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. 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 -0.5 and -0.4; 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 decrease the estimated Gini coefficient by three percentage points, and the poverty head-count ratio by six percentage points.

Keywords: Water delivery; poverty reduction; inequality; Asia; Cambodia

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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 endeavoured to improve water provision. However, the country is still grappling with the consequences of decades of war as 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: (1) to obtain an estimate of the price elasticity of the demand for water, as this has important policy content in its own right[1]; (2) to identify empirically the main constraints for the non-connected households in their access to water provided by the network; and (3) to evaluate, as a suggestive counterfactural exercise, the welfare consequences and the

[1] 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))

income distributional effects if the non-connected households were provided with a connection to network water.[2]

The paper is organized as follows. Section 2 provides an brief overview of 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. Section 4 presents the main econometric results of our research. Section 5 contains concluding remarks and offers some policy implications of our analysis.

2. Cambodia's water provision at a glance

After three decades of war, genocide, and internal strife, Cambodia regained its seat at the General Assembly of the United Nations in the 1990s. In the process of re-establishing itself in the international community, the Government of Cambodia (GOC) signed and committed to the Millennium Declaration, and adopted the following targets: increase the proportion of the rural population with access to a safe water source from 24 percent (in 1998) to 50 percent (in 2015); and increase the proportion of urban population with access to a safe water source from 60 percent (in 1998) to 80 percent (in 2015) (KOC (2003)).

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

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[2] 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 average coverage level is around 15 percent. Furthermore, the service is restricted to the central core urban areas (DeRaet and Subbarao (1999)), and future prospects for more adequate coverage are not helped by high projections for population growth in urban areas.[3] Furthermore, access to safe water decreased in Phnom Penh by about one-fifth between 1997 and 1999, and the percentage of the population with such accessis 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, but are now 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, water-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 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,[4] 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)).[5]

Urban health and sanitary conditions have thus become a matter of great concern. After decades where public infrastructures have either been closed or destroyed, the main constraint for the public sector originates from inadequate financial resources to develop an adequate supply and maintenance system.[6] Moreover, the legal structure governing the

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[3] Though, some caution is required here as according to DeRaet and Subbarao (1999), towns and cities other than Phnom Penh are not likely to experience such rapid population growth.

[4] 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.

[5] However, contrarily to other Asian countries, water pollution does not seem to be a major problem yet (DeRaet and Subbarao (1999))

[6] 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

provincial utilities is confusing and fragmented.[7] 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.

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 network 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.

Despite the lack of regulation,[8] the general uncertainty of the legal basis of the licences, the discrepancy between contract and licence and the lack of transparency in the privatisation process ((see DeRaet and Subbarao (1999)),[9] many new fixed investments have been made by the private companies to improve the quality, the coverage and the overall reliability of their services.

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

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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.

[7] In particular, 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 is uncertain, especially in terms of tariff revision (DeRaet and Subbarao (1999))

[8] The regulation appeared is 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)).

[9] 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)). Detailed production and financial characteristics of the water utilities are reported In (Garn *et al.* (2002)

utilities in Cambodia.[10] 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.[11] The process was randomly implemented in order to avoid conventional 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, *inter alia*, to 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).

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 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

[10] 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.

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

household characteristics (such as total income, expenditure, and information about assets).

3.2 Theory and Methodology

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 full sample may lead to potentially biased estimates. The tobit model (see Tobin (1958)), allowing for both discrete and continuous parts, provides one possible solution to the problem of censoring outlined above . 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)).[12]

[12] The presence of heteroskedasticity is likely to represent a problem with much more serious consequences than in OLS models leading to inconsistency. Furthermore, the violation of the normality assumption also leads to parameter inconsistency .

In contrast, 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. The two-step Heckman procedure treats the problem as one of omitted variables and allows correction for selectivity bias throughinserting 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 data drawn from the connected households provides unbiased and consistent estimates (conditional upon the model passing an array of other important diagnostic tests).

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 relating to the test for the tobit specification,[13] are based on the efficient score tests originally suggested by Chesher and Irish (1987). The tests focus on detecting

[13] 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 Fin and Schmidt (1984)). The chi-squared has ($k^{truncated}+k^{probit}-k^{tobit}$) degrees of freedom, where k indicates the number of parameters estimated.

deficiencies in regard to omitted variables or functional form (RESET), homoscedasticity, and normality. [14] 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 render the procedure less sensitive to violations in this assumption. One technique is based on approximating the selection correction term through a polynomial constructed as a power series of the original inverse Mills ratio term. The polynomial thus obtained is then added to the model as additional regressors in the second stage of the procedure (see Newey (1999) for details).[15]

The econometric analysis allows us to estimate both an access-to-water probability equation and a water demand equation. The former model potentially allows us to distinguish the main barriers 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 that changes from the price applied by the vendors ($P_{(0)}$)[16] (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 $W_{(i)}$). In order to estimate the welfare gain for a household, we use as a template the studies conducted by Strand and Walker (2003, 2004) that derived estimates of access to tap water in 17 cities in Central America and Venezuela.[17] The price differentials used are based on the difference between the price applied by the vendors ($P_{(0)}$)[18] (and the corresponding amount of water consumption $W_{(0)}$) and the official price applied by the water utility ($P_{(i)}$) (and the corresponding amount of

[14] See Orme (1990) for some reservations concerning the finite sample performance of these tests.
[15] See Newey (1999) for a theoretical exposition and Buchinsky (1998) for an application, albeit within a quantile regression model framework
[16] Information reported by DeRaet and Subbarao (1999).
[17] The very detailed data set available allow them to also calculate the welfare gain using the hedonic price method.
[18] Information reported by DeRaet and Subbarao (1999).

water consumption $W_{(i)}$). The log-linear form of the water demand equation can be expressed (ignoring conventional error terms) as:[19]

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

where *A(i)* identifies all factors other than price that influence the i^{th} household's 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)).

This theoretical framework enables us to determine welfare effects. This procedure, however, requires the exercise of some caution for a number of reasons.

First, the *CS* computed through [3.2] does not account for externalities of any kind and implicitly assumes that the only alternative to piped-water is water from vendors. Notwithstanding the fact that purchasing water from vendors is quite a common practice among the non connected households (about 43% of the sampled unconnected households engage in this activity), this clearly ignores other possible sources that might well be cheaper (or more expensive) such as own water-wells, public standpoints, rivers and lakes, tracks, etc.[20] This assumption may be interpreted as relatively strong. However, it must be considered that even if vendor prices represent an upper limit (which thus inflates the

[19] The use of formula [3.1] is obviously inappropriate for the censored tobit specification and more relevant to the Heckman two-step procedure where the dependent variable in the second stage is subject to a logarithmic transformation..

[20] About 27% of the non connected households collect water from river, lake, sping and pond; 46% from own well; the large majority collects and uses also rain water

estimates of the welfare gain from a connection), it is also true that alternative ways of securing water supply are likely to conceal large social and economic cost, such as:

- cost of medicine and medical treatments linked to water-born diseases (e.g., gastro-enteritis and diarrhoea are endemic diseases in Cambodia) caused by the generally poorer quality water fetched, which often leads children to miss school or adults to loose work opportunities;
- cost on fuel, in case the household decided to clean their drinking water by boiling it (a common practice in the selected sample);
- the opportunity cost associated withnot being engaged in other productive activities (which affects mostly women and children, usually the household's members responsible for the collection of water);
- other social costs (through poor health and lost employment), linked to the degraded environments in which poor urban households usually live (Calaguas and Roaf (2001)).

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 yielddifferent results (see Horowitz and McConnell (2002)) with WTA greater than WTP. Finally, all unconnected households are implicitly assumed to have the choice to connect to the piped distribution system. This is not the case. However, it must be born in mind that at the time of the survey almost all the utilities were operating below or well below their capacity, and all of them were willing to expand the network to capture more connections and to improve both the quality of water and service provision. This was listed as the primary concern, especially for private utilities, as revealed by the Water Utility Questionnaire. The scenario is thus one where an increasing demand is matched by a supply eager to expand resources permitting. Thus, this study tries to capture the welfare gains of the unconnected households if such gap was to be bridged (i.e. if they were covered by the network).

3.3 Choice of 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 variables used in the empirical analysis.

Water consumption

The key dependent variable, water consumption, was obtained by dividing the household's monthly bill by the unit tariff. Given that meters (and pumps) are older in public than in private utilities[21]a legitimate question about the reliability of this measure could be raised. . However, the values obtained are perfectly in comport with the estimated average water consumption per person used in the economic analyses for the urban and peri-urban water

[21] The average age of meters for the public utilities is 7.5 (min: 3, max 15 years) and 1.75 for the private utilities (min: 1, max 2).

supply projects financed in Cambodia by the World Bank.[22]. This provides us with some confidence as to the accuracy of the measure.[23]

Nevertheless, it is accepted, that the meters in the public networks were generally very old and presented important leakages' problems (especially in Battambang).[24] Some caution is thus required in interpreting the empirical results, but this caveat would apply in regard to empirical work using data from most developing countries.

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 applied a two-part uniform tariff for all the consumers connected.[25] We constructed the price variable in two ways: *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, in the case of the censored tobit, we assume that all the non-connected households face only the price set by the utilities. This ignores the possibility of a household being supplied by a subcontractor. Unfortunately, the lack of more precise information (e.g., on the

[22] The values used by the Wolrd Bank are slighly lower. However, it must be considered that our estimates are based on the sample of already connected households, that is to say better-off households with a likely higher level of soncumption

[23] On the other hand, if we are concerned more broadly with measurement error in this variable, this can be captured in the regression model's error terms. A more problematic issue would be measurement error in the set of explanatory variables.

[24] Since the networks for the private utilities are all relatively new, there has not been much of a problem in regard to broken pipes and other network problems. The networks for the public utilities are older and present problems. This is in spite of the fact that some of the public utilities were reconstructed during the 1990s. For example, the Kandal/Takhmao Water Utility received loans from The World Bank.

[25] 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.

location of the household and the areas served by sub-contractors) does not allow us to assign more precise values for this variable.

Table 2.1 of the appendix details the water tariff rates by town and utility type.

Fee

In the computation of this variable, we included not only the actual connection fee but the entire amount households paid 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 usedifferent 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)[26] 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 used a town-specific value that includes all the expenses reported by the household (connection fee plus labour charges plus other charges). We eliminated a number of obvious outliers and substituted location-specific mean values instead.[27]

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

[26] 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)).

[27] 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).

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 expenditure (194 versus 95 out of the 782 households). After careful analysis, we substituted the missing information with the mean expenditure 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.[28] 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 distribution. This suggests that some caution is required here, 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 be interpreted as problematic in this context.[29] In order to inform on this issue we conducted a number of Hausman tests. In those cases where a significant test was encountered, predictions were used instead of actual values.

Other Variables

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[28] Sample 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).

[29] 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)).

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 (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)[30], 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));

[30] Standard deviations reported in parentheses in the rest of this sub-section.

- the average age of the respondent is 45 years (10.8);
- on average, there are 1.76 (0.86) earners per household 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 completed primary schooling .

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.[31] 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 a large share of the non-connected households which are poor.[32] The household expenditure for connected households is 124,676 (210,022); for non-connected households it is 58,987 (43,496).[33] 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 (see Footnote 21).[34]

4. Econometric results

4.1 The Probit and Corrected OLS Regression Model Estimates

We first ran a tobit model, using the log of *price1*. In general, the estimated coefficients of the price, expenditure and household-size variables were statistically well determined, register the expected sign, and have reasonable magnitudes. However, the tobit model

[31] At the time of the survey and all along 2002, year of the UNDP statistics considered, the exchange rate was about 3900 Riels=1US$.

[32] According to the Ministry of Planning (2002), the 1999 National Poverty Line was around 54,050 Riels per head per month.

[33] 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))

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

failed all the diagnostics.[35] In the light of the major problems associated with the censored tobit, use of the Heckman two-step procedure is favoured.

As described in the previous section, the probit model includes a set of identifying instruments. As detailed in Table 4.1, the McFadden Pseudo-R^2 indicates a very good fit for a cross-sectional model,[36] and this is confirmed by the measure suggested by Cramer (1999).[37] The percentage of correct predictions is fairly high (80 percent) but Train's (2003, p.73) reservations on the usefulness of this measure are well taken. The null of exogeneity of expenditure is upheld by the data. The set of identifying instruments is comprised of five (or four depending on the specification) variables.[38] The validity of these instruments is tentatively confirmed by the fact their exclusion from the levels regression is upheld by the data (see Wald tests, Table 4.2). 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 in a satisfactory fashion.

[Insert Table 4.1 here]

Based on the results presented in Table 4.1, the estimated coefficient for *logfee* suggests that, *ceteris paribus*, a 10 percent increase in the one-off connection charge reduces the probability of connection by about two percentage points.[39] The estimated coefficient for (log) expenditure, also highly significant, suggests that, *ceteris paribus*, a

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[35] 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.

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

[37] 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.

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

[39] Again, given the logarithmic nature of the regressor, we can obtain the effect of a ten-percentchange in the fee on the connection decision by multiplying the marginal effect by 0.1 (see A3).

10 percent increase in the expenditure level increases the probability of connection by about four percentage points.[40]

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, gives broadly similar results, with a connection-fee elasticity of -0.36 and an expenditure elasticity of about 0.81.[41]

All the estimated coefficients for the assets are plausible (except for the *car* estimate).[42] The non-Khmer, mostly Chinese, are about 31 percentage points more likely to get connected than the Khmer ethnic group. The estimated coefficients for the education dummies are poorly determined. The estimated coefficient for *members* is also statistically insignificant (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 obtain water from 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

[40] 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.

[41] Correcting for the endogeneity of expenditure, s the elasticity point estimates are -0.45 and 1.45 respectively.

[42] 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.

be insufficient to redeem it. Nevertheless, the adjusted asymptotic *t*-values do not deviate much from the original ones and the statistical significance of the estimated coefficients is not materially altered by use of this adjustment.

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. However, the null hypothesis of no selection bias remains upheld by the data using this more elaborate form of correction. In the light of these results, the selection terms are omitted in the final specifications reported in Table 4.2, and the reported estimates are based on the standard OLS procedure. For brevity, the OLS regression results are presented for the models without assets as their inclusion does not alter the estimated magnitude of the price elasticity of demand.

Table 4.2 presents the results for four specifications: [43]

(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 4.2 here]

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[43] 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.

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 using a 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 conflicting results. Although the RESET is passed for those models that use actual household expenditure, it 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 degree of bias.

In spite of the foregoing concerns, many of the results appear to be highly robust across the specifications. In particular, as shown in Table 4.3, 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 the 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 4.3 here]

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 compute the welfare effects of water access and use, exploiting the concept of a change in Marshallian consumer's surplus. Following the approach of Strand and Walker (2003), we present the main results in Table 4.4, reporting the estimates for our lower bound elasticity estimate (η=0.4). 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 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 4.4 here]

The last two columns of Table 4.4 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 an access to the service for all. In particular, a non-connected household would experience a change in welfare of about 56,000 Riels per month -- 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 4.5 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.[44] 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)).

[Insert Table 4.5 here]

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

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.[45] 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.

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 in getting 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?

In line with Garn *et al.* (2002), key results from the first stage estimation confirm that the main barrier for the poor appears 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 -0.5 and -0.4. These estimates are in line with other empirical studies 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.

On average and across the towns, providing water connection to the set of currently non-connected households would increase the ratio of thier household to the household expenditure of connected households from 0.45 to 0.53. Even if , in

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

methodological terms, this is to be considered an upper limit, this perhaps understates the true welfare benefits given that such connections would also generate 'spillover' effects through unmeasured positive externalities on health. In addition, our analysis suggests that the welfare changes would induce the Gini coefficient to decrease by about three percentage points, and the poverty head-count ratio would decrease by about six percentage points.

While our results must be treated with some degree of caution, their general robustness allows us to draw some tentative policy conclusions. 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 monthly expenditure (16 percent for income), which represents a sizeable gain. In the light of this finding, it is reasonable to infer that , once connected, the poor may be able to pay a non-subsidised tariff equal to the general tariff.[46]

This suggests a clear policy option: a connection (rather than a consumption) subsidy scheme would represent an important step in the process of providing water to all households, including the poorest. 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.[47] Furthermore, targeted connection subsidies appear to exhibit leakage rates and 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 would be much lower. The official targeting criterion could be the connection

[46] 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)).

[47] 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))

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 in regard to such a scheme would be the lack of adequate resources. Possible solutions to this problem may be found in a better management of the existing resources aimed at the provision of safe water targeted to the poorest (which could be based on the nature of water as a merit good, accounting for both the welfare gains outlined and the wide-ranging positive externalities of safe water on health), or in new applications of water concessions, such as the out-based coverage expansion scheme (see Marin, 2002), perhaps with the support of external funds (see Mumssen, 2004))

However, the connection subsidy itself should not be viewed as a one-off solution to the water problem. Other factors ought to be considered to facilitate improvements to service access and provision, such as a requirement for the introduction of sound regulations together with an autonomous regulator with a remit to promote accountability and transparency, to provide a basis for competition between the public and private sectors (DeRaet and Subbarao (1999).) The significant and highly robust results reported here are a first step to understanding the demand-side relationship that underlies the Cambodian water sector. Future research should focus on other important issues germane to water provision. Quantifying the amount of a connection fee subsidy requires some measure of household willingness to pay (Foster *et al.* (2000)). Furthermore, a comparative analysis of the performances and of the level of coverage of the private and public sectors, with particular attention to the attitudes of households towards them, ought to be part of a future research agenda.

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Table 2.1: Water tariff (Riels/m^3)

Utility	Tariff	
Bantey Meanchey	1300	Private
Kampong Speu	1500	Private
Takeo	1800	Private
(Kandal) Kien Svay	1400	Private
Kandal (Takmao)	550	Public
Kandal 1	550-1000*	Subcontractors
Battambang	1400	Public
Battambang 1	1400-1900*	Subcontractors
Kampong Chhang	1000	Public
Svay Rieng	600	Public

* Subcontractors in Battambang were allowed to charge up to 2000 Riels/m^3 of water delivered; subcontractors in Kandal up to 550-1200 Riels/m^3 (Garn *et al* (2002))

Table 3.1: Description of Variables

Name	Description
watcon	Amount of water consumed monthly in cubic meters.[48] 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

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

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
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 Connection Model

Probit Model

Variable	**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 4.2: 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
adj χ^2_2	(0.120)	(0.311)	(0.104)	(0.270)
Homoskedasticity	Corrected	Corrected	Corrected	Corrected
Wald Test on the correction term	1.56	*n/a*	1.53	*n/a*
F(3, 398)[49]	(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 4.3: 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 4.4: 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

[49] 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.

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

Table 4.5: 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