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A Study of Water Vending and Willingness to Pay for Water in Onitsha, Nigeria

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Summary. — Most people in Onitsha, Nigeria obtain their water from an elaborate and well-organized water vending system which is run by the private sector. About 275 tanker trucks collect water from private boreholes and sell it to households and businesses equipped with water storage facilities. Many of these households and businesses resell water by the bucket to individuals who cannot afford large storage tanks or who cannot be reached by tanker trucks. During the dry season the private water vending system collects about 24 times as much revenue as the public water utility. On an annual basis, households in Onitsha pay water vendors over twice the operation and maintenance costs of a piped distribution system.

1. INTRODUCTION

For most water utilities and donor agencies, the actual water supply situation in many Third

little point to studying household water-use behavior. Unfortunately this is not the case. For a variety of reasons success often eludes water supply projects. Urban water schemes often fail

expectations and accomplishments is often great (World Bank, 1988).

It is not necessary to plan, design, and manage water systems in the dark. Relatively simple, rapid reconnaissance surveys of household water demand behavior have been devised to provide policy-relevant information to water utility managers in a timely fashion. This paper describes one such survey. A case study of water vending and willingness to pay which was carried out in Onitsha, Nigeria, in July and August 1987 illustrates how such studies can be conducted and what kinds of information they can provide.

The purpose of this particular study was to estimate the willingness of households to pay for water so that the state water authority could make a more informed decision on how much to charge its customers. Stated more simply, the general manager of the water utility wanted to know what was going on at the household level in the water sector and needed some detective work to find out.

2. BACKGROUND

Onitsha is a rapidly growing city of about 700,000 people located on the banks of the Niger in Anambra State in southern Nigeria. The public water system in Onitsha was built in the 1940s and extended during the 1960s. Onitsha's infrastructure, and especially its water system, was hard hit during the 1967–70 civil war, and since then has been totally inadequate to meet the needs of the population. In 1981, the World Bank appraised a water and sanitation project for Onitsha, and subsequently made a loan to the Anambra State Water Corporation (ASWC) which included funds to finance the construction of a new water supply scheme for the city. This New Onitsha Water Scheme was inaugurated in January, 1988, soon after the field work for this study was completed.

During the planning and construction period for this project, discussions were held between officials of the World Bank and the ASWC concerning what prices to charge for water from this new system. As in other parts of Africa (and indeed much of the world), many people in Anambra State believe that piped water is a public service which the government should provide free or for a nominal fee. Whatever the merits of this belief, developing countries rarely have enough resources at their disposal to deliver such subsidized services.

In water sector policy discussions, donors often argue for higher prices in order to promote more efficient use of water, to enable the water authority to generate adequate revenues to provide a higher level of service, and to encourage more efficient capacity expansion. For their part, water authorities in developing countries often want to keep water prices low in order to promote water use and thus improve public health and sanitary conditions. Water authorities are also concerned about the equity (and political) consequences of raising water prices. They fear that people cannot or will not pay higher prices and will not connect to (or will disconnect from) the piped distribution system if prices are raised. If a significant number of households disconnect from the piped distribution system or reduce consumption, as a result of a price increase, total revenues could decline. In such a case, people would not receive the economic and health benefits of an improved water supply.

Until the study described in this paper was undertaken, there was little information available on household demand for improved water services in Nigeria which could help clarify the issues involved in this policy discussion (for an exception, see Reedy, 1987).

3. THE STUDY AREA

Onitsha is one of the most important market towns of West Africa, and much of the population is engaged in trading activities. As a result of the high level of entrepreneurial activities, Onitsha has a prosperous urban economy, by Nigerian standards. Average annual household income is probably about ₦ 7,000 (in August 1987, US$1.00 = ₦ 4.3), but roughly 25% of the households have an annual income below ₦ 2,400.

This relatively high level of wealth is reflected in the housing stock of Onitsha. There are a few thousand modern multi-story, concrete apartment buildings in Onitsha. Most were constructed with indoor plumbing but have not yet been provided with water from the public water system. At the time of this study, people living in these apartments were waiting for the completion of the New Onitsha Water Scheme and often for the extension of the distribution network to their neighborhood. It was a common sight to see women carrying buckets of water into these modern apartment buildings, perhaps so that they could flush their toilets. In some parts of the city, the women may fill their buckets at shallow wells in the middle of a paved sidewalk.

One-third to one-half of the population of Onitsha lives in squatter settlements in one- and two-room tenements, without piped water or

indoor toilets. These areas are, however, generally served with electricity.

The average household size in Onitsha, as in other parts of Nigeria, is 6–7 persons. The majority of the population has completed at least primary school. About 10% of the heads of household have no formal education, and about 10% have some education beyond secondary school. Igbo is the major language spoken in the region.

4. DESCRIPTION OF WATER-VENDING PRACTICES IN ONITSHA

Only about 8,000 households in Onitsha had functioning water connections to the public water supply system at the time this study was undertaken. The vast majority of the population obtains its water from the vending system which has been created and is operated by the private sector. This water vending system is elaborate and well organized. Approximately 275 tanker trucks purchase water from private boreholes and then sell it to households and businesses equipped with water storage facilities (generally either 45-gallon drums or 500–1,000 gallon tanks).[1] Tankers hold 1,000–2,500 gallons. There are probably about 20 major private boreholes scattered throughout the city which supply tanker trucks. Some of these private boreholes were drilled expressly to supply tanker trucks; others serve the water needs of factories or other commercial establishments and sell to tanker trucks only as a sideline. Some private boreholes sell directly to individuals who walk to the borehole and purchase water by the bucket; others sell only to tanker trucks.

After filling their tanks, the tanker trucks cruise around neighborhoods in Onitsha looking for customers. Most do not have regular customers or fixed routes. In the dry season, a tanker truck might sell 6–8 loads per day; in the rainy season about 3–4 loads.

Many of the households which purchase water from tanker trucks resell the water by the bucket to individuals who cannot afford large storage facilities or who live in areas which cannot be reached by tanker trucks. Even though the 1,000-gallon storage tanks are quite expensive — they retail for about ₦ 1,500 — many households in Onitsha have made this large investment in water storage facilities. We term individuals who purchase water from tanker trucks and then resell the water by the bucket "small retail water vendors." There are literally thousands of these small retail water vendors in Onitsha; the majority of households in Onitsha are within 50 meters of such a vendor. Most open between 6–6:30 a.m. and close between 9–9:30 p.m.

These small retailers not only sell directly to individuals, but also to "distributing vendors" (or "Hausa" men) who generally carry two four-gallon tins on their shoulders with a pole. These distributing vendors may also purchase their water directly from a private borehole which sells to individuals by the bucket. Distributing vendors sell water throughout the city. The average distributing vendor has been selling water for 2.6 years. Most work about seven hours per day in the rainy season and nine and one-half hours per day during the dry season. Almost all the distributing vendors sell water most of the year. About one-half work in other jobs. Before they started selling water, most were either farmers or held unskilled jobs in the informal sector. Most of the distributing vendors have a few customers who purchase water from them on a regular basis.

In summary, households can purchase water from several points in the vending system. If they live in an area accessible to tanker trucks, they can purchase a storage tank or drum(s) and buy water directly from a tanker truck. If they are willing to haul water by the bucket to their homes, they can buy it directly from a private borehole or from a small retail water vendor. If the value they place on their time is high, they can have water delivered directly to their door by a distributing vendor. Of course, none of this information on how the water vending system worked was available to us in any systematic way when we first arrived in Onitsha; all we knew was that "there was a lot of water vending going on."

5. FIELD PROCEDURES

In the summer of 1987, the ASWC, the World Bank, and the United States Agency for International Development's Water and Sanitation for Health (WASH) program initiated a project to investigate the existing water supply situation in Onitsha. Since secondary data on household water use and socioeconomic characteristics were not available, we had little choice but to rely on primary data collection. Because we had little sense of the magnitude of the water vending system and were unsure whether water vendors would cooperate with our study, we decided to interview and observe participants at all levels of the vending system (rather than ask one group — e.g., tanker truck drivers about the activities of other groups). This strategy enabled us to cross-check information from different sources.

The fieldwork for this study was conducted

over a three-day period in July 1987 (this time was spent developing and pretesting questionnaires and training enumerators), and a ten-day period in August 1987 (during which the survey work was conducted). This was during the rainy season, which extends from April to October (rainfall in Onitsha averages about 2,000 mm per year.) Five categories of people were interviewed: 31 tanker truck drivers, 12 managers and attendants of boreholes, 104 small water retailers, 34 distributing vendors, and 235 households. In addition, enumerators were placed on tanker trucks and rode with the driver all day, recording in a log book the time required to fill the truck at the borehole, the number of sales, the prices charged for different quantities of water, and the status of each customer (resident or business), and the number of customer(s) who would resell the water. If the customer bought water from the tanker truck to resell, the enumerator asked him how much he charged his customers and how much water he purchased per week on average in the rainy season and in the dry season.

Placing an enumerator on a tanker truck required considerable finesse and negotiation by our field supervisors, as well as a ₦ 10 payment to the driver of the tanker truck. Indeed, although we were not aware of its existence when we began the study, there is a tanker truck drivers' union in Onitsha. The so-called union of tanker truck drivers is in reality an owners' association. In order to keep track of the sales of their drivers, the owners have developed an elaborate record-keeping system which involves posting two union employees at each borehole to record the amount of water purchased by each tanker truck driver. This information enables the owners to determine whether drivers are reporting all of their sales and thus presumably prevents tanker truck drivers from selling water on the side and pocketing the cash.

Five days after we started interviewing tanker truck drivers, the union called a special meeting and decided to prohibit its members from cooperating with our study, but by then we had all the information we needed from the drivers and had proceeded to the household interviews. We were able to place enumerators on tanker trucks 26 times, and thus collected information on 26 different working days of tanker trucks. This information provided concrete, first-hand observations of the water vending transactions between tanker trucks, households, and small retailers.

None of the surveys carried out as part of this research could be conducted in accordance with rigorous social science research protocols in the sense that it was not possible to construct well-defined sample frames from which to select the respondents. However, care was taken in sample selection to avoid obvious sources of bias, and all five types of interviews were carried out in all the major districts of the city. For the household interviews and the interviews with small retailers, enumerators were dropped at points in a district randomly selected from a block map of the city and instructed to walk in a particular direction and interview every other house or small retailer. The household interviews were conducted throughout the day, but a special effort was made to catch people before they went to work and in the evening after they returned from work to avoid oversampling individuals who were unemployed or worked at home. Tanker trucks selected to carry the enumerators were identified at several major boreholes in different parts of the city. For the interviews with distributing vendors, the enumerators were simply dropped in different districts and instructed to interview as many such vendors as they could locate. The interviews with borehole managers and attendants presented even more of a problem in terms of potential bias because many refused to talk with the enumerators (probably in part because they were afraid of being taxed on their revenues from water sales).

The lack of a well-defined sample frame is not a problem which is unique to this study. The data are not available in most urban areas in developing countries — and particularly in squatter settlements — to implement survey research designs in which every member of the urban population has a known probability of being selected. When the necessary secondary data are not available, the construction of such a sample frame is often too time consuming and expensive to be practical for many policy-oriented research efforts in which information is required in a timely manner to support management decision making.

The consequence of this lack of a well-defined sample frame is that we cannot be as confident of our ability to extrapolate the findings from our sample to the general population of Onitsha. In our view, this increased level of uncertainty must be explicitly addressed by managers and decision makers working in the water sector. It is not a limitation of this study *per se* in the sense that there is no reasonable alternative to the sampling approaches we used given the time constraints under which we worked. The real question for policy makers and managers working in the water sector is not whether they would prefer to have more reliable information obtained from studies carried out in accordance with rigorous social

science research protocols versus the kind of information provided by the type of rapid reconnaissance surveys described in this paper. Rather the choice is between information which can be obtained from the kind of surveys carried out in this study versus information which can be obtained from other kinds of fast, relatively inexpensive studies.

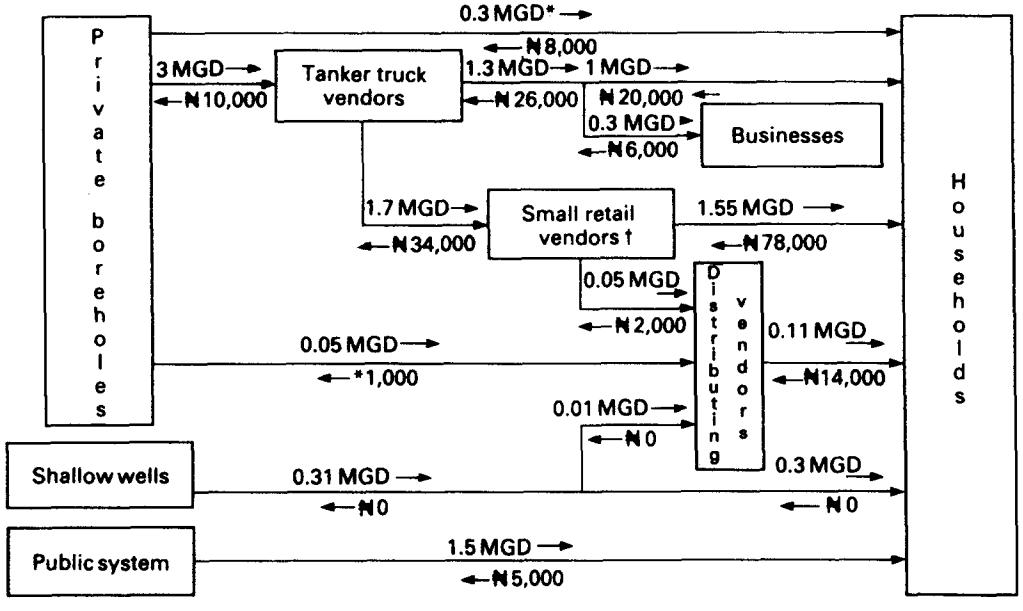
Because of the uncertainty introduced by the lack of a well-defined sample frame, we designed the surveys to include as many cross-checks on the data obtained from the various interviews as possible. For example, the technique of having enumerators ride on the tanker trucks made it possible to verify much of the information obtained from the interviews conducted with different actors in the water vending system and with households. As a result of our ability to cross-check information from more than one source, we are quite confident about the accuracy of the general picture of water vending in Onitsha which is presented in this paper.

6. MONEY AND WATER TRANSACTIONS IN THE WATER VENDING SYSTEM IN ONITSHA

From the information gathered during the course of the fieldwork, it is possible to piece together a general picture of how money and water change hands in the water vending system in Onitsha during both the rainy and dry seasons. These transactions are summarized in Figures 1 and 2.

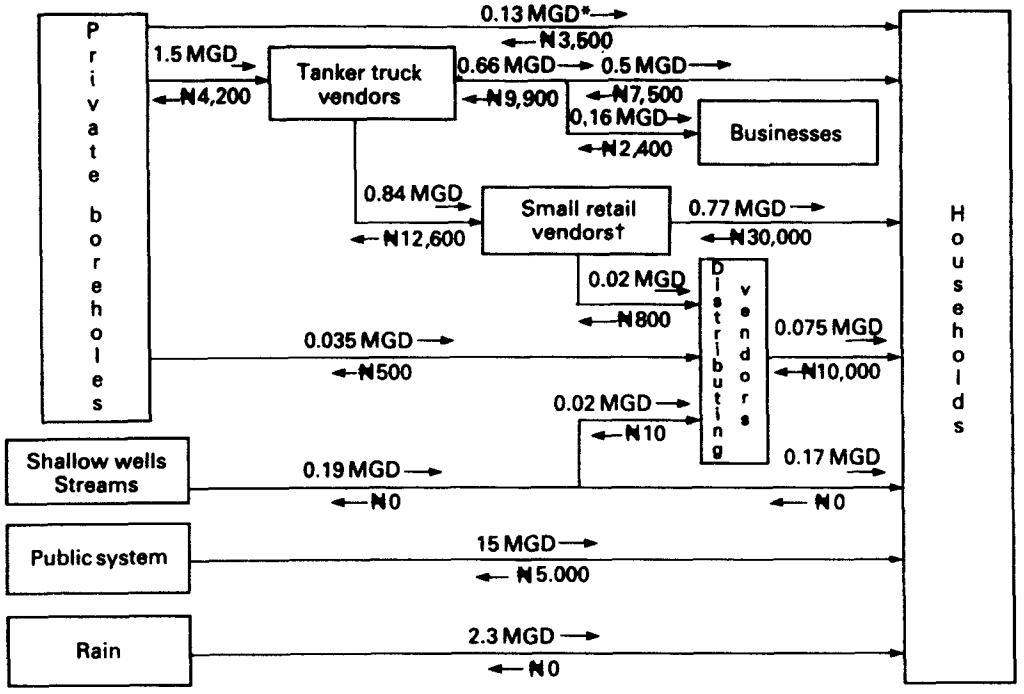
In the dry season, households obtain approximately 2.96 million gallons per day (mgd) from the vending system.[2] Of this vended water about 52% (1.55 mgd) is purchased from small retail water vendors, for which households pay about ₦ 78,000 per day. Tanker trucks sell about one mgd, 34% of the 2.96 mgd total, directly to households, which pay approximately ₦ 20,000 per day. Households purchase another 0.11 mgd from distributing vendors and 0.30 mgd directly from private boreholes, for which they pay ₦ 14,000 and ₦ 8,000 per day, respectively. Thus, households are paying on average a total of about ₦ 120,000 per day to the water vending industry during the dry season.

Before the completion of the New Onitsha Water Supply Scheme, the Anambra State Water Corporation was supplying about 1.5 mgd through the public water supply system during the dry season, only about 50% of the amount supplied by the vending system. For this 1.5 mgd, however, the ASWC managed to collect only about ₦ 5,000 in revenues. During the dry season



*MGD = Millions of gallons of water per day
† Water input is not equal to water output because a small amount of water is consumed by small retail vendors themselves.

Figure 1. *Money and water transactions in Onitsha, Nigeria (per day) — dry season.*



*MGD = Millions of gallons of water per day
† Water input is not equal to water output because a small amount of water is consumed by small retail vendors themselves.

Figure 2. *Money and water transactions in Onitsha, Nigeria (per day) — rainy season.*

the private sector vending system was thus collecting about 24 times as much revenue as the water utility.

As illustrated in Figure 2, the major change in this picture in the rainy season is that households manage to capture about 2.3 mgd of rain water. This means that less water needs to be purchased from the water vending system: only 1.48 mgd (half of the dry season total). These estimates indicate that per capita water use is significantly higher during the rainy season than in the dry season. In the rainy season households purchase about 0.77 mgd from small water retailers (one-half the volume purchased in the dry season), for which they pay ₦ 30,000. Tanker trucks supply 0.50 mgd directly to households, for which they collect about ₦ 7,500. In the rainy season households purchase about 0.08 mgd from distributing vendors (for ₦ 10,000) and 0.13 mgd directly from boreholes (for ₦ 3,500). Thus households are paying a total of about ₦ 51,000 per day to the vending system for water during the rainy season. Although this is only about 40% of the amount paid to vendors in the dry season, it is still over 10 times the revenue collected by the ASWC.

Table 1 summarizes the prices charged by water vendors at different stages of the vending distribution system. Tanker trucks buy water from boreholes for ₦ 0.003–0.004 per gallon and sell it to individuals for 5–10 times this amount. Small retail vendors charge individuals ₦ 0.04–0.05 per gallon, about three times what they pay tanker trucks for the water. On average, distributing vendors charge ₦ 0.12–0.13 per gallon, about three times the cost of water to the distributing vendor if he purchases water from a small retailer, or seven times the cost of water if he purchases from a private borehole. A household which purchases its water from a distributing vendor pays about eight times more per gallon than a household which buys large volumes from a tanker truck.

In other developing countries, we have found water vending to be a competitive industry in which the prices of vended water are determined by market forces, and vendors are not making excessive profits (Whittington, Lauria, Okun,

Table 1. *Average prices charged by vendors in Onitsha, Nigeria (naira per gallon)*

	Rainy Season	Dry Season
Prices charged by		
Private boreholes		
a. to tanker trucks	₦ 0.003 / gal	₦ 0.004 / gal
b. to individuals	₦ 0.01 / gal	₦ 0.02 / gal
Tanker trucks to individuals/businesses		
a. per 1,000 gallons	₦ 0.014 / gal	₦ 0.018 / gal
b. per drum	₦ 0.04 / gal	₦ 0.04 / gal
Small retail water vendors to individuals	₦ 0.04 / gal	₦ 0.05 / gal
Distributing vendors to individuals	₦ 0.12 / gal	₦ 0.13 / gal

and Mu, 1989). The high prices charged by tanker trucks in Onitsha, however, appear to be due to the ability of the owners of tanker trucks to capture significant economic rents (i.e., monopoly profits). Table 2 presents our estimates of the revenues, costs, and annual profits of four sizes of tanker trucks (1,000, 1,500, 2,000, and 2,500 gallon). The monthly revenues of a tanker truck in the dry season are about two and a half times those in the rainy season, ranging from ₦ 1,800 to ₦ 2,900 in the rainy season, to ₦ 4,100 to ₦ 6,500 in the dry season. Operating costs such as labor, gasoline and oil, water (purchased from private boreholes), and maintenance are about 80% of the total monthly costs; the capital costs of the truck account for the remaining 20%. As illustrated in Table 2, the capital costs have been calculated for three different capital recovery factors (0.12, 0.16, and 0.20). Since the capital costs are a small proportion of the total monthly costs, however, the different capital recovery factors do not have a major influence on the total monthly costs.

The monthly profits are calculated as the difference between monthly revenues and costs. For all four sizes of tanker trucks, monthly profits are much larger in the dry season than in the rainy season. The 1,000-gallon and 1,500-gallon tanker trucks essentially just cover their costs during the rainy season, but in the dry season all sizes of trucks are able to make large profits. As a percentage of total capital at risk (i.e., the market value of the tanker truck), the annual profits of tanker truck owners range from 45% to 87%, depending on the size of the truck and the capital recovery factor assumed. The owners of tanker trucks thus seem to be making extremely high rates of return on their capital investment.

Because of the short duration of our fieldwork, we cannot offer a definitive explanation for the existence of such monopoly rents, but there appear to be three plausible explanations. The first relates to the structure of the market for water sold by tanker trucks. The association of tanker truck owners may well have the ability to prevent the entry of new tanker trucks into the industry and thus to maintain prices above free market levels. Such market control could account for the high profits currently being achieved by owners of tanker trucks.

A second possible explanation for the monopoly profits may be that the prospect of the opening of the New Onitsha Water Scheme has discouraged new investment in the industry. Over the last few years, anyone contemplating the purchase of a tanker truck would have known that the World Bank-financed New Onitsha Water Scheme promised to greatly increase the quantity of water in the existing distribution network. This knowledge should have created significant uncertainty about the future profitability of tanker truck vending. As it turned out, however, the opening of the new system was repeatedly delayed, and, even when it opened, the existing distribution network was so inadequate that much of the business of the tanker trucks was not seriously threatened. Nevertheless, the uncertainty surrounding the water supply situation in Onitsha may have resulted in a smaller number of tanker trucks than would otherwise have existed, and this restricted capacity may have enabled the individuals already in the business to charge prices much higher than their costs.

A third partial explanation may have to do with the way in which we calculated the capital costs in the monthly accounts of the tanker truck owners. We asked tanker truck drivers about the market value of their truck. These market values generally range from ₦ 20,000 to ₦ 40,000. At the time of the survey, the naira was worth about US$0.23 (US$1 = ₦ 4.30). As recently as 1985, however, the exchange rate was US$1 = ₦ 0.89. The rapid devaluation of the naira has made the pricing of the existing capital stock in Nigeria extremely difficult.

The prices we were given for the market value of the tanker trucks probably only partially reflect the new foreign exchange regime. If tanker trucks had to be replaced at world prices, the naira price of tanker trucks would probably be somewhat higher. If the naira price of the tanker trucks were higher, the capital charges which we estimated would be correspondingly

Table 2. *Revenues, costs, and profits of tanker-truck vendors in Onitsha, Nigeria (interviews Conducted August 11–15, 1987)*

	1,000-gallon tank (naira)		1,500-gallon tank (naira)		2,000-gallon tank (naira)		2,500-gallon tank (naira)	
	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season
MONTHLY REVENUES (gallons of water price in nairas charged to customers)	1,794	4,136	1,820	5,304	2,496	6,240	2,938	6,500
MONTHLY COSTS								
Operating Costs:								
Labor								
Driver (salary + allowance)	248	261	248	261	248	261	248	261
Assistant (salary + allowance)	130	150	130	150	130	150	130	150
Subtotal Labor Costs	378	411	378	411	378	411	378	411
Oil	35	43	35	43	35	43	35	43
Gasoline	200	284	200	284	200	284	200	284
Maintenance								
Tires	42	50	42	50	42	50	42	50
Repairs	400	430	400	430	400	430	400	430
Subtotal Maintenance Costs	442	480	442	480	442	480	442	480
Water	330	710	335	870	460	1,030	540	1,070
Subtotal Operating Costs (labor + oil + gasoline + maintenance + water)	1,385	1,928	1,390	2,088	1,515	2,248	1,595	2,288

Capital Costs: (truck's market price CRF*)/12 months								
(If CRF: .12 → 15 years, 9%)	240	240	260	260	300	300	350	350
(If CRF: .16 → 10 years, 10%)	320	320	347	347	400	400	467	467
(If CRF: .20 → 10 years, 15%)	400	400	433	433	500	500	583	583
MONTHLY TOTAL COSTS								
(operating + capital costs, if CRF: .12)	1,625	2,168	1,650	2,348	1,815	2,548	1,945	2,638
(operating + capital costs, if CRF: .16)	1,705	2,248	1,737	2,435	1,915	2,648	2,062	2,755
(operating + capital costs, if CRF: .20)	1,785	2,328	1,823	2,521	2,015	2,748	2,178	2,871
MONTHLY PROFITS								
(revenues − total costs, if CRF: .12)	169	1,968	170	2,956	681	3,692	993	3,862
(revenues − total costs, if CRF: .16)	89	1,888	83	2,869	581	3,592	876	3,745
(revenues − total costs, if CRF: .20)	9	1,808	−3	2,783	481	3,492	760	3,629
TOTAL SEASONAL PROFITS								
If CRF: .12	1,014	11,808	1,020	17,736	4,086	22,152	5,958	23,172
If CRF: .16	534	11,328	498	17,214	3,486	21,552	5,256	22,470
If CRF: .20	54	10,848	−18	16,698	2,886	20,952	4,560	21,774
TOTAL ANNUAL PROFITS								
If CRF: .12	12,822		18,756		26,238		29,130	
If CRF: .16	11,862		17,712		25,038		27,726	
If CRF: .20	10,902		16,680		23,838		26,334	
ANNUAL PROFITS/TOTAL CAPITAL INVESTMENT								
If CRF: .12	0.53		0.72		0.87		0.83	
If CRF: .16	0.49		0.68		0.83		0.79	
If CRF: .20	0.45		0.64		0.79		0.75	

*CRF = capital recovery factor.

higher as well, and the annual profits would be less than we report. We have no direct means of determining how owners of tanker trucks perceive the capital costs of operating their trucks, but the high current prices of water charged by tanker trucks may be closer to the real resource costs of supplying the water than our estimates of capital costs and profits indicate.

Although this question of the valuation of the capital at risk in the tanker truck business introduces some additional uncertainty into the picture of the profitability of the tanker trucks, it cannot fully account for the very high rates of return on investment. For example, the total monthly revenues of a 2,000-gallon tanker truck in the dry season are about ₦ 6,240; the monthly operating costs are estimated to be ₦ 2,248. Even assuming a capital recovery factor of 0.20 and a doubling of the naira value of the truck, the monthly capital cost would only increase from ₦ 500 to ₦ 1,000. The total monthly profits would still be about ₦ 3,000, and the annual profits as a percentage of total investment would be about 60%.

7. RESULTS OF THE HOUSEHOLD INTERVIEWS

Following the interviews with water vendors, the enumeration teams successfully completed 235 in-depth household interviews throughout Onitsha. The household interview had five parts. The first dealt with the basic socioeconomic characteristics of the household, such as the number of adults and children in the household. The second part was concerned with household water-use practices. For each of seven possible sources of water (tanker trucks, neighbors and small retail water vendors, distributing vendors, shallow wells, rainwater collection, surface water, and the public piped distribution system), respondents were asked questions about the following: (a) whether the particular source was available in the neighborhood; (b) the prices charged for water from this source; (c) the quality of water from this source; (d) whether this household obtains water from this source, and, if so, how much is used;[3] (e) for what purpose is water from this source used.

The third part of the interview consisted of a series of highly structured questions designed to determine how much households were willing to pay (WTP) for improved water supplies. The fourth part of the questionnaire dealt with housing characteristics and household assets. The enumerator asked for information on the monthly rent, the monthly electric bill, the number of rooms in the house, and whether the household owned each of a series of consumer durable goods (such as a refrigerator, radio, air conditioner). In the fifth part of the interview, the respondent was asked to provide information on the occupations of different family members and their total monthly cash income. (Respondents were not asked to specify precisely the monthly cash income of family members, but rather to indicate the category into which their income fell.)

The focus of the questionnaire was on the estimation of the household's willingness to pay for water. After explaining that the survey was part of a World Bank study, the enumerator read each respondent a carefully worded statement that was designed to set the scene for the "bidding game" in which respondents would tell whether they would be willing to pay certain specified amounts for water under certain circumstances. The enumerator then asked the respondent whether he or she would like to be connected to the New Onitsha Water Scheme and have a meter if the price of water were ₦ 1 per drum.[4] For example, if the respondent answered "Yes" to a price of ₦ 1 per drum, then the enumerator raised the price to ₦ 2 per drum, and again asked whether the respondent would like to have a metered connection. If the respondent answered "No" to a price of ₦ 2 per drum, the enumerator lowered the price to ₦ 1.50 per drum, and again asked the respondent whether he would like to have a metered connection. After this question was answered the enumerator stopped the bidding game. Similarly, in the first instance if a respondent said "No" to water at ₦ 1 per drum, the price was lowered in increments to ₦ 0.12.[5] (See Appendix A for the full text of the opening statement and the bidding game.)

Using this bidding game procedure, it was possible to classify each household into one of the following seven groups based on how much the respondent indicated the household was willing to pay per drum: ₦ 0.00–0.11 per drum; ₦ 0.12–0.24 per drum; ₦ 0.25–0.49 per drum; ₦ 0.50–0.99 per drum; ₦ 1.00–1.49 per drum; ₦ 1.50–1.99 per drum; and ≥ ₦ 2.00. Respondents generally reported that they were willing to pay substantial amounts for water. Figure 3 presents a frequency distribution of the households' willingness-to-pay bids. The price of water charged by the vendors was effectively an upper bound on the amount respondents would bid for water; respondents were not willing to pay more than the price of water charged by vendors because the water provided by vendors was perceived to be of good quality and was generally

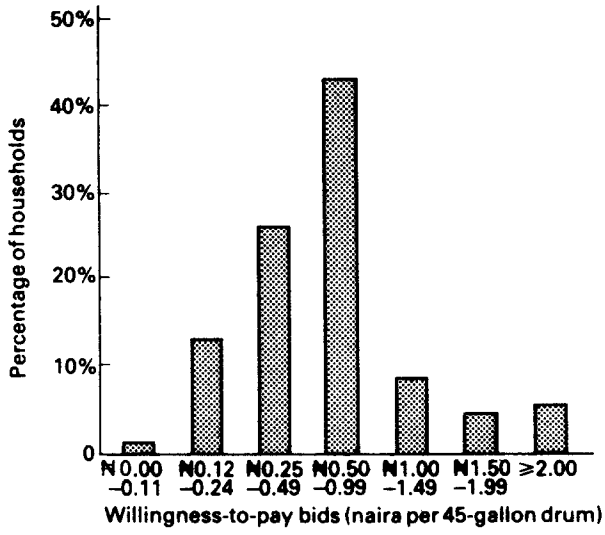


Figure 3. *Frequency distribution of willingness-to-pay bids (Onitsha, Nigeria).*

readily available. This finding of apparent consistency in household preferences is evidence in support of the validity of contingent valuation survey results.[6]

Not only did respondents report in the bidding game that they would pay substantial amounts for water from the piped distribution system, we know from the data collected in the questionnaire on current water use practices (and from the study of water vending) that households were already paying a lot for water. Figure 4 presents a frequency distribution of reported monthly expenditures of households for water during the dry and rainy seasons. In the dry season 74% of the households spent ₦ 10 or more per month on water; 46% spent ₦ 25 or more per month. Even in the rainy season 46% of the households reported spending ₦ 10 or more per month on water.

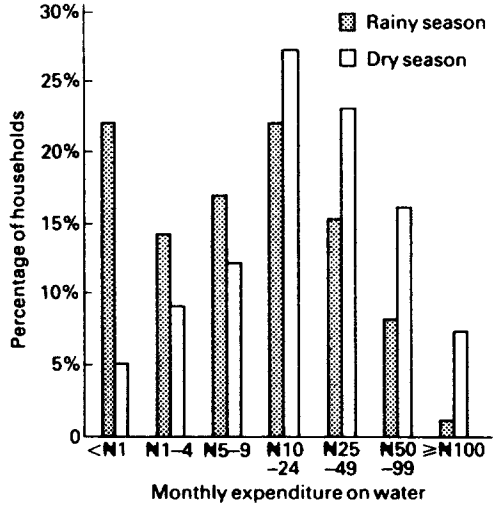


Figure 4. *Frequency distribution of households' monthly expenditure on water (Onitsha, Nigeria).*

Monthly expenditures on water as a percentage of household income vary widely across households. In the dry season, 49% of the sample households report spending 5% or more of their income on water (Figure 5). A third of the households reported spending 10% or more of their income for water in the dry season. In the rainy season 25% of the households still spent 5% or more of their income for water.

It is the poor in Onitsha who are paying the most for water — both in absolute amounts and in terms of the percentage of their income spent on water. Figure 6 presents an estimate of households' water expenditures as a percentage of household income during the dry and rainy seasons. Households making less than ₦ 500 per month (58% of the total sample) are estimated to be paying 18% of their income on water during the dry season versus 2–3% for the upper-income households.

In the past, it has been commonly assumed that households could only afford to pay 3–5% of their income for improved water services, so these data on the proportion of household income being spent on water in Onitsha appear extraordinarily high. Other recent studies of water vending, however, have also shown that many households pay much more than 3–5% of their income on water. For example, in one of the most carefully conducted studies of household

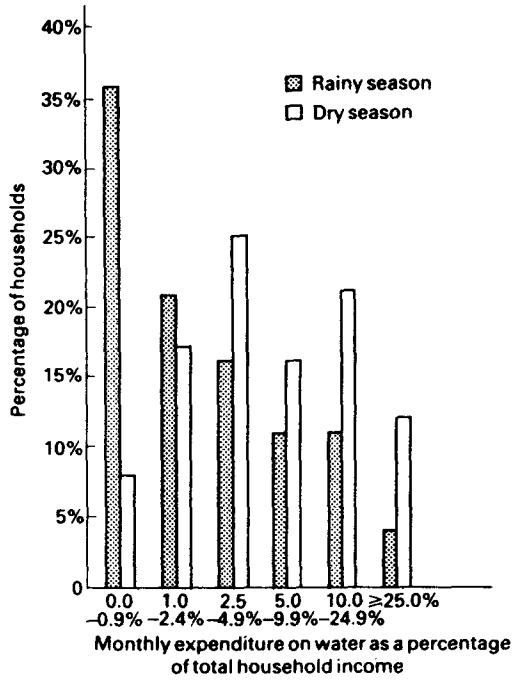


Figure 5. *Frequency distribution of monthly expenditure on water as a percentage of total household income (Onitsha, Nigeria).*

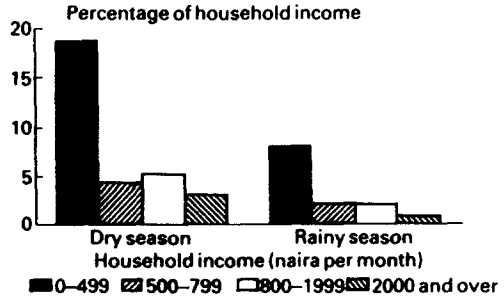


Figure 6. *Household expenditure on water as a percentage of income by income class.*

water expenditures among the urban poor, Fass (1988, p. 175) found that the poorest households in Port-au-Prince, Haiti sometimes spend 20% of their income on water. In Addis Ababa, the urban poor spend up to 9% of their income on water (Linn, 1983, p. 159). In our own work in Ukunda, Kenya — a town of about 5,000 people, 40 kilometers south of Mombasa — we found that *on average* households were spending about 9% of their income on water from vendors; many households were spending a higher percentage (Whittington, Lauria, Okun, and Mu, 1989). In summary, the percentage of household income spent on water in Onitsha is surprisingly high but not inconsistent with evidence from other places.

How could it be possible that a household in Onitsha would spend 18% of its income on water during the dry season? The estimates of household income upon which these percentages are based are only rough approximations derived from answers to questions in the household questionnaire, and some of the estimates at the extremes of the frequency distributions presented in Figures 4–6 may well be due to inaccurate data. We believe, however, that the general magnitude of the results presented in Figures 4–6 is correct.

For example, we know that small retail vendors sell a substantial portion — probably a majority — of the water delivered to households by the vending system. In the dry season this water is generally sold for ₦ 0.20 per bucket. Most single males living in tenements in squatter settlements would probably buy their water from a small retail water vendor. Such an individual might buy two buckets per day at a cost of ₦ 0.40, or ₦ 12 per month. If he made ₦ 75 per month, like many of the laborers working on tanker trucks, he would pay 16% of his income for water during the dry season.

Many of the families we interviewed reported water consumption during the dry season of two buckets per capita per day. If the average size family of six purchased all of its water from a small retail vendor, this would entail a daily expenditure on water of ₦ 2.4, or ₦ 72 per month. Such a monthly expenditure on water is not implausible; in fact, as illustrated in Figure 5, almost 25% of the households interviewed reported monthly expenditures on water during the dry season of more than ₦ 50. If this household of six had two wage earners making ₦ 200 per month each, the monthly expenditures on water of ₦ 72 would represent 18% of monthly household income. Of course, many poor families do not buy all of their water from small retail water vendors, but, on the other hand, some buy part of their water from distributing vendors at even higher prices.

8. TRADEOFFS BETWEEN THE PRICE OF WATER, UTILITY REVENUES, AND THE PERCENTAGE OF HOUSEHOLDS CONNECTING TO THE DISTRIBUTION SYSTEM

The frequency distribution of WTP bids in Figure 3 can be used to address the question

posed at the beginning of this paper about how many households would connect to the distribution system if different prices were charged for water. In the answers to the questions in the WTP bidding game, each respondent expressed his or her preferences as to whether to connect to the piped distribution system at specified prices. Thus, for a given price of water, the percentage of households in the sample which stated that they wanted to be connected to the system can be calculated.

Figure 7 presents the percentage of sample households which would choose to connect at different prices of water. At a price of water of about ₦ 3 per 1,000 gallons, only one respondent out of 226 in the sample indicated that he would choose not to connect to the system. At a price of ₦ 6 per 1,000 gallons, 86% of the respondents reported that their households would connect.

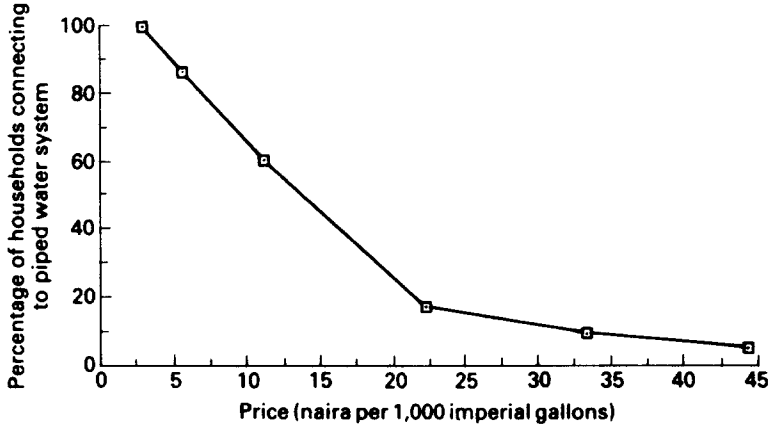


Figure 7. *Price of water (naira per 1,000 gallons) vs. percentage of households connecting to piped water system — Onitsha, Nigeria.*

The percentage of households falls dramatically as the price of water increases from ₦ 6 to ₦ 20 per 1,000 gallons. If the price of water were increased from ₦ 20 to ₦ 40,the proportion of households wanting connections would fall only slightly, indicating that in this price range the demand for connections is much more inelastic.

One objective of a water utility may be financial: to raise sufficient revenues to cover its costs and provide high quality service to its customers. The total revenues which the ASWC will receive from households in Onitsha can be roughly estimated as follows:

Annual revenues = (a) proportion of households which decide to connect to the new system, multiplied by
(b) population of Onitsha, multiplied by
(c) price of water charged, multiplied by
(d) annual per capita water use for individuals connected to the system.

Based on the relationship presented in Figure 7 between the price of water and the percentage of households that would connect to the system, we have calculated the annual revenues associated with different water prices.[7] A population of Onitsha of 700,000 is assumed; calculations are presented for per capita water use of both 20 gallons per day and 30 gallons per day. (These estimates of per capita water use are substantially higher than current usage because it is expected that water use will increase when households are connected to a functioning, piped distribution system.)

Figure 8 presents this relationship between the price of water and the ASWC's annual revenues. At first, as the price of water increases, revenues increase. If the price of water is increased above ₦ 11 per 1,000 gallons, however, total revenues actually decrease because the number of households which connect to the system decreases rapidly. Assuming a per capita daily water use of 20 gallons for a person with a house connection, the maximum attainable revenue is about ₦ 35 million. This level of revenue can be obtained when the price of water is about ₦ 10 per 1,000 gallons. If the price were lowered to ₦ 5 per

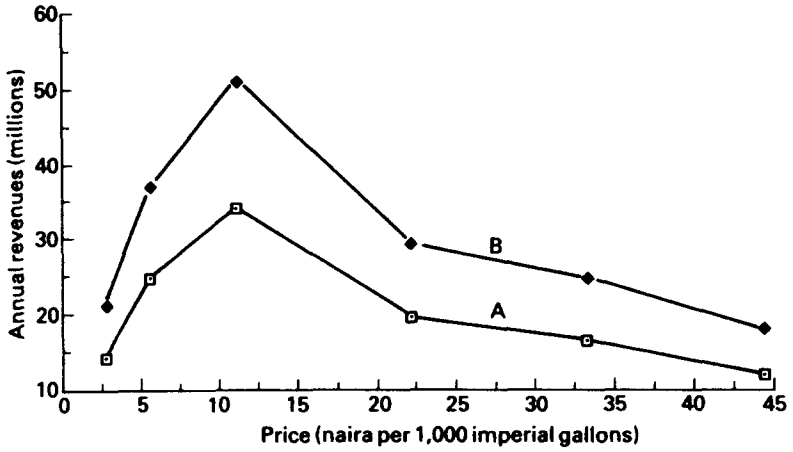


Figure 8. *Price of water (naira per 1,000 gallons) vs. annual revenues of water utility (millions of naira) — Onitsha, Nigeria.*

1,000 gallons, annual revenues would fall to approximately ₦ 25 million. Similarly, if the price were increased to ₦ 45 per 1,000 gallons, annual revenues would decrease to about ₦ 12 million.

Another objective of a water utility is social: to provide safe, reliable, high quality water to as many people as possible. The tradeoff which the ASWC faces between the financial and social objectives is depicted in Figure 9. For example, annual revenues of about ₦ 13 million can be achieved with either 5% of the households in Onitsha connected (point A), or 99% of the households connected (point F). From a social point of view, it is clearly preferable to have a larger percentage of the population served. Similarly, point E (with 86% of the households connecting and revenues of ₦ 25 million) is preferable to point C (with revenues of ₦ 20 million, but only 17% of the households connected).

Moving from point A to point D, both revenue and the percentage of households desiring connections increase. Given the assumptions upon

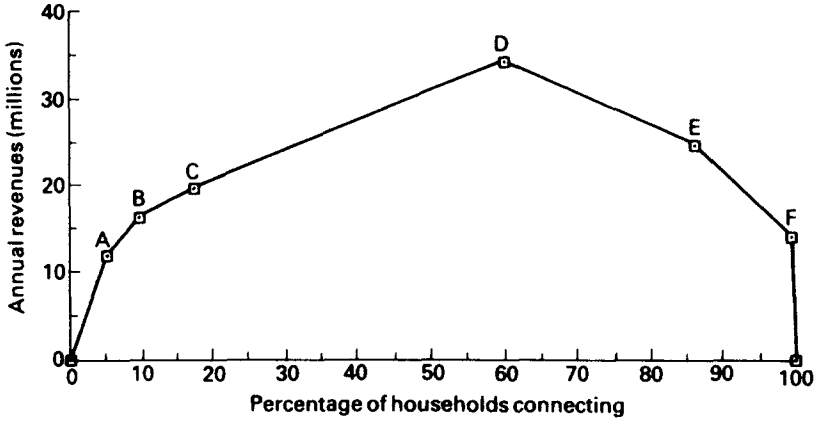


Figure 9. *Percentage of households connecting to piped water system vs. annual revenues of water utility (millions of naira). Onitsha, Nigeria.**

which these calculations are based, this means that prices should not be set higher than a level which would result in the percentage of households with connections falling below 60%. The choice between points on the portion of the curve DF, however, is more difficult because revenues can only be increased by reducing the number of households connected to the system. This "northeast" portion of the curve in Figure 9 characterizes the tradeoffs between the ASWC's financial and social objectives, and presents the management of the ASWC with a hard set of choices.

These calculations of the relationships between the price of water, the percentage of households desiring connections, and annual revenues should only be considered indicative of the general magnitude of the tradeoffs facing the ASWC, and it is important to emphasize their limitations. First, all the relationships in Figures 7–9 depend upon the accuracy and validity of the WTP bids. To the extent that respondents did not reveal their "true" willingness to pay for water from a piped connection, then these calculations will not be accurate. Second, these calculations assume that the frequency distribution of WTP bids of the sample respondents are representative of the population of Onitsha.

Third, the revenue calculations assume that per capita water consumption of individuals with connections is 20 gallons per day regardless of the price charged. To the extent that high prices result in decreased water use, the price-revenue relationships in Figure 8 will be flatter (i.e., at higher prices revenues will be less than indicated). Fourth, the financial objective does not reflect the fact that higher levels of water production will entail higher costs.[8]

Despite these limitations, the data collected from the contingent valuation survey seem generally consistent with the data from the water vending surveys, and we believe the evidence is sufficiently accurate to be useful for decision making. It seems to us that prices on the order of ₦ 8–10 per 1,000 gallons would have been affordable by most of the households in Onitsha in the summer of 1987, and would have resulted in a substantial increase in ASWC's revenues. Prices of this magnitude were more than double the proposed prices under consideration by the ASWC and the World Bank at the time.

9. CONCLUSION

This study of water vending and the willingness of households to pay for water reveals a water supply situation in Onitsha which is really quite extraordinary, and one which puts the policy debates over whether the poor can afford water and whether water should be provided as a subsidized public service in a somewhat different perspective. At the time of our fieldwork, the ASWC was not a major actor in the water market, based on market share defined in terms of sales. The private sector vending system was responsible for over 95% of the water sales — in monetary terms. To argue that the population of Onitsha cannot afford to pay for water is clearly erroneous. Most people in Onitsha are already paying high prices for water from the vending system for service which is inferior to that which could be provided by a well-run piped distribution system.

At the time of our survey, households in Onitsha were paying water vendors about ₦ 30 million annually (US$7 million). The annual capital and operation and maintenance costs of the New Onitsha Water Scheme are difficult to estimate from the information available. At the time the new system was inaugurated, the World Bank had disbursed approximately US$35 million for construction and engineering services. The Anambra State Water Corporation had probably spent the equivalent of US$5 million. The distribution network, however, is not yet complete. Assuming that the total capital costs will eventually reach US$100 per capita for households with private connections when the distribution network is completed and that 80% of the population of 700,000 will be connected, then the total capital cost will reach US$56 million. Assuming a capital recovery factor of 0.12 (9% interest; 15 years), the annualized capital costs for expanding the system are probably on the order of US$6.7 million. Annual operation and maintenance costs are typically about 50% of the annual capital costs for such systems, or US$3.3 million. The total annual cost of the Onitsha water supply system is thus roughly US$10 million, or ₦ 43 million at 1987 exchange rates. At the time of our survey, households in Onitsha were thus already paying water vendors over twice the operation and maintenance costs of the completed piped distribution system, and 70% of the total annual costs.

It should be relatively easy for the water authority to capture a large share of the water vendors' market — even if the prices charged for water from the piped system are high enough to cover the full costs of supply. The results of the household survey, however, indicate that people perceive the water available from tanker trucks and small retail water vendors to be better in quality than the water available from the old public system. Therefore, in order to increase its

market share, the ASWC must not only offer a lower-priced product than the vendors, but also provide a better product in terms of both water quality and reliable service.

In terms of the equity implications of alternative water supply arrangements, it is obvious that the poor would be better off if they could have piped water in their dwellings free of charge, with the costs paid by taxes levied on someone else. In most developing countries this is simply not going to happen. Given this reality, the real question is what policies should a water authority with limited central government resources attempt to pursue? In most cases, the practical choice is between charging a low price and offering low quality, unreliable service on the one hand, and charging a higher price and, one would hope, offering high quality service on the other.[9] Charging a low price typically means that the water authority does not have even enough financial resources to collect what little revenue should be accruing to it.[10]

In our view, in Onitsha this choice is an easy one, even on equity grounds. This study has demonstrated that the willingness of households to pay for improved water services in Onitsha is surprisingly high. Households that can afford to pay for a connection to a piped water system which charges the full economic costs of water will be better off as a result of connecting than they would be buying water from vendors because they will receive more water at a lower price. In Onitsha the majority of households will clearly fall into this category.

The situation for those households which do not choose to connect to the piped distribution system will still be much improved. Since most households will have connections and will be supplied with cheaper water than that previously available from tanker trucks, the price of vended water should fall. Households with connections will probably charge less for water than what small retail water vendors or tanker trucks previously charged.

The data presented in this study show that it is incorrect to imagine that a water authority without central government subventions is without resources. At least in the case of Onitsha, the ASWC's greatest resource is its right to supply piped water services to a ready market which would make any businessman envious. In developing countries, water authorities are typically regulated to prevent them from abusing this monopoly privilege and charging prices which are more than their costs (including a "fair" rate of return on capital). Similarly, the results of this study show that the revenue potential of the ASWC is tremendous, and that the population of Onitsha would be much better served if the ASWC viewed itself as a regulated utility, not as an agency providing a social service.

In summary, the scale and magnitude of water vending activities in metropolitan areas of developing countries has not been widely realized, nor has the value of information on such water vending systems been adequately appreciated by water resources engineers or policy analysts. This case study has shown that a rapid reconnaissance survey of water vending activities and the willingness of households to pay for improved services can yield valuable information for water supply planning and, in this case, unexpected policy insights. Studies such as this are very inexpensive relative to the capital costs of urban water projects, and should become a standard part of water supply project design and planning in developing countries.

NOTES

1. The water volumes reported in this paper are British "imperial gallons." (1 imperial gallon = 4.546 liters).

2. Our estimates of household water use in the dry season are based on the answers to questions which were asked in the rainy season, and are thus probably less reliable than our estimates for the rainy season.

3. The respondent was asked about the quantity of water used by the household in both the rainy and dry seasons. Since the survey was conducted during the rainy season, recall problems may make the estimates for the dry season less accurate than those for the rainy season.

4. In most situations it would be impossible to carry out a willingness-to-pay survey in which the enumerator raised or lowered the commodity price in this manner because individuals would simply not know how much water they consumed in terms of a standardized unit, such as a drum. However, because water vending is so widespread in Onitsha, not only is almost everyone used to thinking in terms of using standardized volumes of water, but they are also used to paying for water by the drum, bucket, or 1,000-gallon tank.

5. This bidding game approach for estimating the willingness of households to pay for water is one of several possible ways of eliciting households' preferences. The general methodology is termed the "contingent valuation method" because the respondent is asked how he would behave in a hypothetical or "contingent" market. For excellent reviews of the

current state of the art, see Cummings, Brookshire, and Schulze (1986), and Mitchell and Carson (1989). For the applications of this contingent valuation technique in the context of developing countries, see Whittington, Briscoe, Mu. and Barron (1990); Whittington, Mujwahuzi, McMahon, and Choe (1989); and Whittington, Okorafor, Okore, and McPhail (1990).

6. It is still possible, of course, that respondents may have failed to give reliable, truthful answers to the willingness-to-pay questions. For example, respondents may have bid low in the hope of influencing the ASWC to set a low price for water, or they may have bid high, thinking that a high bid might convince the ASWC to extend service into their neighborhood sooner. For a discussion of various ways used to test the reliability of such bids, see Whittington, Briscoe, Mu, and Barron (1990); Whittington, Mujwahuzi, McMahon, and Choe (1989); and Whittington, Smith, *et al.*, (1990).

7. It would have been desirable to characterize not only the household's connection decision, but also household water use, as a function of the price of water. A traditional household water demand function cannot, however, be estimated from this data set because we did not ask respondents how much water they would use if they connected to the piped system (it would have been unrealistic to expect that people could have given us reliable answers to such questions).

8. It would be preferable to characterize the water utility's financial objective as the difference between annual revenues and annual costs, but information was not available to us on the relationship between the ASWC's total costs and the volume of water sold to customers.

9. We do not want to minimize the risk that a water authority will charge higher prices and not use the resulting revenues to provide a high quality service. Increased revenues could easily be wasted to fund a bloated, inefficient bureaucracy. Higher prices and increased revenues are a necessary but not sufficient condition for improved operations of the water authority. Higher prices and continued low quality service may result in a water authority losing even more market share to vendors.

10. Installing meters and charging a price for water which covers the full costs of supply is one means of preventing such a situation, and is one argument in favor of metering programs. If the water authority charges a flat rate, households with connections may also offer households without a connection a flat rate for access to their tap. Such an arrangement — in which one household with a tap and a flat rate is supplying water to many households — can represent a serious loss of revenue to the water authority and can result in demands that exceed system capacity.

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APPENDIX A: WILLINGNESS-TO-PAY QUESTIONS FROM HOUSEHOLD QUESTIONNAIRE

Opening statement to bidding game

When the New Onitsha Water Scheme is commissioned and when distribution pipes reach your area, those households with private connections will have safe, reliable water — with good pressure — 24 hours per day, all year round.

The World Bank thinks every family wants its own water connection so that it can have as much water as it needs when it needs it. To be fair, each family should pay only for the amount it uses. Just as people who buy water from vendors only pay for the amount they buy, if you use a lot of water, you should pay more than if you use only a little. It would be up to the household to decide how much to use.

To achieve this, each family would have to have a meter installed on its connection, just like a meter is installed to measure how much electricity people use. Every month the meter would be read to determine how much water the household has used and how much the household would have to pay.

Of course, in some cases it will not be possible to provide a household an individual meter, at least for a long time, but assume that you could have a water meter. The decision on whether or not to connect to the New Onitsha Water Scheme and have a metered connection would be the household's or the landlord's. People would still be free to buy water from water vendors if they wished.

Bidding Game

(a) If the price you are charged for water is one naira per drum (or about 25 naira per 1,000 gallons) would you like to be connected to the New Onitsha Water Scheme and have a meter?

YES ..... GO TO (b)
NO ..... GO TO (d)
NOT SURE ..... GO TO (d)

(b) If the price you are charged for water is two naira per drum (or about 50 naira per 1,000 gallons) would you like to have a metered connection?

YES ..... Finished with this section
NO ..... GO TO (c)
NOT SURE ..... GO TO (c)

(c) If the price you are charged for water is 1.50 naira per drum (or about 37.50 naira per 1,000 gallons) would you like to have a metered connection?

YES/NO/NOT SURE ... Finished with this section.

(d) If the price you are charged for water is 0.50 naira — 50 kobo — per drum (or about 12 naira per 1,000 gallons) would you like to have a metered connection?

YES ..... Finished with this section.
NO/NOT SURE .... GO TO (e).

(e) If the price you are charged for water is 0.25 naira — 25 kobo — per drum (or about six naira per 1,000 gallons) would you like to have a metered connection?

YES ..... Finished with this section.
NO/NOT SURE .... GO TO (f).

(f) If the price you are charged for water is 0.12 naira — 12 kobo per drum (or about three naira per 1,000 gallons) would you like to have a metered connection?

YES/NO/NOT SURE ... Finished with this section.

APPENDIX B. MULTIVARIATE ANALYSES OF THE DETERMINANTS OF THE WILLINGNESS-TO-PAY BIDS

A common practice in contingent valuation studies is to use multivariate techniques to determine how the socioeconomic characteristics of the respondents and other variables affect the WTP bids (Mitchell and Carson, 1989). Such analyses have two main purposes. First, if the WTP bids are correlated with the variables suggested by economic theory, this increases our confidence that the WTP bids indeed reveal information about respondents' preferences and are not simply random numbers. Second, models of the determinants of respondents' WTP bids can be used to predict how changes in socioeconomic characteristics will affect the demand for the good or service offered (Whittington, Briscoe, Mu, and Barron, 1990).

Table B-1 lists the names and definitions for the seven independent variables used to explain the variations in respondents' WTP bids. Table B-2 presents the parameter estimates and *t*-statistics for four models of the determinants of WTP bids. In Model 1, the respondents' WTP bids are regressed on the full set of independent variables using ordinary least squares (OLS). The dependent variable is the mid-point of the interval defined by the respondent's YES/NO answers to the bidding game. Model 2 uses the same dependent variable (and OLS), but two of the independent variables are dropped: education and income.

The results of two ordered probit models of the determinants of the WTP bids are presented in columns 3 and 4. In these models the respondents' answers to the YES/NO questions in the bidding game are simply assumed to indicate a rank ordering of respondents' preferences (Whittington, Smith *et al.*, 1990). Model 3 uses the full set of independent variables to explain these preferences. Model 4 uses a more restricted set, again dropping the education and income variables.

The results of these four models are consistent across estimator and model specification. The *F*-values and Chi-squared statistics indicate that all four of the models are highly significant. The two variables with the largest effects on the WTP bids — TOILET and SLUM — are both significant at the 1% level in all four models. Households which already have a toilet (but are not connected to the water distribution system) are willing to pay much more for water than households without a toilet (₦ 0.45 per drum more). This result is to be expected because the sanitation situation for such

Table B-1. *Variable definitions*

Variable Name	Definition
SLUM	= 1 if household lives in Okpoko 0 otherwise (Mean = 0.29)
TOILET	= 1 if household has a toilet in the house but does not have a connection to the water distribution system 0 otherwise (Mean = 0.40)
WATER STORAGE	= 1 if household has 500 gallons or more water storage capacity at the house 0 otherwise (Mean = 0.38)
SMALL TRADER	= 1 if the head of household is engaged in small-scale trading activities as his or her primary occupation 0 otherwise (Mean = 0.24)
NUMBER OF YEARS OF EDUCATION	= years of education of the most educated member of the household (Mean = 7.2; standard deviation = 3.9)
RETAIL VENDOR	= 1 if the household's primary source of water is from a small retail water vendor or a distributing vendor 0 otherwise (Mean = 0.55)
HOUSEHOLD INCOME	= total monthly household income (in naira) (Mean = 592; standard deviation = 613)

households would obviously improve dramatically without additional capital investments in indoor plumbing.

Households in Okpoko, one of the largest squatter settlements in Onitsha (designated by the dummy variable SLUM), bid ₦ 0.35 per drum more than households in other parts of the city. This may at first seem surprising, but it makes sense for two reasons. First, the existing water situation in Okpoko was one of the worst in the city; roads in the community are very poor and tanker trucks cannot reach most households. In this case a private connection represented a greater improvement than in many other places. Second, the installation of a private water connection may have been perceived as conferring official recognition of the squatter settlement, and thus the high willingness to pay for water in Okpoko may in part reflect the demand for greater tenure security.

Two additional variables were statistically significant for both estimators and in both model specifications — SMALL TRADER and RETAIL VENDOR — although the magnitudes of their effects were smaller than those of TOILET and SLUM. Households engaged in small-scale trading activities were willing to pay more than households in other occupations. We interpret this to mean that some of these households probably have uses for water in their businesses, and are therefore willing to pay more than households which would use the water solely for domestic purposes. Also, households engaged in small-scale trading activities may be less constrained in terms of their cash flow situations, and may be more willing to commit themselves to paying a regular monthly water bill.

Households which are currently buying their water from a small retail vendor or a distributing vendor (designated by the dummy variable RETAIL VENDOR) are willing to pay more for water from a private connection than other households. This is consistent with prior expectations because the price of their alternative to the private connection is so high; they are already paying the highest prices for vended water.

There are two surprising results of these multivariate analyses: (1) the education of the respondent is not a statistically significant determinant of the WTP bids (although it is positive, as one would expect); and (2) household income has a statistically significant and negative effect on the WTP bids. The negative effect of household income is the most difficult to explain: one would expect that higher income households would be willing to pay more for water. This result does not seem to be due to multicollinearity with other independent variables; the correlation coefficients between income and other independent variables are not particularly high. When both the education and income variables are dropped from Models 1 and 3, the parameter estimates for the other variables are quite stable. The negative effect of income on the WTP bids could be due

Table B-2. *Models of the determinants of willingness-to-pay bids*

Model No.	OLS (1)	OLS (2)	Ordered Probit (3)	Ordered Probit (4)
Independent variables				
Intercept	0.36 (3.26)*	0.37 (4.00)*	0.42 (1.48)	0.35 (1.58)
SLUM	0.35 (4.29)*	0.37 (4.53)*	0.72 (3.49)*	0.77 (3.80)*
TOILET	0.45 (5.74)*	0.41 (5.49)*	1.00 (4.59)*	0.87 (4.32)*
WATER STORAGE	−0.12 (−1.24)	−0.16 (−1.77)†	−0.10 (−0.46)	−0.24 (−1.12)
SMALL TRADER	0.23 (2.88)*	0.25 (3.26)*	0.43 (2.36)‡	0.51 (2.88)*
NUMBER OF YEARS OF EDUCATION	0.01 (0.93)	—	0.01 (0.80)	—
RETAIL VENDOR	0.16 (2.00)‡	0.15 (1.92)†	0.37 (2.01)‡	0.35 (1.91)†
HOUSEHOLD INCOME	−0.0001 (−1.85)†	—	−0.0004 (−2.02)‡	—
N	190	190	190	190
F-value	9.72	12.6		
Probability > *F*	0.0001	0.0001		
Adjusted *R*-squared	0.24	0.24		
Chi-square			40.6	40.6
Significance level			0.71E-09	0.93E-09
Log-likelihood ratio			57.74	48.76
Proportion predicted correctly			0.41	0.41

Values in () are *t*-statistics.
*, †, and ‡ indicate significance level at 1%, 10%, and 5% respectively.

to measurement problems with the income variable, or perhaps higher income households were more likely to strategize and offered lower bids in hopes of obtaining lower prices for water.

Another plausible explanation is that many higher income households have already solved their water problems by investing in large water storage tanks and buying in bulk from tanker trucks, and are thus less interested in the convenience of a private connection than households which are fetching water from farther away and paying higher prices purchasing water by the bucket. However, we tried to control for these factors with the variables for WATER STORAGE and RETAIL VENDOR. The amount of water storage capacity a household had was in fact a negative influence on the WTP bid, but it was statistically significant (at the 10% level) in only one of the four models.

In summary, except for the negative effect of income on the WTP bids, most of the multivariate results are consistent with prior expectations. Respondents' answers to the WTP questions are clearly related to the characteristics of their existing water and sanitation situation, and the explanatory power of the models compares favorably with similar models in the contingent valuation literature. Most importantly for policy purposes, the multivariate results reinforce our conclusion that the following groups are able and willing to pay for improved water services: low-income households; households which currently have poor services (such as those living in Okpoko); households buying water from small retail vendors and distributing vendors; and households with toilets but without a connection to the water distribution system.