend to cluster around the 500 and 1000 cedis starting points. This suggests that the values mentioned in the bidding game influenced responses to the final open-ended question about maximum willingness to pay. Most respondents will not pay more than 500 cedis/month (US$1.43) for any type of service; very few respondents are willing to pay more than 1000 cedis/month (US$2.86). However, for all three levels of sanitation service (i.e., excluding the bids for water), there are substantial numbers of respondents who indicate that their maximum willingness to pay is 150–250 cedis/month (US$0.43–0.71).

In general, when a respondent answers "yes" when offered a service at a specified price, it is difficult to get him to raise his bid above this price by asking an open-ended follow-up question. In other words, respondents' answers to the open-ended questions appeared to be "anchored" at the last value to which he or she answered "yes." On the other hand, if a respondent answers "no" when offered the service at a specified price, an open-ended follow-up question may elicit a wide range of bids below the last specified price.

Another test of the effect of the starting point is provided

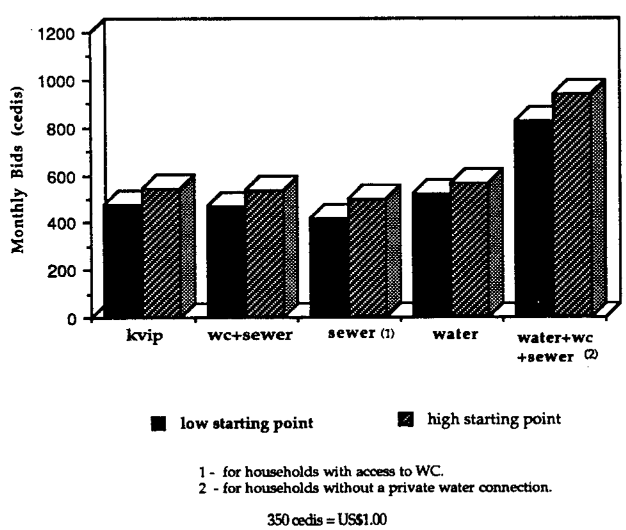

Fig. 1. Effect of starting point on WTP bids.

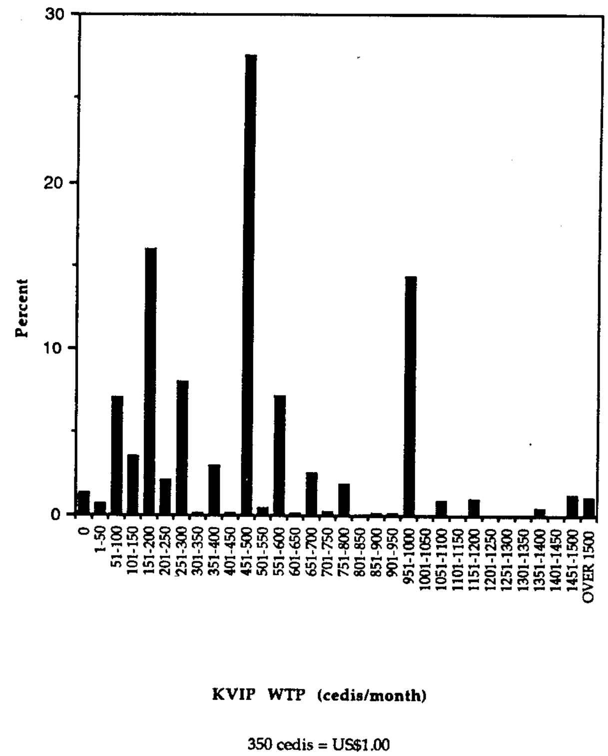

Fig. 2. KVIP WTP frequency distribution.

by the multivariate analyses in which one of the variables (dichotomous) used to explain variation in the willingness-to-pay bids indicates whether the respondent's starting point was high or low. The results of this test for starting point bias are summarized in Table 10. As shown, the results are mixed. Starting point bias is clearly present in the willingness-to-pay bids for improved sanitation services (i.e., for KVIP, WC with sewer connection, and sewer connection), but there is no evidence that the starting point affected the willingness-to-pay bids for water. When improved water and sewer were offered together as a package of services, there is little evidence of starting point bias. One interpretation of these results is that respondents had a clearer sense of the value of water than of improved sanitation services. Because about 60% of households in Kumasi had a water connection in their building at the time of our survey (and the remaining households often collected their water from a neighbors' building that had a water connection), all respondents were familiar with the public water system. Respondents without a water connection in their building thus probably had a clearer sense of what a water connection was worth to them than a sewer connection (which was much less familiar to households in Kumasi). Therefore their willingness-to-pay bid for a water connection would be less likely to be influenced by the proposed starting point.

Effect of giving respondents time to think. A test was carried out to determine whether respondents' willingness-to-pay bids were affected by having time to reflect before giving their bids. Some respondents in the sample were given an extra day to think about how much they would be willing to pay for improved sanitation services; others answered the willingness-to-pay questions immediately. (Due to logistical considerations, this test was carried out only for the sub-

TABLE 10. Effect of Starting Point

	Full Model	Restricted Model
WTP for KVIP		
OLS	***	***
Stewart maximum likelihood	***	***
Ordered probit	*	*
WTP for WC with sewer		
OLS	**	**
Stewart maximum likelihood	**	**
Ordered probit	*	*
WTP for sewer connection		
OLS	**	**
Stewart maximum likelihood	***	***
Ordered probit	*	not significant
WTP for water connection		
OLS	not significant	not significant
Stewart maximum likelihood	not significant	not significant
Ordered probit	not significant	not significant
WTP for water connection and WC with sewer		
OLS	not significant	not significant
Stewart maximum likelihood	**	not significant
Ordered probit	not significant	not significant

Table entries indicate the level of significance of "starting point" as an explanatory variable. Three asterisks, two asterisks, and one asterisk indicate 1, 5, and 10% significance levels, respectively.

group of the sample who were tenants and had a private water connection.) Our hypothesis was that respondents who were given time to think would bid lower than respondents who answered immediately because they would need time to carefully consider the financial and other ramifications of their decisions [*Whittington et al.*, 1992].

In fact, in this study there is little evidence that giving respondents time to think influenced their willingness-to-pay bids. Figure 3 compares the mean bids of respondents who had time to think and those who did not for three classes of willingness-to-pay bids (KVIP, WC with sewer, and sewer). There appears to be almost no difference in the mean bids of the two groups for any of the levels of sanitation service. The results of the time-to-think test from the multivariate analyses are summarized in Table 11. The time-to-think variable shows no effect on the bids for KVIPs or for WCs with sewer connection for any of the three estimators or two model specifications.

The time-to-think variable is significant only for the bids for sewer connections by households with WCs; as hypothesized, respondents who had extra time bid less than those who did not. This may mean that the more that people thought about sewer technology, the less influenced they were by the enumerator's description of it, and the less they liked it. However, the effect of time to think is not strong in three of the six models for sewer connections and not apparent at all in one model. The absence of a time-to-think effect in two of the three groups of willingness-to-pay bids (see Table 11) indicates that the results are robust with respect to the way that the household interviews were conducted and that the possibility of strategic bias resulting

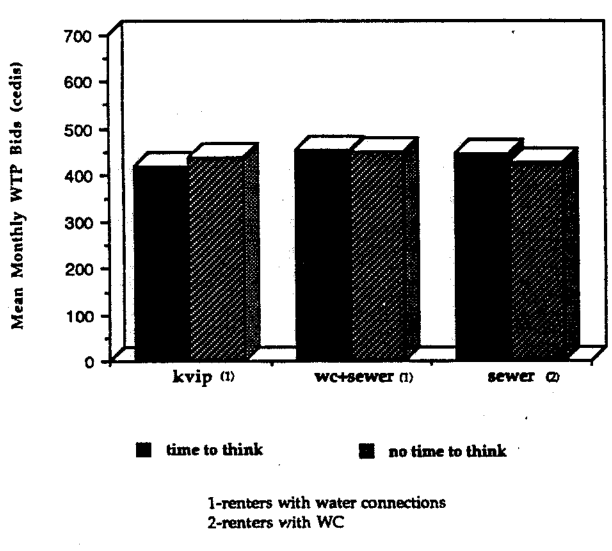

Fig. 3. Effect of time to think on WTP bids.

TABLE 11. Effect of Giving Respondents Time to Think

	Full Model	Restricted Model
WTP for KVIP		
OLS	not significant	not significant
Stewart maximum likelihood	not significant	not significant
Ordered probit	not significant	not significant
WTP for WC with sewer		
OLS	not significant	not significant
Stewart maximum likelihood	not significant	not significant
Ordered probit	not significant	not significant
WTP for sewer connection		
OLS	*	***
Stewart maximum likelihood	*	**
Ordered probit	not significant	*
WTP for water connection	not applicable	not applicable
WTP for water connection and WC with sewer	not applicable	not applicable

Table entries indicate the level of significance of "starting point" as an explanatory variable. Three asterisks, two asterisks, and one asterisk indicate 1, 5, and 10% significance levels, respectively.

TABLE 12. Effect of the Presence of People Listening to the Interview

	Full Model	Restricted Model
WTP for KVIP		
OLS	not significant	not applicable
Stewart maximum likelihood	*	not significant
Ordered probit	not significant	not applicable
WTP for WC with sewer		
OLS	not significant	not applicable
Stewart maximum likelihood	***	***
Ordered probit	not significant	not applicable
WTP for sewer connection		
OLS	not significant	not applicable
Stewart maximum likelihood	***	***
Ordered probit	not significant	not applicable
WTP for water connection		
OLS	not significant	not applicable
Stewart maximum likelihood	not significant	not applicable
Ordered probit	not significant	not applicable
WTP for water connection and WC with sewer		
OLS	**	**
Stewart maximum likelihood	*	not significant
Ordered probit	not significant	not applicable

Table entries indicate the level of significance of "starting point" as an explanatory variable. Three asterisks, two asterisks, and one asterisk indicate 1, 5, and 10% significance levels, respectively.

from giving respondents time to think can be ruled out. The fact that respondents gave consistent answers when they had time to think and when they did not increases our confidence in the reliability of the results.

Effect of the presence of people listening to the interview. Ideally, each respondent would have been interviewed without other people listening. However, due to the crowded housing conditions in Kumasi, many times this was not possible. In approximately one quarter of the interviews, other adults listened as the interview was conducted. This fact was noted by the enumerator. It is possible that the presence of listeners may have biased a respondent's willingness-to-pay bids, but the direction of the potential bias is unclear. Respondents may have been reluctant to indicate their ability to pay a large amount and may thus have bid low. Alternatively, they may have wanted to demonstrate their ability to pay to their neighbors and thus have bid high in an attempt to gain status.

A variable designed to test the effect of the presence of listeners was included in the multivariate analyses; the results are summarized in Table 12. As shown, the results are mixed and depend on the estimator used. The effect of listeners is never statistically significant in the ordered probit models and is statistically significant in only two of the OLS models (both cases are for water and WC with sewer connection). The effect of listeners shows up most strongly in the Stewart maximum likelihood models. The direction of the effect is not consistent. In the models of willingness-to-pay bids for KVIP, for WC with sewer, and for sewer, it is positive, but in the models for water and for water and WC with sewer, it is negative. The parameter estimates are generally small.

We interpret these results to mean that the presence of listeners had little, if any, effect on the willingness-to-pay bids. This suggests that the willingness-to-pay bids are robust with respect to another variation in the interview context, and again increases our confidence that willingness-to-pay bids are not easily manipulated or influenced by contextual issues.

4. POLICY IMPLICATIONS: MATCHING SUPPLY AND DEMAND

In this section of the paper, we illustrate how information obtained from a contingent valuation survey of household demand for improved sanitation services can be used in the assessment of various sanitation options. Our purpose is not to provide a detailed analysis of the choice between KVIPs and WCs with sewers in Kumasi, but rather to suggest the value of incorporating information on household demand for improved services in sanitation planning procedures.

We do not want to suggest, however, that households' willingness-to-pay bids accurately reflect the public health benefits of improved sanitation. If everyone in Kumasi used an improved sanitation system which disposed of excreta in a hygienic manner, the public health benefits would likely be large and would probably not be captured by households' responses to contingent valuation questions. This is because households are probably not fully aware of the health risks to which they are currently exposed by their existing sanitation practices [see *Whittington et al.*, 1993]. The willingness-to-pay bids do appear to reflect households' perceptions of the value of improved sanitation options. Policy makers may not judge these perceptions to be accurate measures of welfare change. However, as we illustrate in the next section, to ignore households' perceptions of the value of improved sanitation options runs the risk of seriously miscalculating the financial feasibility of investments in improved sanitation.

A first step in a financial appraisal of improved sanitation alternatives in Kumasi is to compare the costs of KVIPs and WCs (with sewer connections) to household willingness to pay for them. Such a comparison presents several difficulties. First, the willingness-to-pay bids were obtained for single households, but approximately 90% of households in Kumasi are tenants living in multifamily apartment buildings or compounds. Tenant households cannot act independently; the landlord would decide whether or not to improve sanitation for the entire building. If a sewer system were constructed in the city, the landlord would decide whether or not to connect his building to it. Tenants may try to persuade the landlord to install an improved sanitation system, and they may promise to pay a certain amount each month toward the costs, but ultimately the decision rests with the landlord.

Second, the households in the building would all have to contribute to the cost of the new sanitation facility, similar to what is currently done in sharing water bills or paying for the emptying of bucket latrines [*Whittington et al.*, 1993]. The problem is how to determine how much apartment buildings of different size (i.e., with different numbers of households) are willing to pay for improved sanitation. For purposes of illustration, we assume that the aggregate willingness to pay of households in an apartment building of a given size is equal to the average willingness to pay of households in apartment buildings of that size multiplied by the number of households in the building. The resulting estimate of the total willingness to pay of households in the building could be too high because it might not be possible to persuade all the

TABLE 13. WTP, Costs, and Required Subsidies for New KVIPs in Existing Financial Market (i = 30%, n = 3 Years)

Number of Households in Building	Average Monthly WTP per Household	Required Monthly per-Household Payment to Cover Costs	Required Monthly Subsidy per Building to Cover Costs	Required Lump Sum Subsidy per Module to Make KVIPs Affordable	Required Lump Sum Subsidy per Household to Make KVIPs Affordable
1	$2.01	$10.61	$9	$203	$203
5	$1.67	$3.33	$8	$196	$39
10	$1.52	$2.54	$10	$120	$24
15	$1.44	$2.35	$14	$161	$21
20	$1.38	$2.22	$17	$132	$20
25	$1.33	$2.12	$20	$116	$19
30	$1.29	$2.04	$23	$133	$18
35	$1.26	$1.98	$25	$119	$17
40	$1.23	$1.93	$28	$132	$16
45	$1.20	$1.88	$31	$120	$16

households that gave low willingness-to-pay bids to pay the average willingness-to-pay amount.

Third, the estimates for improved sanitation technologies are for total capital costs, but willingness-to-pay bids are in terms of the amounts households are willing to pay per month. If a household's discount rate (or time value of money) and the economic life of the investment are known, it is a routine exercise to convert total capital costs to monthly costs. Financial markets in Kumasi are, however, highly distorted, and it is difficult to infer much about households' rates of time preference or opportunity cost of capital from information on interest rates in the formal sector. Whether the estimated monthly willingness to pay of an apartment building would be sufficient to retire a loan for the amount of its improved sanitation facility depends to a large extent on the assumed interest rate.

Required Subsidies for KVIPs

Given these limitations, Tables 13 and 14 present cost, willingness to pay, and required subsidy data for new KVIPs and for converting bucket latrines to KVIPs for an annual real interest rate of 30% and a loan period of 3 years (see Appendix B for a more detailed discussion of the costs of sanitation options). This real interest rate and loan period reflect current terms available to creditworthy borrowers in the 1989 informal financial market in Kumasi. In these tables, total monthly costs for installing KVIPs are compared to monthly willingness-to-pay for apartment buildings with different numbers of households living in them. If the building's aggregate willingness to pay cannot cover total costs, the monthly shortfall is calculated, which in turn is used to determine (1) the lump sum subsidy per KVIP module, and (2) the lump sum subsidy per household that are required to make KVIPs affordable for the building.

For example, Table 13 shows that the monthly cost per household for a new KVIP latrine in a building with 10 households based on the existing financial market in Kumasi is US$2.54; the average willingness to pay for a new KVIP in a building with 10 households is US$1.52 per household. (Table 14 presents similar information for installing KVIPs in apartment buildings that currently have bucket latrines.) The monthly cost per household is thus about US$1.00 greater than the monthly willingness to pay; therefore the building requires about 10 additional dollars each month to pay for the service. If the extra money is obtained in the form of a lump sum subsidy for the KVIP unit, the building would need US$120 for each installed KVIP, or in this case, a total of US$240 since two modules are assumed to be needed for 10 households. If the subsidy is awarded on the basis of the number of households in the building, it would be US$24 per household. For typical buildings in Kumasi, the required subsidy per KVIP module is about US$120–130, which is equivalent to about one third of the total capital cost of a new KVIP module. As the number of households in a building

TABLE 14. WTP, Costs, and Required Subsidies for Converting Bucket Latrines to KVIPs in Existing Financial Market (i = 30%, n = 3 Years)

Number of Households in Building	Average Monthly WTP per Household	Required Monthly per-Household Payment to Cover Costs	Required Monthly Subsidy per Building to Cover Costs	Required Lump Sum Subsidy per Module to Make KVIPs Affordable	Required Lump Sum Subsidy per Household to Make KVIPs Affordable
1	$2.11	$6.37	$ 4	$100	$100
5	$1.52	$2.00	$ 2	$ 57	$ 11
10	$1.27	$1.53	$ 3	$ 31	$ 6
15	$1.12	$1.41	$ 4	$ 51	$ 7
20	$1.01	$1.33	$ 6	$ 50	$ 7
25	$0.93	$1.27	$ 8	$ 50	$ 8
30	$0.87	$1.23	$11	$ 64	$ 8
35	$0.81	$1.19	$13	$ 62	$ 9
40	$0.76	$1.16	$16	$ 75	$ 9
45	$0.72	$1.13	$19	$ 73	$ 10

TABLE 15. WTP, Costs, and Required Subsidies for Connecting Existing WCs to New Sewers in Improved Financial Market (i = 10%, n = 20 Years)

Number of Households in Building	Average Monthly WTP per Household	Required Monthly per-Household Payment to Cover Costs	Required Monthly Subsidy per Building to Cover Costs	Required Lump Sum Subsidy per Module to Make WCs Affordable	Required Lump Sum Subsidy per Household to Make WCs Affordable
1	$1.71	$5.02	$3	$342	$342
5	$1.52	$4.63	$16	$1,614	$323
10	$1.43	$4.58	$32	$1,633	$327
15	$1.38	$4.57	$48	$2,476	$330
20	$1.35	$4.56	$64	$2,219	$333
25	$1.32	$4.55	$81	$2,095	$335
30	$1.30	$4.55	$98	$2,529	$337
35	$1.28	$4.55	$114	$2,373	$339
40	$1.26	$4.55	$131	$2,724	$340
45	$1.25	$4.55	$148	$2,564	$342

increases, the average willingness to pay per household decreases. This is more than counterbalanced, however, by the decrease in KVIP costs due to economies of scale.

How would these conclusions change if loan terms were closer to what one finds in an industrialized country? If loans were available at a real interest rate of 10% for 20 years, essentially no subsidies would be necessary to install KVIP latrines in Kumasi. This is true for almost all sized buildings (except for single-family residences) for both new KVIPs and bucket latrine conversions. In other words, if households could engage in financial transactions under terms considered to be more or less normal in industrialized countries, the household willingness to pay for improved sanitation would be sufficient to pay the full costs of KVIPs. This is not to suggest that public authorities should intervene in the financial markets to solve the sanitation problem or offer subsidized loans for the construction of KVIP latrines, but rather to point out that household willingness to pay for KVIP latrines was in fact quite substantial; it just would not buy much in the capital market conditions prevailing in Kumasi in 1989.

Required Subsidies for WCs

There are three categories of houses to be considered for a piped sewerage system in Kumasi. The first includes houses that already have WCs; for them, it is only necessary to construct the sewerage system and make connections. The second category includes houses with piped water but without WCs; the third category includes houses that have neither WCs nor piped water. The cost per WC module of providing sewerage service to houses in the first category with 10 households is about US$2400; this cost increases by US$200 per WC for buildings in the second category to cover the additional cost of providing WCs, and it increases another US$50 per WC to cover the installation of piped water for houses in the third category.

Table 15 shows the average monthly willingness to pay amounts per household for buildings in the first category (with WCs) plus the required monthly payments per household for a sewer connection based on the financial market in industrialized countries. The difference represents the required monthly subsidies per household. The corresponding lump sum subsidies per household and per WC module are also shown in Table 15. (These estimates assume that all of the houses along the route of the sewer are connected to it.)

The required lump sum subsidy per WC module is substantial for all three categories of houses. This is because the bulk of the cost of the WC option is associated with the piped sewerage system, and this is required for all three categories of houses. For buildings with 10 households, the required amount for all three categories is between about US$1600 and US$2000, assuming financing at terms similar to those available in industrialized countries.

Since it is assumed that both a KVIP module and a WC module would each be designed to serve up to eight households, it is possible to compare required subsidies for piped sewerage and WCs with those for KVIPs. Whereas the required subsidy per module for KVIPs in apartment buildings of all sizes is about US$50 to US$200, based on local financing, the required subsidy per module for WCs is about US$1600 to US$3000. This large difference results from the high costs of piped sewerage compared to KVIPs and the fact that willingness-to-pay bids for the two options are not very different.

Technology Choice and the Effect of Subsidies on Sanitation Coverage in Kumasi

It is clear from this analysis that WCs with sewer connections require large subsidies in Kumasi; only about 20% of the cost could be covered by beneficiaries. For the majority of houses in Kumasi (those with piped water but without WCs), a subsidy of about US$360 per household would be required. For the present population of Kumasi, the required lump sum subsidy for WCs and a piped sewerage system would be about US$50 million. Even if all households in Kumasi already had WCs and it were possible to borrow under terms similar to those in industrialized countries, the required lump sum subsidy for this technology would exceed US$40 million.

If a subsidy in this amount is unavailable for Kumasi, then KVIPs are the only financially feasible sanitation technology. The population to be targeted for improved sanitation through the use of KVIPs consists of people living in buildings at present not served by WCs, an estimated 450,000 people. Figure 4 shows how the percentage of these households that could afford KVIPs changes with the

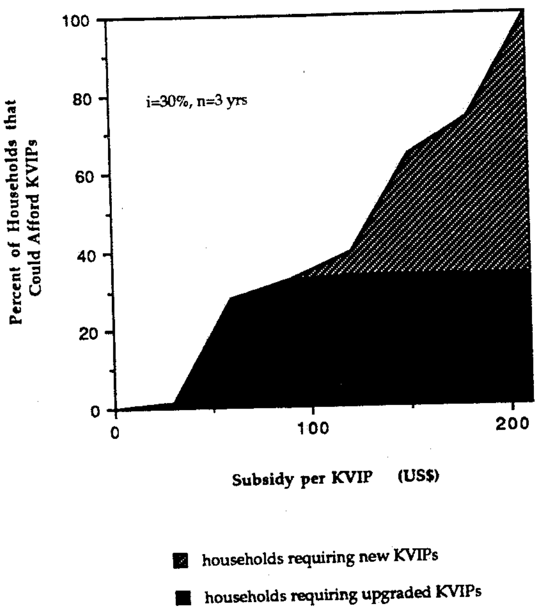

Fig. 4. Effect of subsidy per KVIP module on sanitation coverage in Kumasi.

amount of the subsidy per KVIP module under the existing informal financial market conditions. For a subsidy of US$100 per KVIP module, all of the households with bucket latrines (150,000 people) could afford a KVIP, but almost none of the households currently using public or pit latrines could afford one. Overall, between 30 and 35% of the households without WCs could afford KVIPs with this level of subsidy. At a subsidy level of US$150 per KVIP, 65% of all households without WCs could afford a KVIP. Of this 65%, roughly half at present have bucket latrines, and the rest use public latrines or the bush. A subsidy of approximately US$200 per KVIP is required to insure that almost all the households presently without WCs would have access to KVIPs.

The total subsidy required to install KVIPs in buildings at present not using WCs can be obtained by multiplying the subsidy required per building of a given size times estimates of the number of buildings of that size in Kumasi, and then aggregating across all sizes of buildings. Figure 5 shows the percent of households at present without WCs that could be served with KVIPs for different total subsidy levels under the existing financial market. All of the households in buildings using bucket latrines could be covered for approximately US$1.0 million. A total subsidy of about US$4 million would provide KVIP coverage for all households not currently using WCs.

In addition to the costs of converting to and installing KVIPs, it would be necessary to equip most of the septic tanks that serve existing WCs with soakaways to prevent them from overflowing. If a soakaway costs, say, US$200, then the total cost for all 5000 septic tanks in the city would be US$1 million. Part of this cost would be borne by the present WC users, but some subsidy would be required.

5. SUMMARY AND CONCLUSIONS

This research provides additional evidence that contingent valuation surveys can be successfully conducted in cities in developing countries and that useful information can be obtained on household demand for public services such as sanitation. The multivariate analyses of the willingness-to-pay responses compare very favorably with similar analyses carried out in industrialized countries. The multivariate analyses indicate that the principal determinants of households' willingness to pay for improved sanitation services are household income, whether the respondent's household is a landlord or tenant, the household's current expenditures on sanitation, and the respondent's level of satisfaction with the household's existing sanitation system. Neither the education level of household members nor social or cultural variables had much effect on households' willingness to pay. These results were robust with respect to the estimation technique used in the multivariate analysis and the exact model specification.

The experimental design incorporated numerous tests to check the internal consistency and reliability of the households' willingness-to-pay responses, including a test for starting point bias, a "time-to-think" effect, and the effect of observers listening to the interview. These tests revealed little reason for serious concern about the reliability or validity of the willingness-to-pay responses. From a methodological perspective, however, there was an interesting aspect about the evidence of starting point bias. The research revealed a potential problem with the use of the "abbreviated bidding procedure with follow-up" as an elicitation method. When a respondent was offered an improved service at a specified price, he could answer "yes" or "no." In this study, if he answered "yes," he was not likely to raise his bid above this specified price in response to an open-ended follow-up question. In this case, the open-ended follow-up question did not provide any additional information on the household's preferences. On the other hand, if the respondent answered "no" when offered the service at a

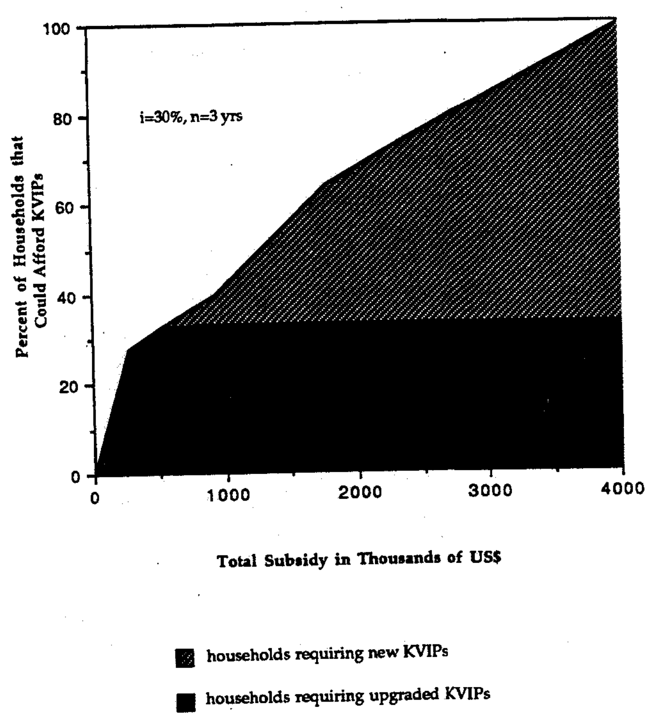

Fig. 5. Effect of total subsidy for KVIPs on sanitation coverage in Kumasi.

given price, an open-ended follow-up question elicited a wide range of answers below the specified price. The apparent reluctance of respondents to offer a bid above the specified price will likely result in a downward bias in the mean of the willingness-to-pay responses to the open-ended questions.

From a policy perspective, the results of the study indicate that conventional sewerage is simply not affordable to the vast majority of households in Kumasi without massive government subsidies. In retrospect this is perhaps not so surprising. What was less apparent before this research, however, was the widespread acceptance of KVIPs and the approximate levels of subsidy which would be required to achieve different coverage goals with a KVIP subsidy program. The results of the CV survey showed that most households were willing to pay about as much for a KVIP latrine as for a WC connected to a conventional sewerage system. The study also indicated that households' willingness to pay for water and for sanitation appear to be of approximately the same order of magnitude and largely separable.

This study also identified two areas where additional research is needed on the application of the contingent valuation method in developing countries to the problem of estimating household demand for improved sanitation services. First, the contingent valuation questions for alternative technologies were asked on a sequential basis, first for KVIPs and then for WCs. Research is needed to develop cost-effective ways of determining how households would choose between two or more options presented simultaneously at alternative prices.

Second, the unit of analysis in this research was the individual household. However, in cities such as Kumasi where improved sanitation facilities are provided for entire apartment buildings, the focus should arguably be on the collective decision of the group of households in a building. In the initial phase of this study, we conducted some experiments to determine the collective willingness to pay of all residents in a building for improved sanitation services, but this approach proved impractical within our time and resource constraints. Additional research is needed on the issue of how to obtain a realistic collective bid for improved sanitation services for a group of tenants living in one apartment building.

APPENDIX A: EXAMPLE OF AN OPENING STATEMENT AND WILLINGNESS-TO-PAY QUESTIONS FOR A KVIP LATRINE

The following version is used for tenants with a piped water connection in their dwelling. (Photographs and diagrams were used to illustrate the points in the following presentation.)

Introductory Statement

Now I would like to ask you some questions about how much your household would be willing to pay for an improved sanitation system. I would like to ask you about two possible types of improved sanitation systems.

The first type of improved sanitation system is called a KVIP latrine, which is a ventilated pit latrine. This KVIP latrine would be private and each toilet room would have two holes (only one of which is in use at a time). It does not use water, but it could be built inside the house (on the ground floor). It can also be entered from inside the house. The excrement falls into one of two adjacent pits. When one pit is full, you switch to the other. The pit is not emptied immediately after it becomes full. You wait to empty the pit until the excreta is turned into manure which is safe to use in a garden. This takes about 2 years. The pit can then be emptied from outside the house.

This kind of latrine is specially designed so that if it is kept clean, it will not smell. It has a vent pipe to eliminate odors, and a fly screen to eliminate flies. The KVIP, a ventilated improved pit latrine, is not like an ordinary latrine. It is a permanent facility. What makes it permanent is that the two pits are lined and can be easily emptied and reused. Because the KVIP latrine has two pits, it does not have to be emptied very often and is thus very inexpensive to operate. It is a safe, sanitary means of excreta disposal.

I would now like to answer any questions you have about the KVIP latrine.

1. Were you familiar with a KVIP latrine before I came here? (yes/no)

The second type of improved sanitation system is a WC in the house which you would share with other tenants. The WC would be private and there would be only one in the house (or one on each floor if this is a multistory building). It would be the responsibility of the tenants and the landlord to keep the WC clean. If it were kept clean, it would not smell.

The WC would be connected to a pipe outside the house. This type of pipe is known as a sewer. The waste from the WC would flow into the sewer. The waste would not flow into a septic tank or holding pit, so it should not overflow or clog up. Therefore the household would not have the expense of emptying a septic tank or holding pit. In order to have a WC, a house must be connected to the water system.

I would now like to answer any questions you have about the WC and the sewer system.

2. Were you familiar with a WC before I came here? (yes/no)

3. Were you familiar with a sewer system before I came here? (yes/no)

Bidding Game for a KVIP Latrine (High Starting Point)

Suppose that the landlord was willing to install a KVIP latrine in this house for the use of the tenants if the costs could be recovered in a separate payment from the tenants. If the landlord installed a KVIP latrine, the excreta disposal system would be improved. There would be no initial charge or fee to have the KVIP latrine installed, only the monthly payment. You would have to pay this monthly payment as long as you lived in this house.

1. If the landlord asked you to pay 1000 cedis per month toward the KVIP latrine, would you want the landlord to install a KVIP latrine or would you prefer not to have a KVIP latrine? (If "yes" (have landlord install a KVIP), go to question 3. If "no" (rather not have a KVIP), go to question 2.)

2. Suppose that instead of 1000 cedis that the monthly payment for the KVIP latrine was 500 cedis. Would you want the landlord to install a KVIP latrine or would you prefer not to have a KVIP? (If "yes" (have landlord install a KVIP), go to question 3. If "no" (rather not have a KVIP), go to question 3.)

3. What is the most you would be willing to pay per

month to have a KVIP latrine in the house which members of your household could share with the other tenants?

Maximum monthly payment —— cedis per month

(Enumerator: Now write down the amount of money the household is spending per month on its present excreta disposal system from the information in part II of the questionnaire on household sanitation practices.)

4. Respondent's current monthly expenditure on sanitation from part II: —— cedis per month.

5. Is the respondent's current expenditure higher than his answer to question 3? (If "yes," go to question 6; if "no," finished.)

If the present expenditure in question 4 is higher than the bid in question 3 above, ask why the respondent is willing to pay less for a KVIP than for his existing sanitation system. Give the respondent an opportunity to change his bid in question 3 above.

6. Reasons given.

7. Respondent's revised bid: —— cedis per month.

APPENDIX B: COSTS OF IMPROVED SANITATION OPTIONS

KVIPs

The cost of a KVIP depends upon several factors. These facilities can be built in different sizes, depending on the number of people they are designed to serve. As the number of people served increases, the number of cubicles and both the number and capacity of holding pits must also increase. There are economies of scale in the construction of KVIPs, so the cost per household will decrease as the number of households in an apartment building using a KVIP increases.

Households living in multifamily buildings would not each have their own KVIP; rather, they would share a latrine with other households. In Kumasi, it is assumed that up to eight households can share a single KVIP "module" (i.e., one hole with one pit in use and another hole with a second pit not in use). Although the size of a module's pits can be reduced for fewer than eight households, the cost savings are not large. Queue times, however, may be reduced as fewer households share a KVIP module, so there may be perceptible differences in the level of service provided by a KVIP serving, say, four households compared to one serving eight.

Table B1 shows the number of KVIP modules required in an apartment building for the assumed number of households and the estimated capital costs. For example, an apartment building with 10 households would need two modules which would cost a total of about US$600. Capital costs range from US$250 for a one-module KVIP which serves a single household to US$2000 for a six-module facility that serves 45 households. The cost per household declines rapidly over the range of one to 10 households (from US$250 to US$60). As the number of households increases above 10, cost per household continues to fall, but not as much. The costs per household for 20 and 45 families are US$52 and US$44, respectively.

If a building already has a bucket latrine, the cost of converting it to a KVIP would be less than constructing a new KVIP because the existing superstructure can still be used. Conversion of a bucket latrine to a KVIP essentially involves construction of its pit and the installation of ventilation. The cost of converting a bucket latrine to a KVIP is approximately 60% of the cost of the new KVIP. Table B2 shows the capital costs of converting existing bucket latrines to KVIPs.

WCs Connected to a Sewer

The costs of providing WCs and sewerage are more difficult to estimate than the costs of KVIPs. The cost per household of the sewerage system (without treatment facilities) is probably of the order of US$470–500 per household. To this must be added the cost of connecting apartment buildings to the sewer and installing WCs and indoor plumbing, where necessary. Table B3 presents estimates of the costs of constructing the sewerage system plus the cost of connecting apartment buildings that now have WCs to the sewerage system. Table B4 presents the capital costs of the sewerage system plus installation of new WCs for buildings that already have water. Table B5 presents similar information (i.e., for the sewerage system, building connections, and new WCs) for buildings presently without piped water. For buildings with piped water but without WCs, Table B4 shows that the costs per household vary from US$720 (for a building with a single family) to US$496 (for a building with 40 households). Since the majority of the costs in these cases is for the sewer system (not for installing WCs or connecting the building to the sewer), the cost per household is nearly the same for buildings with five or 45 families. For most building sizes, the cost per household of providing a WC connected to a sewer is about 11–17 times the cost of providing a household with a KVIP latrine if the building

TABLE B1. Capital Costs of New KVIPs

Number of Households in Building	Number of KVIPs to be Installed	Total Capital Cost for Entire Building	Cost per Household	Cost per KVIP Module
1	1	$250	$250	$250
5	1	$393	$79	$393
10	2	$599	$60	$300
15	2	$829	$55	$415
20	3	$1,044	$52	$348
25	4	$1,248	$50	$312
30	4	$1,444	$48	$361
35	5	$1,633	$47	$327
40	5	$1,817	$45	$363
45	6	$1,997	$44	$333

TABLE B2. Capital Costs of Converting Existing Bucket Latrines to KVIPs

Number of Households in Building	Number of KVIPs to Be Installed	Total Capital Cost for Entire Building	Cost per Household	Cost per KVIP Module
1	1	$150	$150	$150
5	1	$236	$47	$236
10	2	$360	$36	$180
15	2	$497	$33	$249
20	3	$626	$31	$209
25	4	$749	$30	$187
30	4	$866	$29	$217
35	5	$980	$28	$196
40	5	$1,090	$27	$218
45	6	$1,198	$27	$200

TABLE B3. Capital Costs of Connecting Existing WCs to a New Sewer

Number of Households in Building	Number of WCs to Be Installed	Total Capital Cost for Entire Building	Cost per Household	Cost per WC
1	1	$520	$520	$520
5	1	$2,400	$480	$2,400
10	2	$4,750	$475	$2,375
15	2	$7,100	$473	$3,550
20	3	$9,450	$473	$3,150
25	4	$11,800	$472	$2,950
30	4	$14,150	$472	$3,538
35	5	$16,500	$471	$3,300
40	5	$18,850	$471	$3,770
45	6	$21,200	$471	$3,533

TABLE B4. Capital Costs of Providing Sewered WC Service to Buildings With Water

Number of Households in Building	Number of WCs to Be Installed	Total Capital Cost for Entire Building	Cost per Household	Cost per WC
1	1	$720	$720	$720
5	1	$2,600	$520	$2,600
10	2	$5,150	$515	$2,575
15	2	$7,500	$500	$3,750
20	3	$10,050	$503	$3,350
25	4	$12,600	$504	$3,150
30	4	$14,950	$498	$3,738
35	5	$17,500	$500	$3,500
40	5	$19,850	$496	$3,970
45	6	$22,400	$498	$3,733

TABLE B5. Capital Costs of Providing Sewered WC Service to Buildings Without Water

Number of Households in Building	Number of WCs to Be Installed	Total Capital Cost for Entire Building	Cost per Household	Cost per WC
1	1	$820	$820	$820
5	1	$2,700	$540	$2,700
10	2	$5,250	$525	$2,625
15	2	$7,600	$507	$3,800
20	3	$10,150	$508	$3,383
25	4	$12,700	$508	$3,175
30	4	$15,050	$502	$3,763
35	5	$17,600	$503	$3,520
40	5	$19,950	$499	$3,990
45	6	$22,500	$500	$3,750

already has a bucket latrine, and 7–10 times the cost of providing a KVIP if the building does not have a bucket latrine.

Unlike the costs of KVIPs, the per-household costs of WCs connected to a sewerage system are very dependent on the number of buildings which adopt the technology and connect to the system. For example, if only 20% of the apartment buildings in Kumasi decide to install KVIPs, the costs per building are no different than if 100% of the buildings installed KVIPs. However, if only 20% of the apartment buildings decide to connect to the sewerage system and they are scattered throughout the city, the costs per building are much greater than if all buildings connect.

The estimates presented in Tables B1–B5 are for capital costs and do not include operation and maintenance costs. In this instance, the technology with high capital cost (WCs and sewerage) does not have correspondingly lower operation and maintenance costs. In fact, the monthly operation and maintenance cost for the WC and sewerage system would be substantially higher than for a KVIP latrine because a WC uses water and is more likely to break down. Thus, if operation and maintenance costs were included, the WC sewerage system option would be relatively more expensive.

References

Altaf, A., D. Whittington, H. Jamal, and V. K. Smith, Rethinking rural water supply policy in the Punjab, Pakistan, *Water Resour. Res.*, in press, 1993.

Bohm, R. A., T. J. Essenburg, and W. F. Fox, Sustainability of potable water services in the Philippines, *Water Resour. Res.*, in press, 1993.

Briscoe, J., P. F. de Castro, C. Griffin, J. North, and O. Olsen, Toward equitable and sustainable rural water supplies: A contingent valuation study in Brazil, *World Bank Econ. Rev.*, *4*(2), 115–134, 1990.

Cummings, R. G., D. S. Brookshire, and W. D. Schulze (Eds.), *Valuing Environmental Goods: An Assessment of the Contingent Valuation Method*, Rowman and Allanheld, Totowa, N. J., 1986*a*.

Cummings, R. G., W. D. Schulze, S. D. Gerking, and D. S. Brookshire, Measuring the elasticity of substitution of wages for municipal infrastructure: A comparison of the survey and wage hedonic approaches, *J. Environ. Econ. Manage.*, *13*(3), 269–276, 1986*b*.

Dickie, M., A. Fisher, and S. Gerking, Market transactions and hypothetical demand data: A comparative study, *J. Amer. Stat. Assoc.*, *82*(397), 69–75, 1987.

Mitchell, R., and R. T. Carson, *Using Surveys to Value Public Goods: The Contingent Valuation Method*, Resources for the Future, Washington, D. C., 1989.

Singh, B., R. Ramasubban, R. Bhatia, J. Briscoe, C. C. Griffin, and C. Kim, Rural water supply in Kerala, India: How to emerge from a low-level equilibrium trap, *Water Resour. Res.*, in press, 1993.

Stewart, M. B., On least squares estimation when dependent variables are grouped, *Rev. Econ. Stud.*, *50*, 737–754, 1983.

Whittington, D., J. Briscoe, X. Mu, and W. Barron, Estimating the willingness to pay for water services in developing countries: A case study of the contingent valuation method in Haiti, *Econ. Devel. Cult. Change*, *38*(4), 293–311, 1990*a*.

Whittington, D., A. Okorefor, A. Okore, and A. McPhail, Strategy for cost recovery in the rural water sector: A case study of Nsukka District, Anambra State, Nigeria, *Water Resour. Res.*, *26*(9), 1899–1913, 1990*b*.

Whittington, D., D. T. Lauria, and X. Mu, A study of water vending and willingness to pay for water in Onitsha, Nigeria, *World Devel.*, *19*(2/3), 179–198, 1991.

Whittington, D., V. K. Smith, A. Okorefor, A. Okore, J. L. Liu, and A. McPhail, Giving respondents time to think in contingent valuation studies: A developing country application, *J. Environ. Econ. Manage.*, *22*, 205–225, 1992.

Whittington, D., D. T. Lauria, K. Choe, J. A. Hughes, and V. Swarna, Household sanitation in Kumasi: A description of current practices, attitudes, and perceptions, *World Devel.*, in press, 1993.

K. Choe, Department of City and Regional Planning, University of North Carolina at Chapel Hill, Chapel Hill, NC 27514.

J. A. Hughes, D. T. Lauria, V. Swarna, and D. Whittington, Department of Environmental Sciences and Engineering, 315 Pittsboro Street, University of North Carolina at Chapel Hill, Chapel Hill, NC 27514.

A. M. Wright, Infrastructure and Urban Development Department, World Bank, 1818 H Street NW, Washington, DC 20433.

(Received October 16, 1991;
revised October 27, 1992;
accepted January 15, 1993.)