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Natalie Chun is an Economist at the Economics and Research Department, Asian Development Bank.

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ABSTRACT

The design of alternative tariff structures can serve as a low-cost and effective tool in achieving higher take-up of basic services among poor households while allowing the provider to recover costs. A contingent valuation survey from the Water Supply and Sanitation Project of the Asian Development Bank in Cebu, Philippines is used to show that tariff structures with a low one-time connection price and price differentiates based on wealth measures can result in a five-fold increase in the take-up of water services by poor households over the base tariff structure. More moderate impacts, however, are found for the take-up of new sanitation and sewage services.

Highlights

- Model developed takes into account that water provision is often a two-part tariff.
- Paper simulates effects of different tariff structures on demand for water services.
- Two-part tariffs that amortize connection fee into monthly fee increase take-up by poor.
- Tariffs which differentiate on aspects correlated with income increase take-up by poor.
- Changing tariffs results in a 5-fold increase in access to water services by poor.

Keywords: Asia, Philippines, water and sanitation services, tariffs; demand estimation, contingent valuation

JEL Classifications: D12, D61, D63, O21

I. INTRODUCTION

Increasing access to water, sanitation, and health services are seen as essential to human welfare with significant social benefits which are necessary for environmentally sustainable development. Expansion of water and sanitation services, in particular, can allow for greater monitoring and reductions in the contamination of scarce water resources. However, providing these services is expensive, requiring setting tariffs to cover costs of provision. In developing countries, this can result in significant exclusion of the poor as the tariffs required to recoup costs are often too high in relation to household income making it difficult for households to afford these services. Yet, while affordability analysis typically identifies a range of prices in which consumers are willing-to-pay for services, this analysis is rarely extended to provide specific guidance on the range and types of tariff structures that allows a service provider to achieve social or profit maximizing objectives while still recovering costs.

This paper presents a methodological approach to identifying tariff structures that ensure cost recovery for the provider while increasing take-up of basic services among the poor. It entails modeling the demand function for the entire market of potential users of the service using survival curve estimation techniques and knowing the costs faced by the provider.[1] This allows for the identification of differential pricing schemes where less disadvantaged groups are charged higher prices in order to effectively cross-subsidize the lower prices charged to the poor. The low additional cost to implementing tariff structures with differential pricing therefore makes it a potentially powerful tool for increasing take-up of important services among the poor enabling providers of basic services to aid in more sustainable development while still allowing the provision of the service to be viable over the long term. However, we show that altering tariff structures may not work for all types of services where the differences in willingness to pay (WTP) are less determined by level of income.

To provide a concrete example, the approach is applied to a contingent valuation survey that captured household and businesses WTP for access to improved water and new sanitation services provided by the Metropolitan Cebu Water District (MCWD) in the Philippines. It is found that up-front connection charges are a major deterrent to more units opting to connect and access MCWD's water services with only 4% of the non-connected units WTP the connection charges required for MCWD to break-even or 2% of all non-connected households WTP the current connection and average per cubic meter charge. However, by charging a much smaller up-front connection charge and amortizing the remaining costs of the connection charges into the monthly fee results in a substantial rise in demand from 30.9% of households to 49.9%. Moreover, this tariff structure results in 30.4% of non-connected households connecting to water services. Tariff structures that price differentiates to equalize demand across different sub-groups increases take-up of water services by households to 56.8% based on household income sub-groups or 62.2% using geographic sub-groups. Moreover, it increases take-up of water services by poor households from 12.2% to 61.9% of the population. This is nearly a 500% increase over the current pricing scenario. Price differentiation, however, is found to be a less effective tool for increasing total household take-up of potential new septage and sewage services. It is shown to only increase overall household demand by 0.8% in the case of monthly septage service fees and 2.4 percentage points in the case of sewage services. However, it is effective in increasing take-up of services by 4.2 percentage points and 3.3 percentage points in the case of low income households.

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[1] Survival curve techniques are useful for models where the probability that an event has happened is increasing over a continuous variable. In the context of this paper it is the case where a respondent says "no" they will not pay for the service as the price increases. More typically, these models are used for events that are a function of time such as the probability of still being unemployed or remaining in school.

This analysis adds to the literature along several dimensions. In contrast to studies that have assessed average willingness to pay for water services (e.g. Casey, Khan and Rivas 2006; Hensher, Shore, and Train 2005; Wang, Xie, and Li 2010) the demand, revenue and cost structures are mapped out to identify the range of prices that can be charged depending on the goals of the water utility service provider and to assess the number of households and businesses that opt in at any given price. While papers such as Pattanayak et al. (2006) have explicitly examined how pricing policy affects demand for piped water connection among different household income sub-groups they did not extend their analysis to capture that the water service provider also is likely cater to businesses and that this group has an important influence in the design of cost recoverable tariff structures that have a social aim. Furthermore, this paper uses survival curve estimation techniques which are believed to be an appropriate methodological approach for contingent valuation surveys that use a descending bid approach. This contrasts with the literature which often uses bi-variate probit models to identify demand. Mataria et al. (2007) is one of the few papers that have used survival techniques to price the demand for improved health services. However, the model in this paper is extended to consider two-part tariffs. These types of tariffs are more consistent with structures that service providers often use where new services are provided based on a connection charge and a monthly charge to access a service. It also takes into account that in setting new tariff policies, the service provider needs to consider that setting monthly usage charges may be a trade-off between extending services to more people and capturing greater revenue from already connected units. This is an aspect that is often ignored, but has a large impact on the demand for services as high connection costs are shown to significantly diminish the proportion of the population that is willing to opt-in for water services. Finally, the use of simulation techniques to examine the implications of differentiating prices and lowering costs on subsequent demand addresses key policy issues of how to increase access to important services among low-income groups while still maintaining a financially viable operation.

The rest of this paper is outlined as follows: Section II discusses the approach of using survival curves to model demand when data is generated by contingent valuation surveys that use a descending bid approach. Section III describes the identification of various pricing strategies under two-part tariffs. Section IV applies the demand modeling approach and tariff structures to contingent valuation data that aimed to assess the WTP for water and sanitation services of household and businesses in Cebu, Philippines. Section V provides a discussion of other pricing scenarios and the validity of the demand estimation approach. Finally, Section VI concludes with some policy implications and directions for future analysis.

II. ESTIMATING DEMAND USING CONTINGENT VALUATION SURVEYS

A major challenge in estimating the demand for essential services is that service providers rarely price experiment or change their pricing structures making it difficult to assess how consumers would respond to price changes.[2] Contingent valuation (CV) surveys therefore provide an alternative way to identify demand structures for goods that are not typically traded

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[2] Nauges and Whittington (2010) provide a detailed overview of using observational data/revealed preference methods of identifying value households place on water in the least developed countries.

on the market. With carefully structured survey questionnaires and valid sampling strategies, contingent valuation estimates can closely mirror actual demand (Hanemann 1994).[3]

Construction of demand curves provides the means to assess the probability of users purchasing a good or service at a given price. For contingent valuation surveys that use a descending bid approach an appropriate form for modeling demand is to use survival curve estimation techniques. While less commonly used than the simple probit or bi-variate probit models that are used to back out the bid response functions (e.g. Hensher, Shore, and Train 2006; Wang, Xie, and Li 2010), survival curve methods are able to explicitly account for a respondents responses to multiple bid values in the estimation process. This method further adjusts for potential right censoring in the data when the event, in this case the response of “no” to a given bid price, is never observed. Survival curve estimation techniques were recently used by Mataria et al. (2007) to evaluate demand for improved quality of health care for consumers facing a single tariff. This paper extends the approach to consider a two part tariff structure that can capture that new users often are required to pay a connection fee in addition to monthly fees.

The two-part tariff is comprised of a connection charge, p^c, and a monthly charge, p^m, that is flat or associated with a consumer’s level of service usage. In the present formulation a consumer purchases a new service with quality level, *q*, only if utility of the service given quality, connection price, and monthly price exceeds that of all other alternatives. That is $U(q,p^c,p^m) >= \max(U(q_0,p^c_0,p^m_0))$. Since utility is decreasing in price (i.e., service provided is considered a normal rather than a luxury good) this implies that an entity will purchase a good if and only if $WTP^c(q) >= p^c$ & $WTP^m(q)>=p^m$, where *p* is the price for the service.

WTP^c, WTP^m are assumed to be random variables with a joint continuous probability distribution $f(p^c,p^m)$ where p^c, p^m are the observed price realization of WTP. Thus, the cumulative distribution function (CDF), F(.), which represents the probability that the joint WTP is less than any price p^c, p^m is given by:

$$F(p^c,p^m)=\int_0^{p^m}\int_0^{p^c} f(s^c,s^m)ds^c ds^m = \Pr(WTP^c \le p^c, WTP^m \le p^m) \quad (1)$$

The survival function, *S*, essentially is the complement to the CDF and represents the probability that WTP is greater than or equal to the price.

$$S(p^c,p^m)=1-F(p^c,p^m) = Pr(WTP^c \ge p^c, WTP^m \ge p^m)=Pr(WTP^m \ge p^m | WTP^c \ge p^c)*Pr(WTP^c \ge p^c) \quad (2)$$

To simplify the process of estimating the survival curve that accounts for the joint determination of WTP the term on the right hand side of the above equation is used. This is the conditional probability of paying a monthly charge, p^m, given a connection charge, p^c, multiplied

3 Hanemann (1994) emphasizes five key aspects that are important to ensuring that estimates of WTP based on CV methods are valid. First, it must use a reliable sampling strategy. Second, the question has to be designed properly to be concrete and close to the actual situation that would be faced by a person in reality. Third, closed ended questions are better than open questions. Fourth, it is necessary to assess respondents understanding and acceptance of key parts of the CV scenario. Fifth, the methodology applied must be valid to summarize the true distribution and capture long tails that may arise on the right side due to high bidders of WTP, but are not observed.

by the probability of paying the connection charge given a household's WTP for connection and monthly charges.

A Weibull function is used to model the probability density that the WTP is greater than a given price point. This distribution rules out negative costs under the assumption that people would not deny water and sanitation services if offered it for free. This distribution minimizes obtaining large probability values as price grows large and is shown to provide a better fit to the data than other distributional assumptions (such as exponential) based on Akaike information criterion (AIC) test within the survival curve modeling approach. The Weibull distribution is a common distributional assumption made for CV analysis (Carson and Hanemann 2005). Thus, for some service, s, with a charge, p^s, the survival function can be expressed as:

$$S^s(p^s) = \Pr(WTP^s \geq p^s) = e^{-(\lambda p^s)^\rho} \tag{3}$$

In this equation, λ, is the location parameter which determines the shift of the distribution and shape of the survival curve, while ρ is a scale parameter denoting how fast or slow the hazard function decreases. Parameterization of the model is used to investigate how changes in key characteristics affect demand, abstract from unobserved error in responses, and to provide estimates of mean WTP. Parameterization of the model occurs through the location parameter, λ, where external factors x_i are given a role in the survival distribution by letting:

$$\lambda_i = e^{-x_i \beta} \tag{4}$$

This formulation is known as an accelerated failure time model where ρ, λ, β are the parameters to be estimated. Estimation of the survival curve is done via maximum likelihood and provides the means to map out the expected quantity of demand for every price point *p*.

The estimated survival function for each consumer, *i*, in set I, is then used to construct the aggregate demand curve *Q* which can be expressed as:

$$Q_I^x(p^c, p^m) = \sum_{i \in I} w_i q_i^x S_i^m(p^m \mid p^c) S_i^c(p^c) \tag{5}$$

This is the weighted summation of the probability that WTP is greater than price *p* for various consumers, *i*, where w_i represents the weight and q_i^x is the quantity consumed per household or business. For example q_i^x is a value of 1 if it applies to a one-time connection charge, but is the estimated cubic meter consumption of water for a given time period in the case of a variable periodic charge.

III. PRICING STRATEGIES UNDER TWO-PART TARIFFS

There are a variety of potential pricing schemes that can be used under a two-part tariff structure. One type of pricing scheme is a contract which reduces the one-time connection charge, but raises the monthly charge over a set number of years in order to cover not only the cost of provision, but the cost required for connection. In instances where there are already connected consumers that are WTP significantly more, the higher variable or monthly charges can cross-subsidize the lower connection fees of new households that might decide to connect under a connection fee that is set below costs. This type of price structure is useful when connection charges are a major barrier to increasing the connection rates to a service allowing for the broadening of the user base which may result in lower variable or monthly prices in the presence of substantial fixed costs.

It is assumed that the service provider functions in a non-competitive environment where it can set the price of the services it provides rather than being a price taker in a perfectly competitive environment. As service providers for essential services are often working in a non-competitive environment this assumption is considered reasonable.

The demand structure for a service is assumed to be comprised of aggregate new user connection demand, $Q^c_{N,}$ aggregate new user monthly demand (over a 1 year period), $Q^m_{N,}$ and aggregate monthly demand of already connected users, $Q^m_{C.}$ New user connection and monthly demand are decided by both the connection charge, p^c, and a monthly or variable charge, p^m. Already connected users are only affected by the monthly charge. The provider is assumed to be able to enforce a contract for new users of minimum monthly payments for at least, *y*, years, while an assumption is made that the connected users will continue to pay p^m for roughly, *y*, years. It is assumed that the service provider discounts the future returns on an annual basis by an inflationary factor of *r*, assumed to be 0.05 in the analysis. For this two-part tariff structure total profits, *TP*, for providing a service at a connection charge of p^c and a monthly or variable charge of p^m is expressed as:

$$TP(p^c, p^m) = Q_N^c(p^c, p^m)(p^c - c^c) + \big((Q_N^m(p^c, p^m) + Q_C^m(p^m)\big)(p^m - c^m) - FC)(\sum_{j=1}^{y} \frac{1}{(1+r)^{j-1}} \tag{6}$$

In this equation, c is the marginal cost of connection or provision of the product, and FC is the annual fixed cost of providing the service which includes the basics needed for operational and maintenance expenses. Since we only consider financially sustainable pricing structures this entails that TP >= 0.

Thus, given cost estimates of providing the service and estimates of service demand for various prices it is possible to use these relationships to identify potential tariff structures that the provider can use. The above discussion is easily simplified for the case of single part tariffs. The analysis ultimately considers several different tariff structures where the prices identified vary depending on the objectives of the service provider. This allows us to examine the effectiveness of certain tariff structures in extending services to a greater proportion of the poor.

A. Flat Tariff Structures

A flat tariff structure is where all consumers face the same price for a service independent of their type or grouping. It often occurs because it is seen as simple and the most politically feasible way to set a price so that certain groups do not explicitly face price discrimination or disproportionately bear the burden of service provision in absolute terms even if it means explicitly placing the poor at a disadvantage to access the service.

Given that the provider can set its own price, maximum profit pricing solves:

$$\max_{p^c, p^m} TP(p^c, p^m) \tag{7}$$

In contrast, zero-profit pricing assumes that the provider has demand maximizing objectives and therefore finds the prices that solve:

$$TP(p^c,p^m) = 0 \tag{8}$$

subject to

$$\max_{p^c, p^m} Q_N^m(p^c, p^m) + Q_C^m(p^c, p^m)$$

The constraint that the provider solves for optimal demand at zero profit prices arises because different combinations of connection and monthly or variable charges can result in multiple values for zero profit prices. This constraint ensures that there is only one solution and that this solution is the most socially optimal in terms of maximizing the take-up of the service.

B. Price Differentiation Across Sub-Groups

Price differentiation allows a service provider to potentially extract more consumer surplus out of different types of consumers who have different WTP for services. It is assumed that the service provider can charge different prices to different customers.

A profit maximizing provider will charge tariffs which extract the maximum amount of profit from each sub-group. Where the differences in demand between sub-groups are large, this can lead to a substantial rise in profit. More explicitly the provider solves:

$$\max_{p_g{}^c, p_g{}^m} TP(p_g{}^c, p_g{}^m) \cdots \forall g \in G \tag{9}$$

1. Equitable Pricing

The ability to extract more consumer surplus out of different types of consumers by charging differential prices increases the ability to extend services to a greater number of users. To ensure that no group is explicitly disadvantaged, an equitable pricing strategy is used which is defined as setting a price, *p*, which equalizes aggregate demand, *Q*, for different sub-groups, *g*, where prices solve the following relationship:

$$Q_g(p_g) = Q_{g'}(p_{g'}) \;\forall g, g' \in G \;\; and \sum_{g \in G} (p_g - c) Q_g(p_g) - FC = 0 \tag{10}$$

This strategy essentially charges groups who have a higher value or WTP for a service in order to cross-subsidize those with a lower WTP. As WTP is largely dictated by wealth or income such strategies are expected to decrease the burden of payments that are faced by poorer consumers.

The social welfare aspects to connection of some sub-groups may be considered small or non-existent compared to other sub-groups. For example, a service provider may only care about the demand for services of households, but not businesses. In this case, the service provider may consider charging the sub-groups, *b*, that are not priorities for service provision the profit maximizing price, p_b^* to cross-subsidize and raise the take-up of sub-groups, *h,* while still maintaining equality in the percent taking up the service in sub-groups *h* via the pricing strategy. That is the provider solves:

$$Q_h(p_h) = Q_{h'}(p_{h'})\ \forall h, h' \in H \ \ and \sum_{h \in h}(p_h - c)Q_h(p_h) + (p_b^* - c)Q(p_b^*) - FC = 0 \quad (11)$$

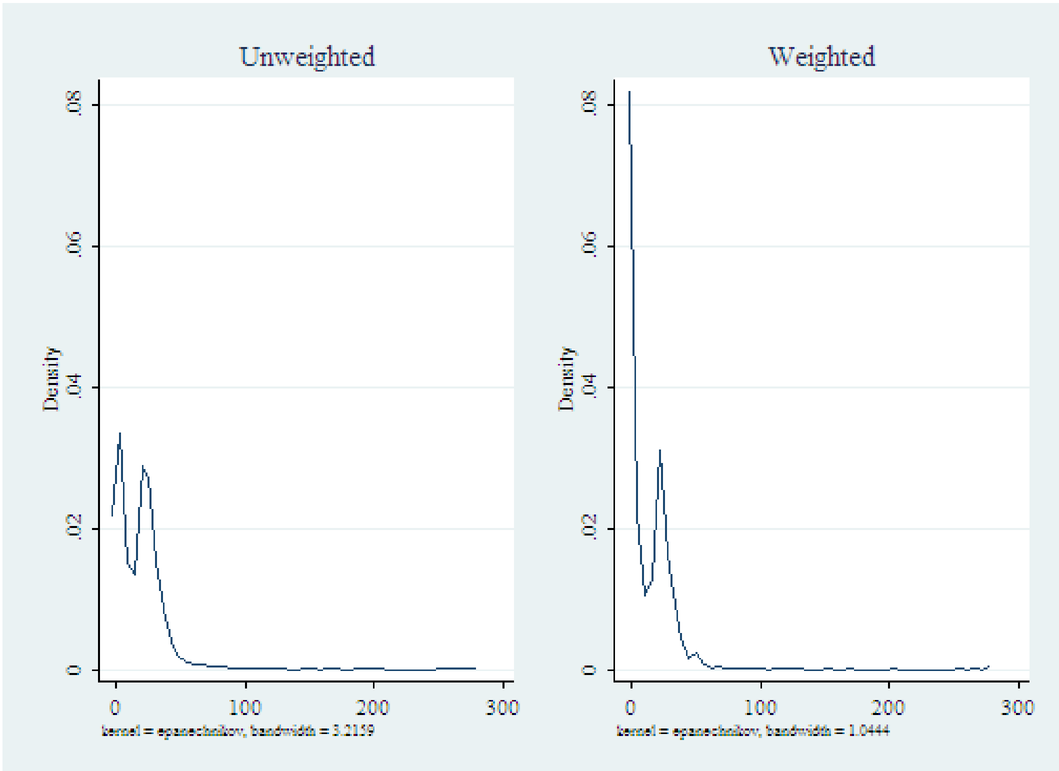
Inevitably there are many different ways and methods to screen customers and achieve certain objectives through pricing. However, the pricing strategies that obtain the best outcomes are best identified through empirical examination.

IV. EXAMPLE: PRICE-DEMAND SIMULATIONS FOR WATER AND SANITATION SERVICES IN CEBU, PHILIPPINES

Metro Cebu Water District (MCWD) is the major formal water service provider for the 2.5 million people living in Cebu, Philippines as of 2012. It currently supplies water to about 35% of all households or 1.1 million people. It produces approximately 200,000 cubic meters of water per day—an amount estimated to be sufficient to supply 1.4 million people or a little more than half of metro Cebu's current population. With the Metro Cebu population expected to grow to 4 million people by 2030 and only a few other small water service providers supplying to the population, there is a strong need to increase the capacity and efficiency in water supply and develop sewage and sanitation services while increasing the user base of these services. In the absence of increasing the percentage of the population using these services, major losses in productivity may arise due to contaminated water sources resulting in increased illnesses or time spent trying to procure alternative sources of clean water.

This study uses a 2011 household and industrial level socioeconomic survey in Metro Cebu, Philippines designed to assess WTP for water and sanitation services provided by the MCWD. It covers approximately 4,090 households in 128 barangays and 903 firms in 8 cities covered by MCWD. Surveying was done to obtain representation of poor, middle, and high-income households and businesses covering a range of industries with a roughly equal proportion of households and businesses surveyed from the connected and the non-connected population. Questions on willingness to pay were asked using a descending bid approach. Since sampling was not done to explicitly represent the Metro Cebu population, the sample was re-weighted to represent the approximate income distribution of households within Metro Cebu using income, household size, education level of household head, and household piped water connection indicator as stratification variables based on weights from the Philippines Family Income and Expenditure Survey (FIES) 2009 urban area of region VII (Central Visayas). The weights dramatically change the distribution of estimated WTP values of households in the sample as seen in Figure 1 for WTP per cubic meter of water. For businesses a multiplicative weight was used based on the 49,057 business estimated to exist in the Metro Cebu area based on the Philippines 2009 list of establishments and an assumption of 55% of businesses hooked up to water services.

Figure 1: Kernel Density WTP per cubic meter of Water Services



WTP =- willingness to pay.

Source: Author's estimates.

The data is used to separately estimate demand curves for businesses and households. All survival curve models include a standard set of variables of city fixed effects, indicators of building/household ownership, and connection to other private water providers. This captures that potential users of water services have different probabilities of investing in connection or service charges depending on ownership and prior investments in water connections. An indicator for ownership of deep water well was also included to capture that users of water in developing countries may utilize several sources of water depending on the purpose (Nauges and Whittington 2010). The household model also included variables that capture the characteristics of the household head such as education level and gender. In addition, total income, total income squared, and total income cubed, number of times a household had health illness attributed to water quality, and whether the respondent is married were also included. Business models additionally included indicators for the number of employees, broad industry indicators as well as interactions between indicators for own-building and own well ownership and number of employees.[4]

[4] A variety of specifications were tested to examine robustness and significance of various coefficients. The final models contain variables that achieved higher r-squared values and where the majority of the variables were significant across models. Other models tested included squared terms for household size, years at present location, time spent collecting water per month, and utilized per capita income instead of total income. For businesses, firm size, building ownership, and firm size own well and firm size-own building interactions were included as additional controls.

Actual estimations set zero values to 0.001 to prevent STATA from dropping these in the estimation process. The rough approach to estimation was as follows: First, estimate weighted survival regressions for different businesses and households for surveyed price points. Second, use estimates to predict demand for every household or business for a large range of price points. Third, use demand estimates and supplier variables and fixed costs to identify estimated costs, revenue, and profits for each price point. Four, sum up different estimates to obtain aggregates. Five, solve for the optimal prices for the various tariff structures described in detail below using estimates of MCWD costs provided in Table 1.

Table 1: MCWD Cost Assumptions (Philippine Pesos)

	Cost
Water Connection	
Per Household/Business (Variable)	4,950
Water Service	
Maintenance/Other O&M/Depreciation (Fixed)	624,977,000
Debt Service (Fixed)	151,630,000
Per Cubic Meter Charge (Variable)	6.72
Septage Service	
Per Desludging (Variable)	1,000
Per Month (Variable)	25
Sewage Connection	
Per Household/Business (Variable)	2,000
Sewage Service	
Maintenance/Other O&M/Depreciation (Fixed)	10,000,000
Per Month (Variable)	25

Source: Author's estimates.

MCWD = Metro Cebu Water District, O&M = operation and maintenance.

The computations for various scenarios of tariff structures were simplified by constraining businesses to price in discrete intervals. The result is that the prices identified are not precisely the profit maximizing or zero profit prices, but are the ones that come as close as possible given the discrete pricing restrictions.

Results from the survival curve estimates for households show that education, household income, household size, and ownership of deep water well are generally significant positive predictors of greater WTP for water and sanitation services. Lack of household ownership and those with a connection through other private water providers are less willing to pay for connections, but are willing to pay more on average for actual monthly or variable services. Survival curve estimates for businesses show that those with a greater number of employees are generally willing to pay more for monthly variable charges given they are already connected to MCWD water sources, but this association is not apparent for non-connected businesses. Building ownership and mining and construction businesses are also characteristics of businesses that have a higher WTP for a variety of service charges.[5]

[5] Estimates from the survival curves are available from the author upon request.

The analysis considers nine different pricing scenarios for MCWD water and sanitation services. These are: (1) Base price structure (where applicable), (2) Single price structure under profit maximization (equation 7), (3) Single price structure under zero-profit pricing (equation 8), (4) Price differentiation by household income and business under profit maximization (equation 9), (5) Equitable price differentiation where demand is equated across three groups of household per capita income and businesses (equations 10) Equitable price differentiation where demand is equated across three groups of household per capita income and profit maximization price is charged to businesses (equation 11). Price scenarios (7),(8), and (9) correspond to price scenarios (4), (5), and (6) except price differentiation for households occurs instead by geographic categorizations according to percent of households in poverty in a barangay. Price differentiation by geographic area is considered in addition to price differentiation by household income because it may be more politically feasible and less costly to implement using geographic area categorizations if trying to identify household income levels are difficult. Moreover, it may better capture aspects of WTP that are not as precisely measured by household income alone.

Income group divisions are poor, middle, and high where those considered poor are those whose monthly per capita income falls below the official 2009 per capita poverty line for Cebu of P1,556 ($37). Middle-income households are those whose monthly income is between the poverty line and 2.5 times the poverty line ($37–$92), while those with more than 2.5 times the poverty line are considered high income. Area group divisions are likewise divided into poor, middle, and high where poor areas are defined as those barangays having more than 33% of households below the poverty line, middle income areas those having between 10%–33% of households below the poverty line, while high income areas have less than 10% of households below the poverty line.

A. Demand for Improved Water Services per Cubic Meter of Water

Water services are currently provided by MCWD, but there is the intent to undertake investments which will improve the quality of water services. The improvement in service is expected to provide a constant supply of water 24 hours a day/7 days a week, prompt repair and customer service, decent water that is acceptable to drink from the tap, and meters that function properly. To access these water services it requires a one-time connection fee and monthly payments. Non-connected households and businesses were asked their WTP to connect to the improved water service and their WTP a monthly fee given they were willing to connect at some positive amount. Connected households and businesses were asked the amount they were willing to pay for the improved service over their currently monthly charges.

Charges are currently levied using a flat monthly fee for the first 10 cubic meters of water usage and rising per cubic meter charges thereafter. Almost all connected households consume greater than 10 cubic meters of water per month meaning that the majority of households face a per cubic meter charge. Thus, we make the simplification of considering the WTP for an average per cubic meter charge to levy on each household by dividing the WTP for monthly water service charges by the estimated monthly water usage that is expected to occur when having a private water connection.[6] Connection prices were constrained to occur in 500 Philippine pesos (P) intervals, with a minimum connection charge of P500 while per cubic meter charges occurred in intervals of P1. The current price structure sets connection charges at approximately P5,000 and the average per cubic meter charges paid by most households are approximately P15.

Table 2 shows the price–demand values for the various pricing scenarios. Under the current base pricing structure only 30.9% of all households will be connected with only 2% of non-connected households choosing to take-up the service. These current prices reflect that the distribution of users is highly unequal with only 12.2% of poor households opting to connect compared to 28.3% of high income households. However, zero-profit pricing using a single price structure for all groups substantially improves upon the current price structure allowing demand to rise to 49.9% of all households. This is due to the lower monthly connection charges that are amortized over a 5-year period and results in a pricing structure that has a connection charge of P500 and a P14 per cubic meter charge. Equitable price differentiation by household groups achieves an even greater take-up of water services resulting in 56.8% when screening by household income and 62.2% when screening by household area. This results in a rise of nearly 27 percentage points in take-up under income screening or 31 percentage points among low-income households over the zero-profit single price structure of 32.2%. The better outcomes for poor households when screening by area reflect unobservable differences in WTP that are better captured by area rather than income allowing the service provider to extract higher amounts from groups on the whole. It shows that price differentiation is able to substantially improve take-up among low income households not only over the baseline results, but also over the single price structure.

6 A limitation with the WTP question for water service is that it was asked in regards to a flat monthly fee that is independent of the amount of water consumption. In reality, households connected to MCWD are metered and therefore are charged by per cubic meter of water consumption. To deal with this, water consumption for non-connected users is estimated using the predicted coefficients obtained from least squares regression models for connected users that utilize the same variables used in the survival curve models. Connected household's WTP per cubic meter is identified from their monthly bill plus their stated WTP over their current monthly bill divided by estimated water consumption.

Table 2: Price–Demand Simulations for Monthly per Cubic Meter of Water Fee

		Price Changed (Philippine Peso)							
		Connection				m^3			
		HH Group			Biz	HH Group			Biz
Pricing Strategy (Profit)	**Est. Profit ('000)**	**Poor**	**Mid**	**High**	**All**	**Poor**	**Mid**	**High**	**All**
5-year Amortization of Connection Cost									
Base	–186	5,000	5,000	5,000	5,000	15	15	15	15
Single (Max)	3,035	1,500	1,500	1,500	1,500	32	32	32	32
Single (Zero)	21	500	500	500	500	14	14	14	14
			Income		**All**		**Income**		**All**
HHInc & Biz (Max)	3,514	1,500	500	1,500	1,500	26	27	28	47
Eq HHInc & Biz (Zero)	76	500	500	500	500	8	10	18	21
Eq HHInc & Max Biz (Zero)	64	500	1,500	1,500	1,500	8	5	17	47
			Income		**All**		**Income**		**All**
HHArea & Biz (Max)	3,536	1,500	500	500	1,500	29	27	26	47
Eq HHArea & Biz (Zero)	869	500	500	500	500	8	16	28	26
Eq HHArea & Max Biz (Zero)	244	500	500	500	1,500	6	12	23	47

		Demand									
		All					Non-Connected				
			HH Income			Biz		HH Income			Biz
Pricing Strategy (Profit)	**Est. Profit ('000)**	**All**	**Poor**	**Mid**	**High**	**All**	**All**	**Poor**	**Mid**	**High**	**All**
5-year Amortization of Connection Cost											
Base	–186	0.309	0.122	0.222	0.483	0.418	0.020	0.012	0.011	0.044	0.032
Single (Max)	3,035	0.186	0.059	0.116	0.304	0.396	0.055	0.025	0.033	0.117	0.201
Single (Zero)	21	0.499	0.322	0.426	0.653	0.626	0.304	0.243	0.282	0.395	0.482
HHInc & Biz (Max)	3,514	0.235	0.100	0.168	0.368	0.325	0.081	0.046	0.058	0.148	0.177
Eq HHInc & Biz (Zero)	76	0.559	0.559	0.559	0.559	0.559	0.323	0.486	0.431	0.286	0.436
Eq HHInc & Max Biz (Zero)	64	0.568	0.568	0.568	0.568	0.325	0.366	0.486	0.408	0.278	0.177
HHArea & Biz (Max)	3536	0.237	0.089	0.164	0.379	0.325	0.073	0.039	0.052	0.137	0.177
Eq HHArea & Biz (Zero)	869	0.513	0.507	0.515	0.514	0.519	0.337	0.437	0.341	0.243	0.410
Eq HHArea & Max Biz (Zero)	244	0.622	0.619	0.619	0.626	0.325	0.452	0.555	0.493	0.296	0.177

Notes: Biz = business, Eq = equitable, HH = household, HHArea = household area, HHInc = household income, m^3 = cubic meter.

Source: Author's estimates.

B. Demand for New Septage Services

A new septage management program is being considered by MCWD which would desludge the septic tank, transport the septage to a septage treatment facility, treat the septage to kill harmful pathogens, and properly dispose of the septage. To access these services it is expected that either per-desludging fee or a monthly septage service fee will be levied with no connection charge. As a result, all households that had a septic tank were asked both their WTP per desludging or their WTP for septage services on a monthly basis.

Survival curves were estimated conditional on households or businesses having a septic tank. 78% of households in the sample have a septic resulting in an effective market size of 531,415 households while 100% of businesses have septic tanks. The cost of septage services were assumed to have a variable cost of P1,800 per desludging while the monthly desludging had a cost of P150—equivalent to P1,800 per year with no fixed costs.

1. Per Desludging

Per desludging prices were constrained to occur in P500 intervals with a maximum charge of P30,000. As the questionnaire only contained a maximum bid price of P4,000 which still resulted in a high degree of positive responses (–2% of the sample) at this price point this introduced substantial error into the calculation of the profit maximizing prices.

Table 3 shows the estimated demand at the zero profit price of P1,800. At this price, only 14% of households are willing to take-up the service and only 6.5% of businesses are interested in using the service. The low WTP of businesses is indicative that it is difficult to use businesses as a way to cross-subsidize desludging service usage of households. Using an equitable pricing scheme to equalize demand across groups therefore is only able to raise household demand to 15.9% using household income as the screening variable and 16.4% of households using area as the screening variable. Area screening is less effective in this case in raising demand among income poor households. Rising from 8.2% under a single price structure to 11.8% under area screening compared to 15.9% under income screening.

Table 3: Price–Demand Simulations for Per Septic Desludging Service Fee

	Est.	**Price Charged** (Philippine Pesos)				**Demand**				
Pricing Strategy	**Profit**	**HH Group**			**Biz**		**HH Income**			**Biz**
[Profit]	**('000)**	**Poor**	**Mid**	**High**	**All**	**All**	**Poor**	**Mid**	**High**	**All**
Single [Max]	228	25,000	25,000	25,000	25,000	0.018	0.007	0.013	0.027	0.003
Single [Zero]	0	1,800	1,800	1,800	1,800	0.140	0.082	0.116	0.185	0.065
			Income							
HHInc & Biz [Max]	231	15,500	22,500	29,000	9000	0.018	0.012	0.015	0.023	0.013
Eq HHInc & Biz [Zero]	12	1,000	2,000	2,500	1,000	0.159	0.159	0.159	0.159	0.159
Eq HHInc & Max Biz [Zero]	20	1,000	2,000	2,500	9,000	0.159	0.159	0.159	0.159	0.013
			Location		**All**					
HHArea & Biz [Max]	231	16,500	24,000	30,000	9,000	0.019	0.008	0.014	0.028	0.013
Eq HHArea & Biz [Zero]	1	1,000	2,000	3,500	1,000	0.151	0.118	0.160	0.156	0.163
Eq HHArea & Max Biz [Zero]	3	1,000	2,000	3,000	9,000	0.164	0.118	0.160	0.187	0.013

Biz = Business, Eq = equitable, HH = household, HHArea = Household area, HHInc = Household income.

Source: Author's estimates.

2. Per Flat Monthly Fee

Pricing for monthly septage services were constrained to occur in P5 intervals. Table 4 shows the estimated price-demand simulations based on the price restrictions and cost assumptions. The WTP for monthly septage services is low with only 8.9% of households and 15.7% of businesses WTP for the service at the P150 break-even point. Prices which equalize demand across household groups results only in a rise in take-up of services to 9.3% under income and 9.7% under area screening. Take up among income poor household rises from 5.8% to a maximum of 9.7% under area screening. As in the case of water services, area screening performs better in increasing take-up among the poor. Compared to per desludging services these results indicate that businesses have a higher preference for paying on a monthly basis while households appear to prefer to pay on a usage basis.

Table 4: Price–Demand Simulations for Septage Service Monthly Fee

		Price Charged (Philippine Pesos)			
	Est. Profit	HH Group			Biz
Pricing Strategy [Profit]	**('000)**	**Poor**	**Mid**	**High**	**All**
Single [Max]	23	260	260	260	260
Single [Zero]	0	150	150	150	150
			Income		**All**
HHInc & Biz [Max]	23	245	255	260	280
Eq HHInc & Biz [Zero]	0	115	135	170	195
Eq HHInc & Max Biz [Zero]	0	115	135	170	280
			Area		**All**
HHArea & Biz [Max]	23	235	255	275	280
Eq HHArea & Biz [Zero]	0	100	160	200	190
Eq HHArea & Max Biz [Zero]	0	100	155	195	280

		Demand				
	Est. Profit	HH Income				Biz
Pricing Strategy [Profit]	**('000)**	**All**	**Poor**	**Mid**	**High**	**All**
Single [Max]	23	0.029	0.016	0.025	0.038	0.049
Single [Zero]	0	0.089	0.058	0.077	0.113	0.157
HHInc & Biz [Max]	23	0.030	0.019	0.026	0.038	0.042
Eq HHInc & Biz [Zero]	0	0.092	0.092	0.092	0.092	0.092
Eq HHInc & Max Biz [Zero]	0	0.093	0.093	0.093	0.093	0.042
HHArea & Biz [Max]	23	0.03	0.018	0.026	0.039	0.042
Eq HHArea & Biz [Zero]	0	0.095	0.095	0.095	0.095	0.095
Eq HHArea & Max Biz [Zero]	0	0.097	0.097	0.096	0.097	0.042

Biz = Business, Eq = equitable, HH = household, HHArea = household area, HHInc = household income, m^3 = cubic meter.

Source: Author's estimates.

C. Demand for Sewage Services

A new sewage management service is being considered by MCWD which would install a combined sewer-drainage system to collect and transport sewage from houses and businesses to a separate sewage treatment facility. Provision of sewage services therefore entails an initial capital investment cost to connect households to the main sewage line and monthly fees to maintain and provide this service. Assumed costs for sewage services entailed variable connections costs of P2,000, monthly variable costs of P25, and fixed costs of P10 million. Households and businesses were asked their WTP for a one-time capital cost of installation and a monthly fee to operate and maintain the system. The model for the two-part tariff structure was used to evaluate pricing for this service based on the connection fee and monthly fee with prices constrained to be P500 for connection fees and P5 for monthly sewage service fees.

Table 5 shows estimated demand for sewage services at optimal and zero profit pricing strategies. By charging a lower connection charge of P1,000 and amortizing the rest over 5 years of monthly fees at P55 per month, compared to the connection charge required to cover costs immediately, demand by households rises to 14.2%. Price differentiation again does little to increase demand resulting in a rise of overall household demand to 15.6% under income screening and 14.1% under area screening. However, it works to substantially increase demand among poor households when screening by income leading to a take-up rate of the service of 15.6% compared to only 8.2% under a single price structure. The gains are much more marginal in the case of area screening where only 9.1% of poor households choose to take-up the service.

Table 5: Price–Demand Simulations for Monthly Per Cubic Meter of Water Fee

		Price Charged (Philippine Pesos)							
	Est.	Connection				Monthly			
	Profit	HH Group			Biz	HH Group			Biz
Pricing Strategy [Profit]	('000)	Poor	Mid	High	All	Poor	Mid	High	All
		5-year Amortization of Connection Cost							
Base	–45	2,000	2,000	2,000	2,000	25	25	25	25
Single [Max]	402	2,000	2,000	2,000	2,000	191	191	191	191
Single [Zero]	19	1,000	1,000	1,000	1,000	55	55	55	55
			Income		All		Income		All
HHInc & Biz [Max]	425	2,500	2,500	2,000	1,000	300	300	185	131
Eq HHInc & Biz [Zero]	51	1,000	1,000	2,000	1,000	20	15	105	15
Eq HHInc & Max Biz [Zero]	4	1,000	1,000	2,000	1,000	20	15	70	131
			Area		All		Area		All
HHArea & Biz [Max]	447	2,500	2,000	2,000	1,000	300	190	175	131
Eq HHArea & Biz [Zero]	2	1,000	1,000	2,000	1,000	25	45	115	15
Eq HHArea & Max Biz [Zero]	17	1,000	1,000	2,000	1,000	25	45	115	131
		2-year Amortization of Connection Cost							
Single [Zero]	5	1,000	1,000	1,000	1,000	80	80	80	80
			Income		All		Income		All
Eq HHInc & Biz [Zero]	1	1,000	1,000	2,000	1,000	20	15	120	15
Eq HHInc & Max Biz [Zero]	3	1,000	1,000	2,000	1,000	20	15	105	146
			Area		All		Area		All
Eq HHArea & Biz [Zero]	4	1,000	1,000	2,000	1,000	25	80	160	15
Eq HHArea & Max Biz [Zero]	3	1,000	1,000	2,000	1,000	25	70	145	146

Table 5 *continued.*

Pricing Strategy [Profit]	Est. Profit ('000)	Demand All HH Income All	Poor	Mid	High	Biz All
		5-year Amortization of Connection Cost				
Base	–45	0.111	0.058	0.088	0.160	0.000
Single [Max]	402	0.073	0.044	0.061	0.097	0.000
Single [Zero]	19	0.142	0.082	0.116	0.196	0.121
HHInc & Biz [Max]	425	0.061	0.029	0.037	0.101	0.068
Eq HHInc & Biz [Zero]	51	0.146	0.146	0.146	0.146	0.146
Eq HHInc & Max Biz [Zero]	4	0.156	0.156	0.156	0.156	0.068
HHArea & Biz [Max]	447	0.073	0.043	0.061	0.098	0.068
Eq HHArea & Biz [Zero]	2	0.141	0.091	0.130	0.177	0.179
Eq HHArea & Max Biz [Zero]	17	0.141	0.091	0.130	0.177	0.068
		2-year Amortization of Connection Cost				
Single [Zero]	5	0.119	0.071	0.099	0.163	0.106
Eq HHInc & Biz [Zero]	1	0.140	0.140	0.140	0.140	0.140
Eq HHInc & Max Biz [Zero]	3	0.146	0.146	0.146	0.146	0.057
Eq HHArea & Biz [Zero]	4	0.128	0.091	0.130	0.144	0.145
Eq HHArea & Max Biz [Zero]	3	0.134	0.091	0.130	0.158	0.057

Biz = Business, Eq = equitable, HH = household, HHArea = Household area, HHInc = Household income.

Source: Author's estimates.

The bottom panel of the table examines amortization over a 2-year period as opposed to a 5-year period. As this is a new service, one-time connection costs account for a greater percentage of overall costs compared to water services. Therefore, amortization over a 2-year period leads to a substantial rise in prices that need to be charged on a monthly basis. A comparison of the flat price structure shows the impact this has on demand decreasing from 14.2% to 11.9% of households taking up the service. The percentage point decrease is larger for more wealthy households leading to a decrease in inequality of take-up of services under this pricing strategy.

V. DISCUSSION

A. Block Tariff Structures

Block tariffs are common in many developing countries and has often been perceived as an effective tool for decreasing the burden of payments incurred by poorer households. This is based on the assumption that poorer households are more sensitive to the price and therefore would alter their consumption pattern to consume less water. This type of pricing scenario was not investigated within the context of our example as the questionnaire design made it impossible to extract direct information about WTP per cubic meter and household consumption responses to rising per cubic meter fees.

Block tariffs are a component of MCWD's current pricing structure. This structure has a flat monthly fee for the first 10 cubic meters and then levies per cubic meter fees which rise for each 10 cubic meters thereafter up to 40 cubic meters of consumption. Thus, the current structure provides some revealing evidence on the effectiveness of rising block tariffs in achieving a more fair distribution of payments among different household income groups. Table 6 shows the water consumptions and the estimated amount connected households pay and are WTP as proportion of their total income. Under the current tariff structure with rising cubic meter charges, but no price differentiation among household groups, poor households that are already connected to MCWD pay far more for monthly water services alone than high income households. In particular, the average connected household pays monthly bills of 4% of their total income. However, the tariff structure is not equitable with low-income households paying 7.4% of their total income to water services compared to only 1.9% for high income households. This indicates that those households below poverty and which are already connected to MCWD are disproportionately burdened by payments for water and sanitation services. While poorer households do consume substantially less water per household member than richer households, total household consumption is roughly the same due to the larger number of household members within poorer households. The trouble with block tariffs in trying to obtain more distributionally fair outcomes was raised by Whittington (1992). This indicates that using price differentiation is still an important pricing strategy in trying to achieve greater take-up among the poor and a more even distribution of payments as proportion of total household income. However, on the whole, the average WTP for water services is about 2.2% of income. The data for Metro Cebu reveals that mean WTP for water services ranges from 1.7% of monthly income for those that are considered high class to 2.8% of monthly income in the case of those in the lowest class. This amount is significantly less than the typical 3%–5% of expenditures rule of thumb that is typically used to assess whether a water service is affordable (Gunatilake and Tachiiri 2012; Wang, Xie, and Li 2010).

Table 6: Water Service Consumption and Affordability of Monthly Fees by HH Per Capita Income Group

	Water Service (Connected HH)			**Water Service** (All HH)		
Per Capita Income Group	**Mt. Water Consump.** (m^3)	**Mt. Fee** (Philippine Pesos)	**% Fee of Income**	**Est. Mt. Water Consump.** (m^3)	**Mean WTP Mt. Fee** (Philippine Pesos)	**% WTP Fee of Income**
All	23	452.3	4.0	23.43	364.7	2.2
Poor	23	449.2	7.4	22.38	184.7	2.8
Mid	23	439.6	5.4	23.11	286.1	2.5
High	23	462.4	1.9	24.11	502.8	1.7

Consump. = consumption, HH = household, m^3 = cubic meter, Mt. = monthly, WTP = willingness to pay.

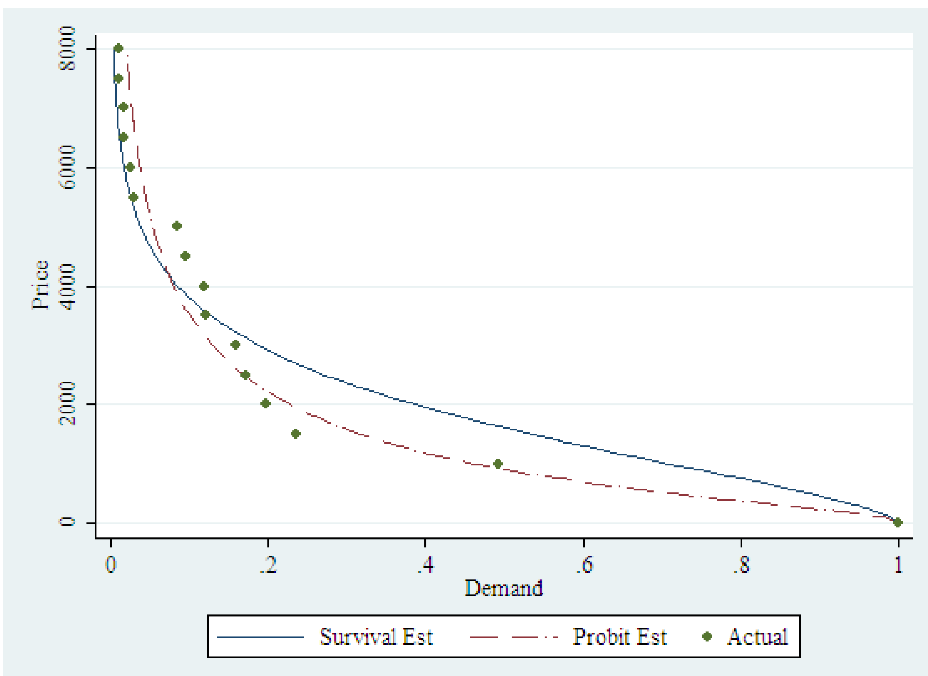
Source: Author's estimates.

B. Validity of Estimated Prices

The more common modeling approach using contingent valuation survey data are those that use bivariate or probit models. The ideal model is one that fits the data as closely as possible while eliminating potential noise in responses that can be attributed to other things outside of the behavioral responses that would occur in actual situations. Deviations from the actual data may inevitably underestimate or overestimate demand resulting in inaccuracies in the estimated prices that are required for a service provider to break even and the prices that should be charged to the consumer base. It would also alter the expected outcomes of percent of users taking up a service.

The use of bivariate probits to estimate demand and WTP for different services was investigated by randomly selecting bid price responses to combinations of connection and monthly or variable price responses for each household. The model run is the probability that the WTP of a household for both charges is greater than the randomly selected bid prices. That is $Pr(WTP^c > p^c, WTP^m > p^m) = \Phi(log(p^c)\text{-}xB^c, log(p^m)\text{-}xB^m)$ where B^c and B^m are coefficient estimates and the x's are the variables included in the survival curve analysis. In this model, bid prices are explicitly included as regressors in the estimation process. The estimated demand for the probit model compared to the survival curve models and the actual data is shown in Figures 2 and 3. It shows the survival curve is better at fitting the data in the extremities when demand is low compared to the bivariate probit model, but that the bivariate probit may have greater precision in the median WTP amounts. If costs are well above the median WTP, meaning that we are more likely toward the extremity of low demand, it indicates that there is greater precision on the price estimates found in the survival curve model than under bivariate probit techniques. While the current set of estimates is less precise than bivariate probits for prices closer to the median WTP values, it may be possible to improve survival curve estimates in its fit to the actual data through inclusion of spline functions.

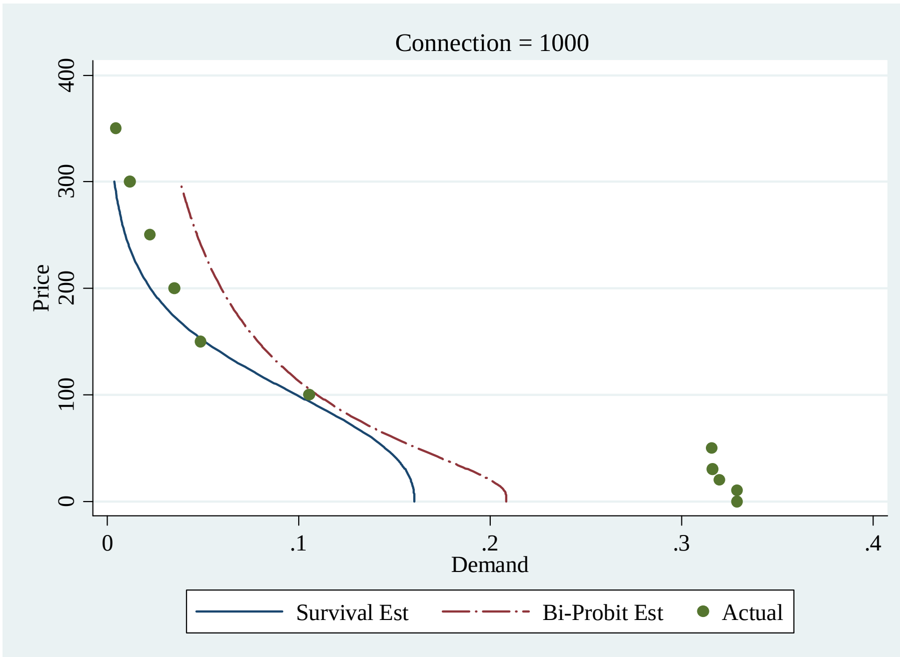
Figure 2: Estimates of Household Demand for Water Service Connection



Est = estimates.

Source: Author's estimates.

Figure 3: Estimates of New Household Demand for Monthly Sewage Services at Connection Cost of P1000



bi-probit = bivariate probit, Est = estimates.

Source: Author's estimates.

VI. CONCLUSION

The low WTP of a population for water and sanitation services can hamper the goal of having wider spread take-up of essential services that are necessary for environmentally sustainable development. A methodological approach for examining tariff structures to increase access to essential services while allowing the service provider to recover costs was applied to water and sanitation services in Cebu, Philippines. The current policy of using rising block tariffs and trying to recover costs of connection upfront through the connection fees are restrictive and a huge deterrent to a larger number of poor households taking up monthly services. The analysis revealed substantial benefits can arise from improving the design of the tariff structure.

Amortization of large up-front connection charges through inclusion in monthly fees can greatly increase take-up of water services. It increases demand of non-connected households by nearly 30 percentage points—a 15-fold increase over the current tariff structure. The poor nevertheless still have much lower rates of take-up of services. However, it is shown that equitable price differentiation which sets prices to equalize demand across different sub-groups of populations can greatly increase take-up of services by the poor while also increasing overall household demand. This is done through charging higher prices to better off users to cross-subsidize the lower prices charged to the poor. This is shown to increase water demand by as much as 10% among household groups.

Consideration of price differentiation by household income groups or degree of poverty in an area reveals that household income is not necessarily the best means to price differentiate in order to increase take-up of services among the poor and price differentiation by area can in some cases lead to even higher take-up of services overall and by the poor. This arises due to potential un-observables in WTP that are correlated with geographic categorizations allowing for a more refined set of prices to be charged that results in the expansion of the user base and can even work to reduce total monthly usage charges for some sub-groups. In the end price differentiation by area may be a more feasible and lower cost method of price differentiation that can improve take-up of services by the poor as it only requires a rough knowledge of the degree of poverty in an area as opposed to having to document each household on a case-by-case basis.

Inevitably there are many tariff structures that could be considered which may improve outcomes further. For example, pricing menus where users are allowed to choose from various pricing combinations can result in users self-selecting combinations that will allow the provider to extract more consumer surplus without explicitly categorizing users. There are also more refined levels of price differentiation, pricing contracts that amortize charges over a longer or shorter period, and the use of three-part tariffs. These may all have significant implications for the take-up of services and have the potential to improve the effectiveness in achieving certain objectives. Moreover, careful analysis needs to be done to examine the feasibility of implementing different pricing scenarios in any given situation. For example, price discrimination which sets much higher prices for businesses may cause businesses to locate elsewhere and hurt the local economy.

The differential pricing policies considered in this paper are just one of many potential tools to improve take-up of services. More cost effective provision of services resulting in lower variable and fixed costs also has the means to greatly aid in enabling firms to lower prices in order to increase the rate of service take-up. Lack of knowledge or understanding on the benefits provided by different services may also be an impediment to take-up of services among the poor meaning that informational campaigns can increase the take-up of essential services. Hence designing more sophisticated and extensive contingent valuation surveys and developing models to understand the effects of different and more complex tariff structures and the use of strategic investments in improving take-up of services are avenues for future research.

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Cost Recoverable Tariffs to Increase Access to Basic Services among Poor Households

The design of alternative tariff structures can serve as a low-cost and effective tool in achieving higher take-up of basic services among poor households while allowing the provider to recover costs. A contingent valuation survey from SEUW's Water Supply and Sanitation Project in Cebu, Philippines is used to show that tariff structures with a low one-time connection price and price differentiates based on wealth measures can result in a five-fold increase in the take up of water services by poor households over the base tariff structure. More moderate impacts, however, are found for the take-up of new sanitation and sewage services.

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