Water Demand and the Welfare Effects of Connection: Empirical Evidence from Cambodia

by

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Water demand and the welfare effects of connection: empirical evidence from Cambodia*

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Abstract

Using cross-sectional household-level data from seven provincial Cambodian towns, we estimate a water demand equation for households connected to the network, and provide an empirical measurement of the economic value of tap water connection. The use of a two-step econometric procedure allows us to analyse issues relating to household access to water and to the volume of household water consumption. We estimate that the connection elasticity with respect to the one-off initial cost of connection is -0.39; the price elasticity of water demand for the connected households lies in a range between -0.4 and -0.5; and the welfare effects of water connection are approximately 17 percent of the actual expenditure of the poor unconnected households. Furthermore, providing a network connection to all households in the sample would have the distributional consequences of decreasing the estimated Gini coefficient by three percentage points, and the poverty head-count ratio by six percentage points.

1. Introduction

As with many developing countries, Cambodia has a low level of water provision: only 24 percent of the rural population and 60 percent of the urban population have access to water services (KOC (2003). In the last decade, the Cambodian government has been trying to improve water provision. However, the country is still grappling with the consequences of decades of war manifested in poor levels of economic and social infrastructures, and depleted public utilities. In the difficult process of recovery, the public expenditure on water and sanitation in the period 1996-1999 was less than 0.1 percent of GDP per year, and comprised less than one percent of the government's total expenditure financed by revenues (WB (1999) in DeRaet and Subbarao (1999); ADB (2000)). In response to poor development of the network outside the capital, the government awarded four private-sector operators the rights to administer and operate four water utilities between 1997 and 1998. Thus, both public and private operators are currently present in the country as water providers.

In a developing country setting characterised by low-coverage and a high level of poverty, a key question in designing urban water policy is how the service should be designed to meet the needs of both the connected and the (usually poor) non-connected households. Using data originally collected in seven provincial towns (more specifically, seven towns and one district) by Garn *et al.* (2002), we attempt to model the water demand relationship for Cambodian households. Our analysis has three main objectives:

- First, to obtain a robust and reliable estimate of the price elasticity of the demand for water, as this has important policy content in its own right. Most empirical studies on developing countries report price elasticities that vary in a range between -0.6 and –0.2 (see World Bank (1996); Abdala (1996); Strand and Walker (2004); David and Inocencio (1998); Bachran and Vaughan (1994));

- Second, to identify empirically the main constraints for the non-connected households in their access to water provided by the network. According to Garn *et al.* (2002), low coverage and high connection fees represent the main barriers to connection for the poor in Cambodia.
- Third, to evaluate the welfare consequences and the income distributional effects if the non-connected households were provided with a connection to network water. Studies that attempt to capture the welfare effects of different types of water provision include Abdala (1996), Clarke *et al.*, (2002), Moilanen and Schulz (2002), Abou-Ali and Carlsson (2004), Torero and Pasco-Font (2001). In our research, we use as a partial template the study of Strand and Walker (2003), which derives welfare estimates of access to tap water for 17 cities in Central America and Venezuela.

The paper is organized as follows. Section 2 provides an overview on the current socio-economic status of Cambodia, emphasizing in particular the current urban water supply context. Section 3 presents the data and the main methodological issues. The use of a two-step estimation procedure allows us to analyse separately issues relating both to water access and water consumption. Section 4 presents the main econometric results of our research. The estimated price elasticity of water demand provides the basis for welfare analysis using the concept of Marshallian consumer's surplus. Section 5 contains concluding remarks and offers some policy implications of our analysis.

2. The Current Background

2.1 Cambodia at a glance

After three decades of war, genocide, and internal strife that resulted in widespread instability, massive loss of life and the devastation of economic and social infrastructures (Wright (1989); Chandler (1991)), Cambodia entered a new era in 1993 with national elections. From the establishment of the Royal Government of Cambodia (GOC) in 1993 up to 2002, the average annual GDP growth has been 5.5 percent, and the inflation rate has been sharply reduced and stabilised. However, despite these macroeconomic improvements, about 36 percent of the population is still currently below the basic needs poverty line, and Cambodia is placed at 130^{th} out of 175 countries in the world, as measured by the broader human development indicators (UNDP (2001, 2003)). Furthermore, the situation is worsened by a strong population growth rate (2.5 percent per year - KOC (2002)) that strains government finances and affects the quality of public services' supply.

2.2 Urban water: the current context

After a long period of international isolation, Cambodia regained its seat at the General Assembly of the United Nations in the 1990s, began negotiations to join the WTO[1] and in 1999 became a member of the Association of South East Asian Nations (ASEAN) (KOC (2001)). In the process of re-establishing itself in the international community, the GOC signed and committed to the Millennium Declaration, agreeing to commit itself to achieve the Millennium Development Goals by the year 2015: the government subsequently adapted its general commitments to country-specific targets (Cambodian-MDGs). In particular, the GOC adopted the following targets:

- Increase the proportion of rural population with access to safe water source from 24 percent (in 1998) to 50 percent (in 2015);
- Increase the proportion of urban population with access to safe water source from 60 percent (in 1998) to 80 percent (in 2015) (KOC (2003)).

Access to a safe water supply is twice as high in urban areas in Cambodia than in rural areas, but remains low compared to many of the neighbouring states, with Thailand, Vietnam and Malaysia well above 50 percent) (UNDP (2003); WHO (2000)). Initial projections suggest

[1] On 31 August 2004, the Cambodian parliament ratified the country's WTO entry (Bridges (2004))

that Cambodia will be able to meet the target only in rural areas, while in urban areas it will reach about 70 percent (NIS, 2000; MOP, 2000 and WHO/UNICEF, 2001 in KOC (2003)).

These forecasts may be far too optimistic, however, as only the capital city of Phnom Penh exhibits a level of coverage close to 60 percent. In the other provincial towns the average coverage level is around 15 percent. Furthermore, the service is restricted to the central core areas (DeRaet and Subbarao (1999)), and future prospects for more adequate coverage in urban areas are not helped by high expected population growth rates in urban areas.[2] Furthermore, access to safe water decreased in Phnom Penh by about one-fifth between 1997 and 1999, and the percentage of the population with access to safe water is low in other urban areas and negligible in the rural areas (JBIC (2001). To complete the portrait, many of the existing public utilities, re-opened with depleted facilities only in the 1980s, after a long period of shut-down between 1975 and 1979, and are generally characterised by frequent breakdowns and poor treatment quality (Garn *et al.* (2002)).

Due to this low network coverage, many people either get their water from rivers, streams, tanks, wells or purchase it from vendors. These vendors buy the water either from the network utilities or acquire it from rivers and tanks and sell it on without any treatment, charging prices that are usually about 10 times higher than the official unit-price (DeRaet and Subbarao (1999)). Furthermore, water from rivers and lakes, though abundant,[3] is often contaminated due to the lack of treatment plants where wastewater from households and industries is discharged directly without treatment into the rivers and canals (JICA (1999)).[4]

Urban health and sanitary conditions have thus become a matter of great concern. The Cambodian health system continues to suffer from the legacy of the Khmer Rouge period, where

[2] Though, some caution is required here as according to DeRaet and Subbarao (1999), all the towns but Phnom Penh do not experience such a population growth rate.
[3] The country has a rich endowment of water, thanks to the Mekong and the Tonle rivers and their tributaries, with abundant rainfalls and groundwater largely available but in the hill tract.
[4] However, contrarily to other Asian countries, water pollution does not seem to be a major problem yet (DeRaet and Subbarao (1999))

there was widespread destruction of primary health infrastructures and a dramatic reduction of trained Cambodian doctors (Wright (1989)). Hence, the new government has planned to increase public investments to develop better physical and social infrastructures (and human resources) in order to meet the increasing pressure on water and sanitation provision in urban areas.

However, after decades where public infrastructures have either been closed or destroyed, the main constraint for the public sector comes from inadequate financial resources to develop an adequate supply and maintenance system. In 1999, government revenues barely covered current expenditures. Public expenditure on water and sanitation in the period 1996-1999 was less than 0.1 percent of GDP per year and less than one percent of the Government's total expenditure as financed through revenues (World Bank (1999) in DeRaet and Subbarao (1999); ADB (2000)). The 0.3 percent of GDP per year invested in capital was entirely financed by donors. But after initial interest in the water sector in the early 1990s, more recent years have attracted less funding (Budds *et al.* (2003); KOC (2001)), with finance and NGO activity largely confined to Phnom Penh. Moreover, the legal structure governing the provincial utilities is confusing and fragmented, characterized by uncertainty about the extent of the authority of the Unit of Potable Water Supply (UPWS) (part of the Ministry of Industry, Mines and Energy - MIME) and the Provincial/Municipal Governors, especially in terms of tariff revision (DeRaet and Subbarao (1999)). Thus, the goal of improving service deliveries is in strong need of reform, and requires new and more efficient management of the existing infrastructures and a better understanding of the demand-side.

2.3 Public and private provision of urban water

In response to the poor development of the public network (CNPRD (2004)), the government awarded four private-sector operators the rights to administer and operate four water utilities between 1997 and 1998. In particular, the private companies took over the whole supply in three provincial towns: Bantey Meanchey, Kampong Speau and Takeo. In Kandal, however, the company does not operate the service in the central area of the towns but in a peripheral area close to the Mekong River, called Kien Svay. By contrast, in the other 20 towns the service is still operated by the public sector.

The form of privatisation varies across towns: in Kien Svay the Mekong Water Electricity Company signed a build-own-operate (BOO) contract with the Ministry of Industry, Mines and Energy, where no public assets were transferred. By contrast, in the other three cases the public assets were transferred to the companies in the form of outright concessions for a period of between 23 to 40 years. Each company was awarded a three year licence for supplying water to residential consumers in the first instance, with the renewal conditional upon water quality and tariff stipulations. The discrepancy between the period of the licence and of the contract makes the basis of the renewal decision unclear (DeRaet and Subbarao (1999)).

The legal basis for the licenses was also very uncertain and the privatisation process was not transparent and characterised by *ad hoc* unsolicited bids made by the government (CNPRD (2004)). In all the towns but Kandal there was no competition, and even in Kandal the winner was selected through unofficial criteria (Garn *et al.* (2002)). Moreover, the regulation appeared to be deficient, and a clear regulatory framework on the operation of the private companies, such as tariff revision and contractual disputes, does not exist. Also the tariff setting formula, on paper based on water cost calculation methods, appears to be vague and somewhat ambiguous (DeRaet and Subbarao (1999)). Despite this lack of regulation and this general uncertainty, many new fixed investments have been made by the private companies to improve the quality, the coverage and the overall reliability of their services.

Thus, at present, both private and public sectors provide water services in Cambodia. Since privatisation represents a very recent phenomenon and in the light of the historical pattern of the public utilities, it is worth investigating if the actual service, private or public, effectively meets the demand of water, and especially the demand of the low-income part of the population.

3. Data and Methodology

3.1 Description of the data

This study exploits a dataset originally used by Garn *et al.* (2002) to assess and compare the performances and consumer satisfaction for four private and four public utilities in Cambodia.[5] In addition to the four areas served by private companies (three towns and one district), four other cities were selected to allow a direct comparison, namely: Kandal (Takmao), Battambang, Kampong Chhang and Svay Rieng.[6] The selection process was randomly implemented in order to avoid standard problems associated with selection bias.

In each town 50 households served by either public or private utilities were randomly selected and surveyed through a household questionnaire. Further, in the two towns characterised by the presence of sub-contractors, namely Battambang and Kandal, respectively 25 and 26 additional households were also surveyed. Overall, a total of 451 connected and 375 non-connected households provided responses.

The questionnaire was administered to an adult member of each household. The 186 questions yielded information on a total of 200 variables divided into a number of categories relating to, *inter alia*, respondent characteristics, head of household characteristics (e.g., educational attainment), water service provider, cost of connection, cost of service, water availability and use, water quality, service breakdown/failures, service orientation of water utility, satisfaction with water service, household health, general questions about the household (e.g., number of members and nature of assets).

3.2 Theory and Methodology

Since a key part of the survey contained questions designed to capture the level of satisfaction with the existing service, these questions were only answered by the sub-set of connected

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[5] Garn *et al.* base their analysis on three questionnaires: Household Questionnaire, Water Utility Questionnaire, Technical Assessment Questionnaire. In estimating the water demand equation, our main source of information was the Household Questionnaire. However, both the other two have been used for data comparison and to obtain additional insights.

[6] Takmao is the provincial town where the survey was carried out for the part of Kandal served by the public sector.

households. However, the first and the last parts of the survey questionnaire were common to all respondents. In particular, we have information for all households on the head of the household (such as education level, age, ethnic group), and on general household characteristics (such as total income, expenditure, and information about assets).

Water is considered a commodity consumed by households and thus enters a utility function in a standard fashion. The consumer's utility is considered to be a function of the amount of water and on the total amount of other goods consumed. Further, assuming standard neoclassical assumptions, if the service is provided applying a constant unit pricing system (as in our case), the link with the conventional consumer theory is straight-forward: consumers are assumed to maximise utility subject to a budget constraint based on an exogenously determined price that is independent of the quantity (previously) consumed, (Dalhuisen *et al.* (2001)). Thus, in an econometric model the volume of water consumption (W_d) ought to be expressed as a function of its relative price (P) and other independent variables (Z), including income and a variety of household characteristics:

$$W_d=f(P,Z)$$

However, while “common” information is observed for all individuals, the continuous values for water consumption are only observed for those households who have a metered water connection. This creates a censored data problem and Ordinary Least Squares (OLS) estimation on the whole sample may lead to potentially biased estimates. The tobit model (see Tobin (1958)), containing both discrete and continuous parts, provides one possible solution to the problem of censoring outlined above (tobit results are reported in the empirical section.) However, the main constraint of the tobit model is that the effect of the explanatory variables that predict the binary choice of connecting and those that predict the consumption level are constrained to have the same sign (Johnston and DiNardo (1997)).[7]

The Heckman procedure (Heckman (1979)) allows separate estimation of the selection and the levels equation, and does not constrain the sign effect of covariates on the probability and on the levels. It also deals with another of selectivity bias problems: since we observe water consumption only for households who are connected, these households may not represent a random drawing from the population of households. Thus, fitting an OLS regression model to the sample of connected households potentially leads to biased coefficients. The two-step Heckman procedure treats the problem as one of omitted variables and it allows us to correct for selectivity bias by inserting a proxy variable for the selection effect. If this correction term -- the inverse Mills ratio -- is statistically insignificant, then no selectivity bias is present, and an OLS regression using only the connected households provides unbiased and consistent estimates (conditional upon the model passing an array of other important diagnostic tests). This approach is sometimes referred to as a generalised tobit.

In order to identify the correction term's parameter, it is crucial to have variables that shift the probability of household connection but not the level of household water consumption. (These represent the identifying variables that will be discussed in more detail in the empirical section.) However, the coefficient estimates are also highly sensitive to the distributional assumption of the underlying probit model (Greene 2003), as the construction of the correction term is derived using this explicit assumption. Thus, only after testing for the normality in the pseudo-residuals of the reduced form probit selection model will it be possible to test for selectivity bias in an adequate or meaningful fashion.

All the diagnostic tests reported for the probit and the censored tobit models, except one

[7] The presence of heteroskedasticity is likely to represent a problem with much more serious consequences than in OLS (linear) regression models leading to biased coefficients. Furthermore, the violation of the normality assumption also leads to inconsistency in both estimates.

relating to the test for the tobit specification,[8] are based on the efficient score tests originally suggested by Chesher and Irish (1987). These tests use the score contributions[9] of the coefficients of the model to implement Lagrange Multiplier tests based on the matrix expression:

$$\mathbf{i'R(R'R)^{-1}R'i}$$

where **i** is an *n* x 1 vector of ones and **R** is an *n* x *q* matrix of the score contributions for each of the *k* parameters from the original specification and the *k* + 1, …*q* parameters assumed to be 0 under the null hypothesis, with the test statistics distributed as a chi-squared with $p = q – k$ degrees of freedom. In this way, functional form can be tested by inserting (predicted) higher order terms of the standardised probit index; homoskedasticity by using the set of original variables of the model to provide a heteroskedastic alternative; and normality by allowing for skewness and kurtosis in the pseudo-residuals.[10]

Since in the absence of normality any inference about selectivity bias may be incorrect, a recent literature suggests use of a combination of non-parametric and parametric techniques to make the procedure less sensitive to violations in this assumption. One technique is based on approximating the selection correction term through a polynomial formed by a power series of the original Mills ratio term. The polynomial thus obtained is then added to the model as additional regressors in the second stage of the procedure.[11]

The econometric analysis will allow us to estimate both an access-to-water probability equation and a water demand equation. The former model allows us to identify the main barriers

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[8] This test is computed as a Likelihood Ratio Test: $-2[L^{tobit}-(L^{truncated}+L^{probit})]$, where the maximized log-likelihood value of the tobit and the sum of the two maximised log-likelihood values of the truncated tobit and the probit models are compared (see Lin and Schmidt (1984)). The chi-squared has $(k^{truncated}+k^{probit}-k^{tobit})$ degrees of freedom, where *k* indicates the number of parameters estimated.

[9] The score contributions for the coefficients are given by multiplying the pseudo-residuals of the model by the explanatory variables. The former are obtained as the first order derivatives of the log-likelihood function with respect to the probit model's constant term.

[10] Using Monte Carlo simulations, Orme (1990) demonstrated the poor finite sample properties of the type of outer-product- gradient (OPG) tests used here, arguing that efficient score tests constructed with the OPG variance-covariance matrix tend to reject the null hypothesis too frequently. It should be noted that passing a given score test thus provides a more stringent task for us given the findings of Orme (1990) in this case.

[11] See Newey (1999) for a theoretical exposition and Buchinsky (1998) for an application, albeit within a quantile regression model framework

and potential constraints to connection. Determining the value of obtaining water connection, in particular, would allow us to simulate possible income redistribution scenarios, since non-connected households have generally a lower income than the connected ones and face higher prices for a unit of water.

We estimate the welfare gain for a household that changes from the price applied by the vendors ($P_{(0)}$)[12] (and a certain amount of water consumption $W_{(0)}$) to the official price applied by the water utility ($P_{(i)}$) (and a certain amount of water consumption $W_{(i)}$). Since estimates of the economic values of such amenities are highly uncertain and due to difficulties in using other methods, we use as a template the study conducted by Strand and Walker (2003, 2004) that derived estimates of access to tap water in 17 cities in Central America and Venezuela.[13] The log-linear form of the water demand equation can be expressed (ignoring conventional error terms) as:[14]

$$\ln W(i) = A(i) - \eta \ln P(i) \qquad [3.1]$$

where *A(i)* identifies all factors other than price that influence household's *i* water consumption and η is the estimated price elasticity. Starting from equation [3.1] and exploiting the definition of consumer's surplus, and thus calculating the area under the Marshallian demand curve between the old and new price (monetary measure of the individual's utility change), it is possible to obtain the following expression:

$$CS(i) = \frac{1}{1-\eta} P(i) W(i) \left[\left(\frac{P(0)}{P(i)} \right)^{1-\eta} - 1 \right] \qquad [3.2]$$

which allows us to calculate the change in *CS(i)* without having to proxy *W(0)* (see Strand and Walker (2003)).

[12] Information reported by DeRaet and Subbarao (1999).
[13] The very detailed data set available allow them to calculate the welfare gain also using the hedonic price method.
[14] The use of formula [3.1] is obviously inappopriate for the censored tobit specification and more relevant to the generalised tobit model we use below.

Following this theoretical framework, and conditional upon obtaining unbiased estimates of the price elasticity of water demand, we are thus able to determine welfare effects. This procedure, however, requires the exercise of some caution for a number of reasons. First, the *CS* obtained is calculated implicitly assuming that the only alternative to piped-water is water from vendors (ignoring other possible sources, that might well be cheaper or more expensive, such as own wells, public standpoints, rivers and lakes, tracks, etc.) and not accounting for any kind of externality. Second, performing the analysis on the sample pooled across the public and private providers may neglect differences in consumer responses across these two types of provision. Third, since the values used in deriving the income reduction of losing the connection comes from the connected-households, the measure obtained is more interpretable as a Willingness To Accept (WTA) rather than a Willingness To Pay (WTP) concept. It should be noted that the two measures usually give different results (see Horowitz and McConnell (2002)) with WTA greater than WTP.

3.3 Choice of the Variables and Data Reliability

A preliminary analysis was undertaken to identify potential outliers and unreasonable observations (e.g., households with a water bill higher than the expenditure/income declared). After cleaning the data and dealing with the problem of missing information, the sample size was reduced from 826 to 782 usable observations, specifically yielding 354 non-connected and 428 connected households corresponding to the set of censored and uncensored observations respectively. We now turn to a discussion of the independent variables used in our analysis.

Price

The price variable identifies the unit tariff paid per cubic meter of water consumed. At the time of the survey, all the utilities analysed were applying a two-part uniform tariff for all the consumers connected.[15] Since the price declared by the household often differed from the

[15] The consumer pays a fixed charge to get connected and a charge related to water consumption. The price per unit consumed is constant, and the water bill is given by quantity used times the unit tariff.

official one,[16] we constructed the price variable in a number of ways. We report here results obtained using the following two price variables:

- *price1* was generated using the official price reported by the utilities for the corresponding town. Even though the price reported by the companies is likely to be less prone to measurement error, this variable neglects the presence of subcontractors;
- *price2* was generated using the official prices reported by the utilities for the corresponding town but substituting the subcontractors prices for the households supplied by subcontractors. However, it must be borne in mind that in the case of the censored tobit using only the official prices for the missing values, we assume that all the non-connected households face only the price set by the utilities, ignoring the possibility of being supplied by a subcontractor. Unfortunately, the lack of more precise information (e.g., the location of the household and the areas served by sub-contractors) does not allow us to assign more precise values to this variable.

Fee

In the computation of this variable, we included not only the actual connection fee, but the entire amount households have to pay to get connected (which sometimes includes extra charges), in order to have a better proxy for overall connection costs. While all private utilities apply a fixed fee that covers labour charges, cost of piping materials, the water meter and other connection expenses, public utilities have different methods to set the fee. This varies with the distance from the network and with the condition of the road (as in Kampong Chhang, Kandal and Svay Rieng)[17] to cases where the connection does not cover the cost of materials (as in Svay Rieng). Due to the lack of information and to the large variation in the self-reported amounts, we decided once again to use a town-specific value that includes all the expenses reported by the

[16] The respondent ma have reported a different price than the one actually paid (depending on, say, level of education or other characteristics), or there may have been episodes of recall error.
[17] In Kandal and Svay Rieng, costumers had to pay for the permission and for any damages caused by the lying of the pipe on the bitumen road. Apparently, this is not a peculiarity of Cambodia (see Brocklehurst et al. (2002)).

household (connection fee plus labour charges plus other charges). We eliminated a number of obvious outliers and substituted the location-specific mean value instead.[18]

Expenditure versus Income

The development literature supports the notion that, when dealing with household surveys in developing countries, estimated household expenditure is a better proxy of household welfare than income. The fact that households are likely to purchase and consume a narrow range of goods and services (Hentschel and Lanjouw (1996)) makes total expenditure less volatile than income. Furthermore, households surveyed are more likely to understate their incomes than overstate their expenditures (Deaton (1997)). Besides these conceptual considerations, in our case the choice of the expenditure measure also relates to practical considerations, since the income variable contained more missing observations than the expenditure one (194 versus 95 out of the 782 households). After careful analysis, we substituted the missing information with the expenditure mean values for each town.

In order to explore the robustness of the measures used, we calculated the monthly mean expenditure per capita, the Gini coefficient, and the poverty head-count ratio (using the household expenditure variable constructed by substituting missing values with the town mean expenditure values.) In all cases, the values obtained were fairly close to the ones reported in official statistics.[19] However, additional analysis suggested that households with assets are less likely to declare their expenditure, but are more likely to be in the top end of the expenditure

[18] It is also worth pointing out that for the public utilities but for the Komponch Chhang Water Utility we do not know when the fee was set. This requires caution in interpreting the results, given the very high inflation rate that characterized the country in the early 1990s (NIS (2004)). Contrarily, all the private water utilities started operating quite recently (1997-1998), just after inflation had been drastically reduced and stabilized (the inflation rate at the year of the questionnaire was around 3.3 percent).

[19] Sample monthly mean expenditure per capita: 292.1 US$ (KOC (2003), reports a GDP per capita in 2002 US$ of 297 and UNDP (2002), of 280); sample Gini coefficient: 40.9 (UNDP (2003), reports a GINI coefficient of 40.4, calculated in 1997); sample head-count ratio: 35.2 percent (UNDP (2003) and KOC (2003) reports an head-count of around 36 percent, according to 1997 and 1999 estimates).

distribution.[20] This suggests that some caution about the applied methodology is required, as the missing information might be interpreted as belonging to a part of the population with expenditure levels somewhat above the mean.

The treatment of expenditure as an exogenous measure may also be interpreted as problematic.[21] In order to inform on this issue we conducted a number of Hausman tests for each relevant empirical application. In those cases where a significant test was encountered, predictions were used instead of actual values.

Other Variables

In all model specifications, we control for ‘city effects’ by introducing six city dummies (using the two cities Bantey Manchey and Kandal as the omitted dummy variable). Due to the two-part uniform tariff system and the possibly high level of collinearity, one of our major methodological concerns was the use of the city-dummies together with the price and the fee variables. However, in all the estimated models these dummies generally possess strong explanatory power. A possible explanation for this is that they capture other town-specific characteristics such as population characteristics, life quality, industrialization level, network characteristics, environment, and climate, etc. We presume that the low level of coverage of the service, one of the main constraints to obtaining a connection according to Garn *et al.* (2002), is captured by the city specific fixed -effect control.

Table 3.1 lists and describes the other variables used in our analysis.

[Insert Table 3.1 here]

In some model specifications we allow a number of asset-variables to be present together with household expenditure. Despite the risk of high correlation, we believe that assets may more accurately capture household wealth, beyond the narrow household expenditure definition

[20] The analysis was conducted dividing the observations for those who declared their expenditure by quintile, creating a dummy for each quintile plus an additional “control” dummy containing all the missing values, and running a tobit and a OLS regression with these variables as additional regressors.

[21] The uniform-price system does not present the econometric issue typical of the increasing block rate systems, where the price of water both determines, and is determined by, consumption (Nieswiadomy and Molina (1989)).

(Filmer and Pritchett 2001). The use of wealth measures may be helpful if individuals tend to understate their level of income and expenditure. Thus, all the regressions for all the models were run with and without assets.

3.4 Discussion of Summary Statistics

Selected summary statistics of the sub-sample used for this analysis are as follows:

- each household comprises, on average, about 6.3 members (the standard deviation is 2.6)[22], with no substantial difference between connected and non-connected households. This is slightly higher than the average household size reported by official statistics: 5.7 in urban areas (CNPRD (2004));
- the average age of the respondent is 45 years (10.8);
- on average, there are 1.76 (0.86) people earning money among the non-connected households, versus 2.40 (1.45) among the connected ones ;
- more than 30 percent of the non-connected, and about 18.5 percent of the connected heads of household, have not primary completed school .

The mean household total income is Riels 548,823 (980,489) and the mean total expenditure is Riels 547,511 (985,901), around US$140.[23] However, the difference between connected and non-connected households is quite striking. The average income per capita for the connected households is 123,398 (206,542); for non-connected households it is 64,178 (54,011), which indicates that a large share of the non-connected households are poor.[24] The household expenditure for connected households is 124,676 (210,022); for non-connected households it is

[22] Standard deviations reported in parentheses in the rest of this sub-section.
[23] At the time of the survey and all along 2002, year of the UNDP statistics considered, the exchange rate was about 3900 Riels=1US$.
[24] According to the Ministry of Planning (2002), the 1999 National Poverty Line was around 54,050 Riels per head per month.

58,987 (s.d. 43,496).[25] A comparable difference in household assets between the two sub-samples is detailed in Table 3.2.

[Insert Table 3.2 here]

For the 428 connected households, the average monthly water consumption is about 13.9 cubic meters (10.8) (see Table A1), which translates to about 2.2 monthly cubic meters per capita, or 72 litres per day.[26]

4. Econometric results

4.1 Censored Tobit Estimation and Model Diagnostics

Table 4.1 reports the results for the tobit model using the *price1*. (We verified that the use of *price1* or *price2* does not materially affect the main results). Columns (1), (2) and (3) indicate three different specifications:

(1) with assets, treating (according to the exogenity test) expenditure as exogenous;

(2) without assets, without correcting for the endogeneity of expenditure;

(3) without, assets correcting for the endogeneity of expenditure.

[Insert Table 4.1 here]

In general, the estimated coefficients of the price, expenditure and household-size variables have the expected sign and reasonable magnitudes, and are well determined. Only in specification (3) does the magnitude of the expenditure coefficient seem to be implausibly large, and the estimated coefficient for household size is insignificant. As expected, the coefficient of expenditure in (1) is somewhat lower than in the other specifications. The coefficients for the wealth proxies exhibit the expected sign and, in most of the cases, are statistically significant at a conventional level.

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[25] This pattern is observed also in other parts of Asia (e.g., India - Foster et al. (2003a)) and in other developing countries (e.g., Guinea - Clarke et al. (2002))

[26] Compared to a European average of about 4.5 cubic meters per capita per month (roughly 150 litres per capita per day - EEA (2003)).

Table 4.2 reports price and expenditure elasticities computed by dividing the marginal effects[27] (see A2) by the unconditional expected value of the continuous variable *watcon*, reported as 7.64 at the mean sample values.

[Insert Table 4.2 here]

Ceteris paribus, a 10 percent price increase decreases monthly water consumption by about 3.4 percent, 4.7 percent and 5.6 percent for specifications (1), (2), and (3) respectively.[28, 29] For household expenditure, the results are less clear-cut. For specifications (1) and (2) the elasticity is estimated at 0.56 and 0.80 respectively (0.55 and 0.80 using the log of *price2*). However, the elasticity estimate for specification (3), 1.64, suggests an effect that is well in excess of unity.

However, as shown in the last section of Table 4.1, the tobit model fails all the diagnostics, which casts doubt on both the consistency of the ML coefficients and their sampling variances.[30] The key distributional assumption of the tobit model is violated, and (except for specification (3) the model fails the RESET. In addition, the model fails the tobit specification test based on a Likelihood Ratio Test (LRT) and there is evidence of heteroscedasticity. In the light of the major problems associated with the censored tobit, we obtain estimates using the more flexible generalized tobit model or the Heckman two-step procedure.

4.2 The Probit and the Corrected OLS Regressions

As described in the previous section, the probit model includes – in addition to the variables featured in the tobit model -- a set of identifying instruments. As detailed in Table 4.3, the McFadden Pseudo-R^2 indicates a very good fit for a cross-sectional model,[31] and the goodness

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[27] Marginal effects are evaluated at the means of the independent variables

[28] Using the marginal effects evaluated at the observed censoring rate of the dependent variable the elasticities are only slightly higher (by one percentage point)

[29] Using *price2* (in its logged form) the estimates are statistically insignificant for the corresponding specification (1), but suggest relatively inelastic effects for the other two specifications. See Table A2 for details.

[30] We have already stressed how the presence of heteroskedasticity, in particular, contains more severe consequences for the tobit model than does its presence in a linear regression model.

[31] The Pseudo R^2 is defined as [1-($L^{restricted}/L^{unrestricted}$], where L identifies the maximised value of the Likelihood function.

of fit of the model is also confirmed by the measure suggested by Cramer (1999).[32] The percentage of correct predictions is fairly high (80 percent) but Train's (2003, p.73) reservations on this measure are well founded. The null of exogeneity of expenditure is upheld by the data. The set of identifying instruments is comprised of five (four depending on the specification) variables.[33] The validity of these instruments is tentatively confirmed by the fact that their omission from the levels regression is upheld by the data (see Wald tests, Table 4.4). The variables that perform the task of identifying the selection effect in this case are thus *logfee*, *ethnic*, *age*, *agesq*, *years* and *D_mul*. It is conceded that these are somewhat ad hoc but appear to perform the necessary task.

[Insert Table 4.3 here]

Based on the results presented in Table 4.3, the estimated coefficient for *logfee*, a relevant identifying variable, is well determined, and suggests that, *ceteris paribus*, a 10 percent increase in the one-off connection charge reduces the probability of getting connected by about two percentage points.[34] The estimated coefficient for (log) expenditure, also highly significant, suggests that, *ceteris paribus*, a 10 percent increase in the expenditure level increases the probability of connection by about four percentage points.[35]

The average connection elasticity with respect to the connection fee, computed by dividing the original marginal effects by the sample average connection rate (0.547), is -0.39, while that calculated with respect to expenditure is 0.68 (which appears on the high side). The probit model without assets (not reported), though somewhat inferior in terms of diagnostics,

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[32] Cramer's $\lambda = \left[\overline{\Phi\left(X_i \hat{\beta}\right)} \mid D\_watcon = 1\right] - \left[\overline{\Phi\left(X_i \hat{\beta}\right)} \mid D\_watcon = 0\right]$=0.424. This measure is merely descriptive, and it is not considered a proper statistic with a known distribution (Cramer (1999)).

[33] Correcting for the endogeneity of expenditure, one variable (*ethnic*) no longer performs the task of identification.

[34] Again, given the logarithmic nature of the regressor, we can obtain the effect of a ten percentage change on the connection decision by multiplying the marginal effect by 0.1 (see A3).

[35] It is likely that this last estimate understates this effect, due to collinearity between the expenditure measure and household assets. However, the model with assets outperforms the model without assets and the difference in the implied marginal effect is not too large. For example, without assets a 10 percent increase in the expenditure level would increase the probability of getting connected by about 4.44 percentage points.

gives very similar results, with a connection elasticity with respect to the fee of -0.36 and an expenditure elasticity of about 0.81.[36]

All the estimated coefficients for the assets are plausible except for the *car* estimate. It is worth noting the large coefficient for the variable *telephone*: a household with such an appliance, *ceteris paribus*, is about 33 percentage points more likely to be connected than a household without a telephone. The coefficient on *ethnic* is also notable: non-Khmer people, mostly Chinese, are about 31 percentage points more likely to get connected than Khmer people. The estimated coefficients for the education dummies are poorly determined. The estimated coefficient for *members* is also statistically insignificant (this is in line with the findings of Alaba and Alaba (2002)). The negative sign may tentatively suggest that the greater the number of members, the more possibilities the household has to get water in a number of different ways and from a number of different sources.

The model fails the key econometric assumptions of normality and homoscedasticity but the RESET value is marginal and could be viewed as less of a concern. As a consequence, the estimated variance-covariance matrix is adjusted using Huber's (1967) correction. Greene (2000, pp.823-4) notes, however, that such a correction to the variance-covariance matrix for an otherwise inconsistent estimator may be insufficient to redeem it. Nevertheless, the adjusted asymptotic *t*-values do not deviate much from the original ones and do not alter materially the statistical significance of the estimated coefficients.

This model provides us with some degree of confidence about the factors that influence connection, and those that represent the main obstacles to connection. However, the marginal nature of the normality test suggests some caution about the construction of the selectivity correction term. For this reason, higher orders (to the third power) of the inverse Mills are added as additional regressors in the second stage of the procedure, to proxy for selection effects.

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[36] Though, in this second case the model would have to be corrected for the endogeneity of expenditure, altering the elasticity point estimates to -0.45 and 1.45 respectively.

Surprisingly, the null hypothesis that the connected sample of households is random is upheld by the data at a conventional level in the water demand equation. Furthermore, a joint Wald test on the three additional components of the Mills reveals that they exert no role in the regression model (see Table 4.4).[37] In the light of these results, the selection terms are omitted in the final specifications reported in Table 4.4, and the reported estimates are based on the standard OLS procedure. (For brevity, we present the results of the OLS regression without assets. It should be noted, however, that the inclusion the assets in the various specifications does not alter the estimated magnitude of the price elasticity of demand, a primary focus of our policy interest.)

Table 4.4 presents the results for four specifications: [38]

(1) OLS with *price1* (logged), treating expenditure as exogenous;

(2) OLS with *price1* (logged), correcting for the endogeneity of expenditure;

(3) OLS with *price2* (logged), treating expenditure as exogenous;

(4) OLS with *price2* (logged), correcting for the endogeneity of expenditure.

[Insert Table 4.4 here]

The overall explanatory power in all the cases is more than adequate and is somewhat higher than OLS-based models that have used cross-sectional micro-data in this type of application (see Strand and Walker (2004), Bachran and Vaughan (1994), Jones and Morris (1984)). Since all the models exhibit heteroskedasticity, the variance-covariance matrix was corrected with the Huber robust estimator (Huber (1967)). However, as in the case of the probit model, the statistical significance of the estimated coefficients is affected only marginally by the modification. All the specifications perform well in terms of normality, which allows us to have some confidence in the testing principle adopted. In contrast, the RESET provides some

[37] Since the presence of heteroskedasticity violates the use of a conventional F-test (which assumes a constant variance), a Wald test (that uses the corrected variance covariance matrix) was performed instead.

[38] As noted earlier, there is an issue about whether the inclusion of the city effects in conjunction with the logged price variables allows for a clean identification of the price effect. This is a more accute issue in regard to price1 than price2. All the models for which estimates are reported in table 4.4 were re-estimated without the city controls. The estimated price effects are only marginally attenuated by the exclusion of these controls. Our preference is to include the city controls to capture omitted city-specific factors that may be important in the determination of water demand.

conflicting results. Although the RESET is passed for those models that use actual household expenditure (though only at 95 percent and 90 percent confidence level), the test is not passed for the models that use the predicted values. Some degree of caution is thus warranted when drawing conclusions as our estimates may be subject to some bias.

In spite of the foregoing concerns, many of the results appear to be highly robust across all the specifications. In particular, as shown in Table 4.5, the price elasticity, always significant, displays the most robust behaviour ranging in the interval -0.5 to –0.4. These plausible estimates are in line with the estimated price elasticity of demand obtained using tobit (as reported in the previous section) and OLS models (not reported) with the set of assets. By contrast, the expenditure elasticity, also highly significant, ranges from around 0.2 in specifications that use actual expenditures, to around 0.7 in specifications that used the predicted values. In specifications (2) and (4), the estimated coefficients for other variables appear to be affected by the endogenous treatment of expenditure. However, caution is again required in interpreting these estimates, since the specifications do not pass the Ramsey RESET.

[Insert Table 4.5 here]

Other results of this model richly portray the nature of water demand among connected households in Cambodia. The estimated coefficient for the variable *quality*, significant at the 10 percent level for two of the specifications, confirms the positive relationship between perceived water quality and consumption. The coefficient for the variable *trade* is always highly significant, and suggests, *ceteris paribus*, that households engaged in trade consume around 85 percent more than those who do not engage in trade of one kind or another.[39] This result appears robust across all the reported specifications. Using water for gardening or for animals does not influence the level of household water consumption. In addition, sharing the connection does not affect consumption. Thus, one of the arguments presented by Whittington and Boland (2002b)

[39] The effect is calculated using the formula: $[e^{0.6203}-1]x100=85.9$, where *e* represents the anti-logarithm of the natural logarithm. This procedure is used when the dependent variable is expressed in natural logarithm and the explanatory variable is a dummy measure.

against the IBTs system, by which the households that share a connection consume and pay more, does not appear to have relevance in this application.[40] The presence within a household of one additional member, *ceteris paribus*, increases monthly water consumption by between two percent (specifications (2) and (4)) and six percent (specifications (1) and (3)), which is in line with the estimated marginal effects reported in the tobit.[41] The household-size elasticity ranges from 0.14 (specifications (2) and (4)) to 0.36 (specifications (1) and (3)). The range in these estimates is comparable to ones found in other studies (see Razafindralambo *et al.* (2002); Strand and Walker (2004); Rietveld *et al.* (1997)). The estimated coefficient for the variable *education* is statistically insignificant in most of the specifications, despite the fact that, on average, non-connected households have lower levels of education than connected households (see summary statistics). This may suggest that education effects in regard to water consumption are mediated through the expenditure measure.

4.3 The Welfare Analysis

In the light of the significant and highly robust results obtained for the price elasticity, we are in a position to calculate, with a certain degree of confidence, the welfare effects of water access and use, exploiting the concept of a change in Marshallian consumers' surplus. Following the approach of Strand and Walker (2003), we present the main results in Table 4.6, reporting the estimates for our lower bound elasticity estimate (η=0.4). (In table A4 results based on η=0.5 are also reported, together with those obtained using the income rather than the expenditure variable.)

The first two columns give average household real-expenditure figures, by town, for connected and non-connected households (in Riels). Since the connected households already benefit from the welfare gain, their real-expenditure (RE) includes the computed net consumer

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[40] Further, according to the summary statistics in the Cambodian case this type of households does not necessarily belong to the low-income group, which makes the Whittington critique not applicable

[41] According to the censored tobit, the percentage would range from around 2.6 percent (if computed on the average consumption for those who consume) to around 4.5 percent (if computed on the unconditional expected value of water consumption at the mean sample values).

surplus. The third column indicates the change in *CS*, and the fourth column gives the expenditure figures when all currently non-connected households are provided with the water connection.

[Insert Table 4.6 here]

The last two columns of Table 4.6 report the ratios, by town, of real-expenditure of non-connected households to real-expenditure of connected households. On average and across the eight towns, the change from 0.45 to 0.53 in the ratio clearly indicates the potential gains of providing the service to all.

Our results are not directly comparable to those reported in Strand and Walker (2003) due to differences in the context and to the different price elasticity of demand used. However, in relative terms, the change in percentages can provide some insights. The change in the ratio for Strand and Walker (2003) is, on average across the cities and using their elasticity estimate of 0.3, about 13 percentage points, in our case the same ratio using an absolute elasticity of 0.4 induces a change of about eight percentage points (seven using η=0.5). Considering that the ratio *P(0)/P(i)* in our case is, on average, around 7.5, while in Strand and Walker it assumes far higher values (over 20), and given the higher elasticity, our results can be considered plausible. On average and across the towns, a non-connected household would experience a change in welfare of about 56,000 Riels -- representing roughly 17 percent of its actual monthly household expenditure (the percentage would be 15 percent using a price elasticity estimate of 0.5).

Table 4.7 reports the change in the Gini that would be obtained if one tentatively added the welfare gains of the connection to the expenditure/income of the non-connected households.[42]

[Insert Table 4.7 here]

[42] Again, the use of *price1* or *price2* does not affect the main results

It is clear that the estimated Gini coefficient would decrease by between 2.5 to 3.5 percentage points. This is not an inconsequential effect, considering that currently the Cambodian Gini coefficient is among the highest within the set of Asian countries (KOC (2001, 2003)).

Our welfare analysis also reveals that, using an elasticity estimate of 0.4, providing connection to all would decrease the poverty head-count ratio by about 6.8 percentage points; using the higher absolute elasticity of 0.5, this would decrease by about 5.4 percentage points. Using the income variable, the corresponding changes would be 4.5 and 3.8 percentage points respectively.[43] The interpretation of these large changes merits some caution since this poverty measure is clearly biased in favour of individuals placed close to the poverty line. Furthermore, the poverty line itself, upon which the head-count is calculated, does not take into account differences between rural and urban areas.

It could be argued that use of the city fixed-effects in the process of obtaining the price elasticity of demand does not capture adequately the differences between the private and the public sector in the effect of the variables on households' water consumption. Unfortunately, the limited variation in the price data across the two service provider types does not allow us to conduct a deeper analysis of this issue. However, as a suggestive exercise, in the water consumption OLS regressions we substituted a dummy assuming a value 1 if public-supplier and a value of 0 if a private-supplier. Our analysis suggests that households supplied by private utilities may be more price-sensitive. Thus, for the four areas supplied by the private sector, in light of the higher price elasticity, the welfare analysis may need to be adjusted downwards. Further investigation of this potentially important issue is clearly required; given data limitations, we are not able to pursue it to rigorously here.

[43] The calculations are based on the 1999 National Poverty Line reported in the summary statistics (Ministry of Planning (2002))

5. Concluding Remarks and Policy Implications

The micro-level analysis reported for seven provincial Cambodian towns addressed three main questions. First, what are the main barriers for the poor to get connected to the water distribution network? Second, how does consumption of the existing consumers change with price? Third, what are the welfare consequences of pursuing a policy that provides water to all households?

A censored tobit and a Heckman two-step procedure were used to address these questions. In line with Garn *et al.* (2002), key results from the first stage estimation confirm that the main barrier for the poor seems to be the one-off initial cost, where the connection fee elasticity was estimated at about -0.39. The second stage analysis provided significant and robust price elasticity estimates ranging between -0.4 and -0.5. These estimates are in line with other empirical studies that using data from developing countries. The expenditure elasticity estimates, however, were more variable across the estimated models and provided estimates in the range between 0.2 and 0.7.

Using the price elasticity estimate and exploiting the concept of Marshallian consumers' surplus, the possible welfare gains achievable through providing water connection to set of currently non-connected households were highlighted. On average and across the towns, using the estimated price elasticity of -0.4, the ratio of household expenditure of the non-connected households to the household expenditure of connected households would increase from 0.45 to 0.53. This perhaps understates the true welfare benefits, as such connections would also generate 'spillover' effects through unmeasured positive externalities on health. (It is stressed, however, that our study did not provide a framework for exploring this latter issue.) In addition, there would also be effects on household expenditure (income) distribution. Our analysis suggests that the welfare changes would induce the Gini coefficient to decrease by about three percentage points. The poverty head-count ratio is also estimated to decrease by about six percentage points. As noted, the results from the welfare analysis have to be treated with some degree of caution for a number of reasons, ranging from assumptions used in the specification and estimation of our demand equation (*e.g.*, the construction of the price and the fee variable, our treatment of missing values on expenditure) to the ones invoked for the welfare analysis (*e.g.*, the vendors' price is assumed to be the only alternative, and the fact that the measure captures a WTA rather than a WTP concept). However, the general robustness of the earlier results in regard to the price elasticity of demand allows us to draw some tentative policy conclusions.

The case of connection subsidies

As stressed earlier, one of the main obstacles for the non-connected households is the one-off initial cost of the connection fee. The large benefits that would occur connecting the poor would amount, on average, to roughly 17 percent of their actual expenditure (16 percent for income), which represents a sizeable gain , bearing in mind that international benchmarks suggest that water bills amounting to between 3 percent and 5 percent of income are most affordable for the poorest households (Foster *et al.* (2000)). In the light of this result, it is reasonable to infer that -- once they are connected -- the poor may be able to pay a non-subsidised tariff equal to the general tariff.[44]

This suggests a clear policy option: a connection (rather than a consumption) subsidy scheme. This may represent an important step in the process of providing water to all households, including the poorest households. In the Cambodian case, as in other developing countries, the fact that the non-connected households exhibit an expenditure which, on average, is half that of the connected would make targeting connection subsidies relatively easy to implement.[45] Furthermore, targeted connection subsidies appear to exhibit leakage rates and

[44] Once connected, as many case studies show, the willingness to pay for water and sanitation services of the poor is often higher than the actual operating and maintenance (O&M) costs and higher than actual tariff per unit (Foster et al. (2000) for Panama; Walker et al. (2000) for South American cities; Ahmad et al. (2003) for Bangladesh; Brocklehurst and Evans (2001)).

[45] Other alternatives based on geographic targeting are ruled out by the Cambodian context: in the provincial towns the poor communities do not live together, being they scattered all over the town (DeRaet and Subbarao (1999))

errors of inclusion that are less than one quarter of the ones associated with the application of consumption subsidies (Foster *et al.* (2003b)). Most of all, errors of exclusion, a great concern from a poverty reduction perspective (as they identify the people genuinely poor that do not receive the subsidy (Cornia and Stewart (1983)), would be much lower.

The official targeting criterion could be the connection itself, together with certain household characteristics, so as to reduce the incentive effect and further leakages. Moreover, since the subsidies would represent a one-off capital payment, administrative costs could be kept relatively low (Estache *et al.* (2002)).

Despite these apparent advantages, if a connection subsidy scheme was approved, the main obstacle for the government would be the lack of adequate resources. On the one hand, the public sector cannot expect the private operators to use their own revenues but on the other hand, the public sector generally lacks the resources to do so. Besides, an external regulator cannot compel a company to provide new connections at lower costs without compensation (Abdala (1996)).

In the past, Cambodia has based its revenue collection on international trade taxes (in 1997, they represented 58 percent of total tax revenue - Lao-Araya (2003)). However, Cambodian membership of ASEAN and its adoption of the Common Effective Preferential Tariff (CEPT) scheme, which requires the reduction of tariff rates among the members, are both likely to lead to a reduction in total tax revenues, certainly in the short-term. This may be problematic for Cambodia, where the tax base is quite restricted, with few taxpayers in the formal sector who have either high taxable income or consumption, and where the share of direct taxes is very low (in 1999 it was only 6.3 percent of total revenues as compared to 33 percent of indirect and trade taxes), much lower than in Vietnam or Thailand (20 percent and 30 percent respectively – ADB (2000)). Though, in the light of the current situation in regard to poverty, Cambodia is not in a position to reduce its social expenditures. In fact, the country has already initiated important reforms of its tax system in regard to the expansion of the tax base, the development of robust tax auditing procedures and the introduction of stronger tax administration institutions.

In the light of these reforms and in the context of Cambodia's recent strong economic performance, the government has managed to increase expenditures on socioeconomic development enhancing fiscal revenues (which increased from 8 percent of GDP in 1998 to 12 percent in 2001), attracting more foreign financing for public investments and reducing expenditures on defence and security (CDC, CRDB (2002)). However, the level of spending on economic services is still regarded as inadequate to achieve poverty reduction objectives (see Naron (2002), Deputy Secretary General, Ministry of Economy and Finance) and this raises the obvious question as to where additional resources for the development of the water distribution system would come from.

From 1995 to 2002 the total funding in health by the government increased threefold, with important achievements in this sector. However, data show that the incidence of benefits is skewed away from the poor and toward the middle and wealthy groups, with certain areas left behind (Naron (2002)) and with maternal and child health neglected (IFAPER (2003)). Thus, a possible solution may be found in the nature of water as a merit good and in terms of both the welfare gains outlined and the wide-reaching positive externalities of safe water on health, a better management of the existing resources aimed at the provision of safe water targeted to the poorest may lead to broader social benefits.

Concluding, it must be borne in mind that the connection subsidy itself is not to be considered as a one-off solution to the water problem, even though it could represent a first step to serve the poor. The literature identifies other factors that ought to be considered to facilitate improvements to the service:[46]

- the introduction of private operators in the Cambodian environment may represent a good stimulus for the government and MIME. However, regulation of utilities should be seen as a priority, both for private and public sector operators, so as to promote accountability and a basis for competition among them (DeRaet and Subbarao (1999)).[47] The presence of a regulator should also reduce information asymmetries and protect the consumers from the exercise of monopoly power. However, it is also important to ensure that the regulator itself is eager to address the special needs of the poor. For this to happen, a clear policy environment in which to function is a *sine qua non*;[48]
- over the next years it will be important to see if the government will be able to reduce inefficiencies, giving more autonomy and decentralizing the public utilities[49] and giving autonomy to the regulator. Also the contract between the government and the private sector requires re-thinking. Besides introducing a clearer and more transparent licensing procedures, the relationship should allow for a greater degree of flexibility within a clear (binding) mandate to serve the poor;
- in this sense, it would be important to allow also a certain degree of flexibility in service provision, considering alternative solutions, from the material used (varying diameter pipes according to the location) to the payment modalities (at the time of the survey some of the utilities had already started allowing a small percentage of households to pay in instalments (e.g., Kompong Chhnang, Bantey Meanchey, Kompong Speu));

[46] A number of these policy recommendations do not draw on the empirical analysis undertaken.
[47] Clarke et al. (2003), hypothesise that benchmark-competition may encourage public utilities to improve their own performance.
[48] "*It is not the role of the regulator to set policy but to ensure that it is implemented*". Brocklehurst and Evans (2001), p.10.
[49] The Provincial Management Law PBML of February 1998 devolves water supply to provinces and municipalities.

The results reported in this study can be considered as a first necessary step to understand the demand-side relationship that underlies the Cambodian water sector. However, it is acknowledged that future analysis should be undertaken to capture other important factors. In particular, in order to assess precisely the need and the amount of a subsidy, the cost of the service should be directly compared with some measure of household willingness to pay (Foster *et al.* (2000)), taking into account the fee-elasticity. Furthermore, an accurate analysis of the performances and of the level of coverage of the private and public sectors and the attitudes of the households towards them ought to be conducted. The rather superficial and tentative analysis undertaken here supports the notion that households supplied by private utilities appear more price-sensitive implying lower welfare effects. In the light of these results, in cities supplied by private operators the "additional factors" listed above become even more important, confirming the need to capture those elements that can form the basis for future mutual improvements for the two sectors and for the system as a whole.

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Table 3.1: Description of Variables

Name	Description
watcon	Amount of water consumed monthly in cubic meters.[50] The variable was constructed dividing the amount of the last monthly water bill by the unit tariff charged by the water utility (Riels/m^3)
D_watcon	Dummy=1 if the household (h/h) is connected, zero otherwise
D_kspeu	Dummy=1 if town= Kampong Speu, zero otherwise
D_bmchy	Dummy=1 if town= Bantey Meanchey, zero otherwise
D_tak	Dummy=1 if town= Takeo, zero otherwise
D_kandtak	Dummy=1 if town= Kandal (Takmao), zero otherwise
D_btbg	Dummy=1 if town= Battambang, zero otherwise
D_kchng	Dummy=1 if town= Kampong Chhang, zero otherwise
D_srieng	Dummy=1 if town= Svay Rieng, zero otherwise
D_kankie	Dummy=1 if town= (Kandal) Kien Svay, zero otherwise
logprice1	The log of the official price reported by the water utilities
logprice2	The log of the official price reported by the water utilities, considering the presence of subcontractors for those households supplied by a subcontractor
logexp	The log of total household expenditure
logfee	The log of the one-off cost the h/h needs to pay to get connected to the network
television	Dummy=1 if the h/h owns a colour television, zero otherwise
telephone	Dummy=1 if the h/h owns a telephone, zero otherwise
motorcycle	Dummy=1 if the h/h owns a motorcycle, zero otherwise
car	Dummy=1 if the h/h owns a car, zero otherwise
fridge	Dummy=1 if the h/h owns a refrigerator, zero otherwise
rental	Dummy=1 if the h/h owns a rented property, zero otherwise
electricity	Dummy=1 if the h/h has electricity, zero otherwise
members	How many people live in the h/h
edu1	Dummy=1 if the head of the h/h has no education, zero otherwise
edu2	Dummy=1 if the head of the h/h has Pagoda school, zero otherwise
edu3	Dummy=1 if the head of the h/h has primary school (incomplete or complete), zero otherwise
edu4	Dummy=1 if the head of the h/h has secondary school (incomplete or complete), zero otherwise
edu5	Dummy=1 if the head of the h/h has high school (incomplete or complete), zero otherwise
edu6	Dummy=1 if the head of the h/h has vocational college or other type of school, zero otherwise
edu7	Dummy=1 if the head of the h/h has university, zero otherwise
ethnic	Dummy=1 if the head of the h/h belongs to non Khmer ethnic groups, zero otherwise
age	Age of the head of the h/h
agesq	Squared age of the head of the h/h
years	How long has the h/h lived on that house. The variable was used (also) with splines, with the knots places at 1, 4, 19, 19
D_mul	Variable constructed dividing the number of people earning income by the number of members of the h/h. Dummy=1 if > than the threshold value 0.3077, zero otherwise
quality$f$	Dummy=1 if the respondent is very satisfied or satisfied with the quality of the water supplied, zero otherwise
reliability$f$	Dummy=1 if respondent believes the piped water supply to be very reliable or reliable, zero otherwise

[50] Conversion units: 1000 L=1 cubic meter

gardening*f*	Dummy=1 if the h/h uses piped water for gardening, zero otherwise
animals*f*	Dummy=1 if the h/h uses piped water for animals, zero otherwise
washing*f*	Dummy= if the h/h uses pied water for washing and bathing, 0 otherwise
trade*f*	Dummy=1 if the h/h uses piped water for commercial purposes, zero otherwise
share*f*	Dummy=1 if the h/h shares the water connection with its neighbours, zero otherwise
clear1*f*	Dummy=1 if the piped water is clear, 0 otherwise
clear2*f*	Dummy=1 if the piped water is not clear, 0 otherwise
clear3*f*	Dummy=1 if the piped water is clear depending on the season, 0 otherwise

Notes: *f* denotes variables, only available for those households who consume connected water, used in the second stage of the Heckman two-step procedure.

Table 3.2: Asset Ownership in Cambodian Households

Asset	Percentage of households that own the asset	
	Non-connected	Connected
Television	62.2	90.2
Telephone	2.8	27.6
Motorcycle	61.6	86.2
Car	8.8	17.1
Refrigerator	0.6	6.8

Table 4.1: Household Water Consumption Model

Tobit model			
Variable	**Estimated coefficients**[a]		
	(1)	**(2)**	**(3)**
logprice1	-4.81**	-6.71***	-7.95***
	(-2.01)	(-2.71)	(-3.24)
D_kspeu	7.95***	8.87***	17.09***
	(3.07)	(3.33)	(5.85)
D_tak	3.91	5.54*	9.12***
	(1.42)	(1.95)	(3.18)
D_btbg	7.87***	9.21***	8.47***
	(3.53)	(3.95)	(3.67)
D_kchng	-0.54	-0.82	0.86
	(-0.27)	(-0.39)	(0.42)
D_srieng	0.71	0.30	3.41*
	(0.37)	(0.15)	(1.65)
D_kankie	0.82	2.40	5.21**
	(0.35)	(0.99)	(2.15)
logexp	7.94***	11.42***	23.41***
	(8.35)	(12.21)	(12.09)
television	4.79***	τ	τ
	(2.82)		
telephone	8.34***	τ	τ
	(5.74)		
motorcycle	3.11**	τ	τ
	(2.07)		
car	0.65	τ	τ
	(0.41)		
rental	5.75**	τ	τ
	(2.42)		
electricity	5.68*	τ	τ
	(1.68)		
members	0.56***	0.72***	-0.22
	(2.63)	(3.19)	(-0.86)
edu2	3.20	5.38	3.63
	(0.94)	(1.51)	(1.03)
edu3	-5.49**	-4.22*	-5.69**
	(-2.53)	(-1.87)	(-2.52)
edu4	-2.36	-0.71	-1.71\
	(-1.25)	(-0.36)	(-0.87)
edu5	-2.23	0.45	-1.63
	(-1.1)	(0.21)	(-0.77)
edu6	-2.32	1.73	-2.14
	(-0.73)	(0.53)	(-0.65)
edu7	-1.49	2.73	-1.80
	(-0.49)	(0.87)	(-0.56)
ethnic	3.33*	5.01**	2.40
	(1.67)	(2.38)	(1.14)
age	0.71**	0.68**	0.36
	(2.17)	(1.97)	(1.05)
agesq	-0.01**	-0.01*	-0.00
	(-2.12)	(-1.86)	(-0.83)
yearsa	-2.37	-1.02	-6.27
	(-0.35)	(-0.14)	(-0.88)
yearsb	-0.40	-0.48	0.50
	(-0.4)	(-0.45)	(0.48)
yearsc	-0.23	-0.26	-0.36
	(-0.63)	(-0.66)	(-0.94)
yearsd	0.43*	0.40*	0.55**
	(1.9)	(1.7)	(2.32)
yearse	-3.33***	-3.64***	-3.37***
	(-2.93)	(-3.06)	(-2.78)
D_mul	7.13***	7.67***	5.66***
	(6.06)	(6.21)	(4.58)

_cons	-101.0*** (-4.75)	-123.8*** (-5.55)	-254.6*** (-8.8)
Number of obs = 782			
LRT[b] χ^2_{30}	401.1*** (0.0000)	*n/a*	*n/a*
LRT[b] χ^2_{24}	*n/a*	323.3*** (0.0000)	316.5*** (0.0000)
Pseudo R^2	0.097	0.078	0.076
Log likelihood	-1876.7	-1915.7	-1919.1
Tests on the Model[b]			
RESET χ^2_{3}	11.04*** (0.015)	21.26*** (0.000)	7.73* (0.052)
Normality χ^2_{2}	31.18*** (0.008)	16.58*** (0.000)	29.93*** (0.000)
Homoskedasticity χ^2_{30}	70.15*** (0.000)	*n/a*	*n/a*
Homoskedasticity χ^2_{24}	*n/a*	73.37*** (0.000)	49.57** (0.0137)
Specification χ^2_{31}	122.7*** (0.000)	*n/a*	*n/a*
Specification χ^2_{25}	*n/a*	120.5*** (0.000)	91.40*** (0.000)
Exogeneity F(1, 751)	0.95 (0.3290)	*n/a*	*n/a*
Exogeneity F(1, 757)	*n/a*	63.22*** (0.0000)	Corrected

Notes: *a:* *t*-values in parentheses; *b*: *p*-values in parentheses;
*** significance at 1%; ** significance at 5% ; * significance at 10%;
τ variable omitted in the estimation; *n/a*: not applicable

Table 4.2: Price and Expenditure Elasticities using *Price1* – Tobit Model

Specification	**Price Elasticity**	**95% Conf. Interval**	**Expenditure Elasticity**	**95% Conf. Interval**
1	-0.337	[-0.672 / -0.001]	0.556	[0.423 / 0.690]
2	-0.468	[-0.813 / -0.123]	0.796	[0.666 / 0.926]
3	-0.558	[-0.903 / -0.213]	1.64	[1.372 / 1.915]

Table 4.3: Household Water Connection Model

Variable	Probit Model Estimated Coefficients[a]
Logfee	-.544*** (-3.75)
D_kspeu	.654*** (2.6)
D_tak	.223 (1.12)
D_btbg	.563** (2.33)
D_kchng	-.039 (-0.18)
D_srieng	-.221 (-0.79)
D_kankie	-.363* (-1.91)
Logexp	.963*** (7.34)
Television	.426*** (2.59)
Telephone	.989*** (4.69)
Motorcycle	.366** (2.57)
Car	-.341* (-1.79)
Fridge	.771* (1.66)
Electricity	.477 (1.42)
Members	-.008 (-0.31)
edu2	-.007 (-0.02)
edu3	-.495** (-2.16)
edu4	-.229 (-1.1)
edu5	-.144 (-0.65)
edu6	-.671* (-1.86)
edu7	-.125 (-0.31)
Ethnic	.982*** (3.40)
age	.097*** (3.04)
Agesq	-.00093*** (-2.79)
Years	-.014* (-1.7)
D_mul	.583*** (4.95)
_cons	-9.16*** (-3.56)

Number of obs = 782
Wald χ^2_{26} = 223.31
Pseudo R^2 = 0.3665
Log pseudo-likelihood = -341.15188

Tests on the Model[b]	
RESET	6.339*
χ^2_3	(0.0962)
Normality	6.243**
χ^2_2	(0.0440)
Homoskedasticity	94.683***
χ^2_{26}	(0.000)
Exogeneity	0.12
χ^2_1	(0.7317)

Notes: a:(asymptotic) *t*- values in parentheses; *b*: *p*-values in parentheses; ***significance at 1% ; **significance at 5%; *significance at 10%

Table 4.4: Household Water Consumption Model

OLS Model				
Variable	**Estimated coefficients**[a]			
	(1)	**(2)**	**(3)**	**(4)**
logprice1 / logprice2	-0.407***	-0.470***	-0.523***	-0.522***
	(-3.66)	(-3.96)	(-4.86)	(-4.62)
quality	0.205*	0.165	0.198*	0.160
	(1.88)	(1.61)	(1.83)	(1.56)
reliability	0.121	0.133	0.128	0.141
	(1.21)	(1.43)	(1.3)	(1.53)
share	0.090	0.171	0.090	0.166
	(0.62)	(1.22)	(0.62)	(1.18)
gardening	-0.066	-0.094	-0.055	-0.080
	(-0.62)	(-0.93)	(-0.53)	(-0.81)
animals	-0.113	-0.085	-0.094	-0.068
	(-1.47)	(-1.15)	(-1.25)	(-0.92)
trade	0.635***	0.604***	0.620***	0.592***
	(5.6)	(5.01)	(5.39)	(4.88)
clear1	0.070	0.067	0.084	0.076
	(0.75)	(0.77)	(0.91)	(0.88)
clear3	-0.064	-0.09	-0.038	-0.065
	(-0.4)	(-0.61)	(-0.24)	(-0.44)
washing	1.127***	1.209***	1.125***	1.205***
	(4.17)	(4.42)	(4.12)	(4.41)
D_kspeu	-0.246	0.140	-0.205	0.121
	(-1.32)	(0.73)	(-1.13)	(0.66)
D_tak	-0.207	-0.049	-0.146	-0.044
	(-1.27)	(-0.28)	(-0.91)	(-0.27)
D_btbg	0.140	0.125	0.227*	0.176
	(1.06)	(0.93)	(1.67)	(1.3)
D_kchng	-0.330***	-0.193*	-0.330***	-0.214*
	(-2.84)	(-1.69)	(-2.88)	(-1.92)
D_srieng	-0.141*	0.004	-0.207**	-0.053
	(-1.69)	(0.05)	(-2.48)	(-0.62)
D_kankie	0.261**	0.412***	0.295***	0.404***
	(2.45)	(3.46)	(2.94)	(3.66)
logexp	0.191***	0.731***	0.189***	0.705***
	(3.44)	(6.92)	(3.42)	(6.81)
members	0.058***	0.022*	0.056***	0.022*
	(5.41)	(1.83)	(5.28)	(1.84)
ethnic	τ	-0.210**	τ	-0.206*
		(-1.97)		(-1.95)
edu2	0.103	0.059	0.079	0.051
	(0.73)	(0.39)	(0.56)	(0.33)
edu3	-0.103	-0.184	-0.116	-0.193*
	(-0.89)	(-1.55)	(-1.01)	(-1.65)
edu4	-0.098	-0.163*	-0.099	-0.160*
	(-1.06)	(-1.73)	(-1.08)	(-1.69)
edu5	-0.043	-0.173*	-0.0510	-0.174*
	(-0.46)	(-1.79)	(-0.55)	(-1.8)
edu6	0.146	-0.061	0.115	-0.080
	(0.65)	(-0.29)	(0.52)	(-0.38)
edu7	0.198	-0.044	0.169	-0.061
	(1.38)	(-0.31)	(1.19)	(-0.43)
cons	0.935	-5.482***	1.776	-4.750***
	(0.93)	(-3.92)	(1.74)	(-3.31)
R^2	0.374	0.431	0.383	0.436
Tests on the Model[b]				
Reset	2.59*	*n/a*	3.41**	*n/a*
F(3,400)	(0.0524)		(0.0175)	
Reset	*n/a*	6.49***	*n/a*	7.23***
F(3, 399)		(0.0003)		(0.0001)
Normality	4.23	2.34	4.53	2.62
	(0.120)	(0.311)	(0.104)	(0.270)

adj χ^2_2				
Homoskedasticity	Corrected	Corrected	Corrected	Corrected
Wald Test on the correction term	1.56	*n/a*	1.53	*n/a*
F(3, 398)[51]	(0.1985)		(0.2051)	
Wald Test on the correction term	*n/a*	0.73	*n/a*	0.85
F(3,397)		(0.5346)		(0.4671)
Wald Test on the instruments	0.90	*n/a*	0.76	*n/a*
F(6,397)	(0.4935)		(0.6009)	
Wald Test on the instruments	*n/a*	0.23	*n/a*	0.11
F(5,397)		(0.951)		(0.990)
Exogeneity	31.16***	Corrected	29.58***	Corrected
F(1,402)	(0.0000)		(0.0000)	

Notes: a: t-values in parentheses; *b*: *p*-values in parentheses; ***significance at 1% ; **significance at 5%; *significance at 10%; τ variable omitted in the estimation; *n/a* not applicable

Table 4.5: Price and Expenditure Elasticities – OLS Estimates

Specification	Price Elasticity	95% Conf. Interval	Expenditure Elasticity	95% Conf. Interval
(1)	-0.407	[-0.625 / -0.188]	0.191	[0.082 / 0.300]
(2)	-0.470	[-0.702 / -0.236]	0.732	[0.524 / 0.940]
(3)	-0.523	[-0.735 / -0.312]	0.190	[0.080 / 0.300]
(4)	-0.522	[-0.744 / -0.300]	0.704	[0.501 / 0.908]

Table 4.6: Estimated Welfare Effects of Water Connection

Town	(1) Real expenditure (connected households)	(2) Real expenditure (unconnected households)	(3) Change in consumer surplus (i)	(4) Real expenditure (unconnected households) with service provided to all	(5) Ratio: unconnected/ connected	(6) Ratio: unconnected/ connected, with service provided to all
***η* =0.4**						
B. Meanchey	1,147,265	428,201	73,648	501,848	0.373	0.437
K. Speau	391,768	207,751	40,413	248,163	0.530	0.633
Takeo	1,054,341	290,732	50,690	341,421	0.276	0.324
Kandal	711,918	367,918	76,800	444,718	.517	.625
	(713,222)		(78,104)	(446,023)	(.516)	(.625)
Battambang	820,698	368,357	82,548	450,905	.449	.549
	(821,122)		(82,971)	(451,329)	(.449)	(.550)
K. Chhang	915,290	305,349	34,146	339,495	0.334	0.371
S. Rieng	555,067	341,739	17,445	359,184	0.616	0.647
K. Svay	701,749	351,001	77,187	428,188	0.500	0.610

Notes: The first four columns are in Riels: the last two are ratios. The variable *logprice1* was used throughout to be consistent with the previous analyses. However, for Kandal and Battambang, the only two towns with subcontractors, the results using *logprice2* are reported in parenthesis

[51] The test reported is based on a Wald test, that uses the corrected variance covariance matrix, converted automatically to an F-test by STATA. This conversion is valid when the degrees of freedom of the denominator are large.

Table 4.7: Welfare Effect of Connection on the Gini Coefficient

Variable	Gini	Gini providing connection	Change
η=**0.4**			
Expenditure	0.409	0.380	0.029
Exppos	0.439	0.407	0.032
Income	0.403	0.375	0.028
Incpos	0.470	0.435	0.035
η=**0.5**			
Expenditure	0.409	0.383	0.027
Exppos	0.439	0.410	0.029
Income	0.403	0.378	0.025
Incpos	0.470	0.439	0.031

APPENDIX

A1 - SELECTED PRODUCTION AND FINANCIAL CHARACTERISTICS OF THE WATER UTILITIES

	PUBLIC UTILITIES				*PRIVATE UTILITIES*			
	Battambang	**Kampong Chhang**	**Kandal**	**Svay Rieng**	**Bantey Meanchey**	**Kampong Speau**	**Kien Svay**	**Takeo**
Population of town	139,964	41,703	58,264	21,205	98,848	41,478	-	39,186
Number of h/h[52]	25,584	7,692	10,266	4,112	18,374	7,552	-	7,257
Year establishment in current form	1993	1996	1979	1980	1998	1997	1998	1997
Current Production capacity (m^3/day)	3750	960	780	400	3000	1500	1632	1300
Current production (m^3/day)	2750	200	780	320	1200	560	176	120
Capacity utilized (%)	73.33	20.83	100	80	40	37.33	10.78	9.23
Tot. number of direct connection	1766	409	580	393	1500	1700	230	450
Residential	1618	406	561	375	1423	1510	229	N/A
Business	78	N/A	5	N/A	50	180	N/A	N/A
Government	70	2	14	18	25	10	1	13
% of h/h covered	6.33	5.28	5.47	9.13	7.74	19.93	-	6.21
N. of sub-contractors to utility	4	0	3	0	0	0	0	0
N. of connections served by sub-contractors	2046	0	239	0	0	0	0	0
Connection fee as declared by the utility (Riels)	200,000	190,000	136,500-390,000	5,000-35,000 + materials	350,000	76,000	190,000	228,000
Average one-off connection cost as declared by the h/h (Riels)	175,222.5	182,720	357,487	108,204.4	384,708.3	182,384.1	195,957.5	233,446.8
Water tariff (Riels/m^3)	1400	1000	550	600	1300	1500	1400	1800
Average price of vendor in town[53]	10,000	6,000	10,000	2,500	10,000	7,500	10,000	7,500

[52] CNPRD, 2004
[53] DeRaet and Subbarao, 1999

Average h/h water consumption,[54] in m^3	15.700	10.614	17.831	12.881	14.156	9.938	14.681	12.476

Note: the information are taken from Table 1 of Garn *et al.* (2002), but for the ones with footnotes

[54] Computed using the cleaned-up data and using information from the h/h questionnaire

A2 – THE TOBIT MODEL

TOBIT MODEL: specification with assets, using the variable *price1*
- marginal effect, unconditional expected value -

variable	dF/dx	Std. Err.	z	P>|z|	[95% C.I.	]
logprice1	-2.57541	1.281828	-2.01	0.045	-508.775	-0.063073
D_kspeu*	4.977223	1.384393	3.6	0	2.26386	7.69058
D_tak*	2.273515	1.469719	1.55	0.122	-0.607082	5.15411
D_btbg*	4.919137	1.193244	4.12	0	2.58042	7.25785
D_kchng*	-0.2869681	1.059547	-0.27	0.787	-2.36364	1.78971
D_srieng*	0.3871941	1.033635	0.37	0.708	-1.63869	2.41308
D_kankie*	0.4469746	1.245584	0.36	0.72	-1.99433	2.88828
logexp	4.252678	0.5095156	8.35	0	3.25405	5.25131
television*	2.366415	0.9092426	2.6	0.009	0.584332	4.1485
telephone*	5.163953	0.7771365	6.64	0	3.64079	6.68711
motorcycle*	1.590394	0.8070569	1.97	0.049	0.008591	3.1722
car*	0.3534877	0.8503545	0.42	0.678	-1.31318	2.02015
rental*	3.532462	1.269737	2.78	0.005	1.04382	6.0211
electricity*	2.602801	1.812881	1.44	0.151	-0.950381	6.15598
members	0.3003477	0.1143514	2.63	0.009	0.076223	0.524472
edu2*	1.861526	1.824029	1.02	0.307	-1.71351	5.43656
edu3*	-2.627323	1.162451	-2.26	0.024	-4.90568	-0.34896
edu4*	-1.239999	1.008061	-1.23	0.219	-3.21576	0.735763
edu5*	-1.15399	1.091407	-1.06	0.29	-3.29311	0.985128
edu6*	-1.165163	1.699788	-0.69	0.493	-4.49669	2.16636
edu7*	-0.764614	1.619225	-0.47	0.637	-3.93824	2.40901
ethnic*	1.92962	1.067142	1.81	0.071	-0.161939	4.02118
age	0.380749	0.1757863	2.17	0.03	0.036214	0.725284
agesq	-0.0039106	0.0018445	-2.12	0.034	-0.007526	-0.000295
yearsa	-1.268115	3.622509	-0.35	0.726	-8.3681	5.83187
yearsb	-0.2143787	0.5368502	-0.4	0.69	-1.26659	0.837828
yearsc	-0.1223688	0.1948663	-0.63	0.53	-0.5043	0.259562
yearsd	0.2304666	0.1210111	1.9	0.057	-0.006711	0.467644
yearse	-1.781.071	0.6069339	-2.93	0.003	-2.97064	-0.591503
D_mul*	3.671897	0.6301673	5.83	0	2.43679	4.907
_cons	-54.04614	11.38317	-4.75	0	-76.3568	-31.7355

Note: the STATA .dtobit command provides the marginal effects evaluated at the means of the independent variables.
(*) dF/dx is for discrete change of dummy variable from 0 to 1.

TOBIT MODEL: specification without assets, non correcting for the endogeneity of expenditure
- marginal effect, unconditional expected value -

variable	dF/dx	Std. Err.	z	P>|z|	X_at	[95%	C.I.]
logprice1	-3.57805	1.319319	-2.71	0.007	6.98461	-6.16387	-0.99223
D_kspeu*	5.570711	1.417876	3.93	0	0 --> 1	2.79173	8.3497
D_tak*	3.287941	1.517171	2.17	0.03	0 --> 1	0.31434	6.26154
D_btbg*	5.805784	1.241366	4.68	0	0 --> 1	3.37275	8.23882
D_kchng*	-0.4291	1.113337	-0.39	0.7	0 --> 1	-2.6112	1.753
D_srieng*	0.162759	1.085209	0.15	0.881	0 --> 1	-1.96421	2.28973
D_kankie*	1.341349	1.292084	1.04	0.299	0 --> 1	-1.19109	3.87379
logexp	6.084978	0.498382	12.21	0	12.8948	5.10817	7.06179
members	0.381581	0.119714	3.19	0.001	6.28772	0.146946	0.616215
edu2*	3.258122	1.900995	1.71	0.087	0 --> 1	-0.46776	6.984
edu3*	-2.07485	1.204292	-1.72	0.085	0 --> 1	-4.43522	0.28552
edu4*	-0.37502	1.048851	-0.36	0.721	0 --> 1	-2.43073	1.68069
edu5*	0.242215	1.130751	0.21	0.83	0 --> 1	-1.97402	2.45845
edu6*	0.963692	1.754369	0.55	0.583	0 --> 1	-2.47481	4.40219
edu7*	1.55429	1.674947	0.93	0.353	0 --> 1	-1.72855	4.83713
ethnic*	2.986117	1.124294	2.66	0.008	0 --> 1	0.782542	5.18969
age	0.361527	0.183247	1.97	0.049	44.789	0.002369	0.720684
agesq	-0.00357	0.001923	-1.86	0.063	2122.74	-0.00734	0.000194
yearsa	-0.54418	3.840351	-0.14	0.887	0.990107	-8.07113	6.98277
yearsb	-0.2525	0.562933	-0.45	0.654	2.71125	-1.35583	0.850832
yearsc	-0.13463	0.203943	-0.66	0.509	4.34399	-0.53435	0.265093
yearsd	0.21402	0.12626	1.7	0.09	4.26087	-0.03344	0.461484
yearse	-1.93846	0.632672	-3.06	0.002	0.492327	-3.17847	-0.69845
D_mul*	3.930235	0.658664	5.97	0	0 --> 1	2.63928	5.22119
_cons	-65.9715	11.88752	-5.55	0	1	-89.2706	-42.6724

TOBIT MODEL: specification without assets, correcting for the endogeneity of expenditure
- marginal effect, unconditional expected value -

variable	dF/dx	Std. Err.	z	P>|z|	X_at	[95% C.I.	]
logprice1	-4.26666	1.317508	-3.24	0.001	6.98461	-6.84893	-1.68439
D_kspeu*	12.05093	1.565695	7.7	0	0 --> 1	8.98222	15.1196
D_tak*	5.782918	1.539384	3.76	0	0 --> 1	2.76578	8.80006
D_btbg*	5.312027	1.238558	4.29	0	0 --> 1	2.8845	7.73956
D_kchng*	0.471224	1.102229	0.43	0.669	0 --> 1	-1.6891	2.63155
D_srieng*	1.960962	1.10754	1.77	0.077	0 --> 1	-0.20978	4.1317
D_kankie*	3.091534	1.299925	2.38	0.017	0 --> 1	0.543729	5.63934
logexphat	12.56171	1.038832	12.09	0	12.8948	10.5256	14.5978
members	-0.1172	0.135559	-0.86	0.387	6.28772	-0.38289	0.148487
edu2*	2.128173	1.896652	1.12	0.262	0 --> 1	-1.5892	5.84554
edu3*	-2.7352	1.211747	-2.26	0.024	0 --> 1	-5.11018	-0.36022
edu4*	-0.90861	1.050951	-0.86	0.387	0 --> 1	-2.96843	1.15122
edu5*	-0.85347	1.136782	-0.75	0.453	0 --> 1	-3.08152	1.37459
edu6*	-1.0842	1.774432	-0.61	0.541	0 --> 1	-4.56203	2.39362
edu7*	-0.92158	1.70946	-0.54	0.59	0 --> 1	-4.27206	2.4289
ethnic*	1.359537	1.128242	1.21	0.228	0 --> 1	-0.85178	3.57085
age	0.19322	0.183889	1.05	0.293	44.789	-0.1672	0.553634
agesq	-0.00161	0.001932	-0.83	0.404	2122.74	-0.0054	0.002176
yearsa	-3.36415	3.814154	-0.88	0.378	0.990107	-10.8398	4.11145
yearsb	0.267399	0.559979	0.48	0.633	2.71125	-0.83014	1.36494
yearsc	-0.19205	0.203471	-0.94	0.345	4.34399	-0.59084	0.206747
yearsd	0.295046	0.127346	2.32	0.021	4.26087	0.045453	0.544639
yearse	-1.80673	0.649207	-2.78	0.005	0.492327	-3.07915	-0.53431
D_mul*	2.949249	0.663393	4.45	0	0 --> 1	1.64902	4.24948
_cons	-136.583	15.51659	-8.8	0	1	-166.995	-106.171

TOBIT MODEL: price and expenditure elasticities using *price2*, for specifications 1, 2, 3

Specification	***H*** **Price**	**95% Conf. Interval**	***η*** **Expenditure**	**95% Conf. Interval**
1	-0.178 n.s.	[-0.511 / 0.155]	0.549	[0.416 / 0.683]
2	-0.345	[-0.688 / -0.002]	0.794	[0.664 / 0.925]
3	-0.366	[-0.709 / -0.025]	1.622	[1.351 / 1.893]

n.s.= non significant

A3 – THE PROBIT MODEL

PROBIT MODEL: marginal effects

Variable	dF/dx	Robust Std. Err.	z	P>|z|	x-bar	[95%	C.I.]
D_watcon							
logfee	-0.2116755	0.05655	-3.75	0	122.021	-0.322512	-0.10084
D_kspeu*	0.2302707	0.076038	2.6	0.009	0.118926	0.081239	0.379302
D_tak*	0.0845908	0.073355	1.12	0.264	0.120205	-0.059182	0.228364
D_btbg*	0.2020516	0.076523	2.33	0.02	0.121483	0.052069	0.352034
D_kchng*	-0.0150609	0.08318	-0.18	0.856	0.116368	-0.178091	0.147969
D_srieng*	-0.0871046	0.111587	-0.79	0.431	0.122762	-0.305811	0.131602
D_kankie*	-0.1435682	0.075268	-1.91	0.056	0.121483	-0.291091	0.003954
logexp	0.3747345	0.051298	7.34	0	128.948	0.274192	0.475277
television*	0.167663	0.064751	2.59	0.01	0.774936	0.040753	0.294573
telephone*	0.328801	0.05265	4.69	0	0.163683	0.22561	0.431992
motorcycle*	0.1440405	0.056078	2.57	0.01	0.750639	0.03413	0.253951
car*	-0.1349215	0.075532	-1.79	0.073	0.132992	-0.282962	0.013119
fridge*	0.256054	0.118181	1.66	0.097	0.039642	0.024423	0.487685
electricity*	0.1881665	0.130759	1.42	0.156	0.933504	-0.068116	0.444449
members	-0.0030612	0.009917	-0.31	0.758	628.772	-0.022499	0.016376
edu2*	-0.0028693	0.130772	-0.02	0.982	0.030691	-0.259178	0.253439
edu3*	-0.1949709	0.089081	-2.16	0.03	0.170077	-0.369567	-0.02038
edu4*	-0.0893117	0.081379	-1.1	0.272	0.377238	-0.248812	0.070188
edu5*	-0.0565515	0.086809	-0.65	0.513	0.2289	-0.226693	0.11359
edu6*	-0.2618985	0.131743	-1.86	0.063	0.038363	-0.52011	-0.00369
edu7*	-0.0492157	0.160981	-0.31	0.758	0.039642	-0.364732	0.266301
ethnic*	0.3099744	0.063161	3.4	0.001	0.065217	0.186181	0.433768
age	0.0377268	0.012393	3.04	0.002	44.789	0.013436	0.062017
agesq	-0.000362	0.00013	-2.79	0.005	2122.74	-0.000616	-0.00011
years	-0.0054238	0.003186	-1.7	0.089	127.985	-0.011668	0.00082
D_mul*	0.226165	0.044643	4.95	0	0.590793	0.138667	0.313663

Number of obs = 782
Wald χ^2_{26} = 223.31
obs. P = 0.5473146
pred. P = 0.5880945
Prob > χ^2 = 0.0000
Pseudo R^2 = 0.3665
Log pseudo-likelihood = -341.15188
pred. P= 0.5880945 (at x-bar)

Note: the STATA command .dprobit reports the change in the probability for an infinitesimal change in each independent, continuous variable and, by default, the discrete change in the probability for dummy variables. Thus, (*) dF/dx is for discrete change of dummy variable from 0 to 1. z and P>|z| are the test of the underlying coefficient being 0.

A4 - WELFARE EFFECT ANALYSIS

WELFARE EFFECT: Household Expenditure

Town	1 RE (real exp) con. h/h	2 Exp unc. h/h	3 δCS(i)	4 2 with service provided	5 % unc./con. h/h exp	6 % unc./con. h/h exp with service provided to all
η=0.5						
B. Meanchey	1138891	428200.8	65274.07	493474.8	.3759805	.4332941
K. Speau	388209.1	207750.7	36853.64	244604.3	.5351515	.6300839
Takeo	1050416	290731.5	46764.59	337496.1	.2767776	.3212977
Kandal	699137.2	367918.4	64019.39	431937.8	.5262464	.6178156
	(700585.4)		(65467.56)	(433385.9)	(.5251586)	(.6186054)
Battambang	811680.6	368357.9	73530.18	441888.1	.4538213	.5444113
	(812326.8)		(74176.45)	(442534.4)	.(4534602)	(.5447739)
K. Chhang	911915.3	305348.8	30771.46	336120.3	.3348434	.3685872
S. Rieng	553715.9	341738.7	16094.62	357833.3	.6171733	.6462399
K. Svay	693316.6	351001	68755.05	419756.1	.5062637	.6054321
η=0.4						
B. Meanchey	1147265	428200.8	73647.66	501848.4	.3732363	.4374304
K. Speau	391768.2	207750.7	40412.73	248163.4	.5302898	.6334444
Takeo	1054341	290731.5	50689.64	341421.2	.2757472	.3238244
Kandal	711918.3	367918.4	76800.48	444718.8	.5167986	.6246768
	(713222.6)		78104.84	446023.2	(.5158535)	(.6253632)
Battambang	820698.4	368357.9	82548.03	450905.9	.4488347	.5494173
	(821122)		(82971.66)	(451329.6)	(.4486032)	(.5496498)
K. Chhang	915290.2	305348.8	34146.34	339495.2	.3336087	.3709154
S. Rieng	555066.8	341738.7	17445.47	359184.2	.6156713	.6471008
K. Svay	701748.8	351001	77187.27	428188.3	.5001804	.6101732

WELFARE EFFECT: Income

Town	1 RI (real inc) con. h/h	2 Inc unc. h/h	3 δCS(i)	4 2 with service provided	5 % unc./con. h/h inc	6 % unc./con. h/h inc with service provided to all
η=0.5						
B. Meanchey	1123526	399574.3	65274.07	464848.3	.3556431	.4137405
K. Speau	431306.3	204848.6	36853.64	241702.2	.4749492	5603957
Takeo	1058484	364440.8	46764.59	411205.4	.3443046	.3884854
Kandal	657844.9	401628.3	64019.39	465647.8	.6105213	.7078383
	(659293.1)		(65467.56)	(467095.9)	(.6091803)	(.7084799)
Battambang	838275	350974.2	73530.18	424504.3	.4186862	.5064022
	(838921.3)		(74176.45)	(425150.6)	(.4183637)	(.5067825)
K. Chhang	889015.3	309106.2	30771.46	339877.7	.347695	.382308
S. Rieng	489256.5	349243.4	16094.62	365338.1	.7138247	.7467209
K. Svay	693828.1	373975.5	68755.05	442730.6	.5390031	.6380984
η=0.4						
B. Meanchey	1131900	399574.3	73647.66	473221.9	.3530121	.4180776
K. Speau	434865.4	204848.6	40412.73	245261.3	.4710621	.5639936
Takeo	1062409	364440.8	50689.64	415130.5	.3430326	.3907447
Kandal	670626	401628.3	76800.48	478428.8	.5988857	.7134063
	(671930.4)		(78104.84)	(479733.2)	(.5977231)	(.7139627)
Battambang	847292.9	350974.2	82548.03	433522.2	.4142301	.5116556
	(847716.5)		(82971.66)	(433945.8)	(.4140231)	(.5118997)
K. Chhang	892390.1	309106.2	34146.34	343252.6	.3463801	.3846441
S. Rieng	490607.4	349243.4	17445.47	366688.9	.7118593	.7474182
K. Svay	702260.3	373975.5	77187.27	451162.8	.5325312	.6424439

The variable *logprice1* was used in this calculations. However, for Kandal and Battambang, the only two towns with subcontractors, the results using *logprice2* are reported in parenthesis.