

Study of the Distributional Performance of Piped Water Consumption Subsidies in 10 Developing Countries

Laura Abramovsky

Luis Andrés

George Joseph

Juan Pablo Rud

Germán Sember

Michael Thibert



WORLD BANK GROUP

Water Global Practice

May 2020

Abstract

This paper provides new evidence on how effectively piped water consumption subsidies are targeting poor households in 10 low- and middle-income countries around the world. The results suggest that, in these countries, existing tariff structures fall short of recovering the costs of service provision, and the resulting subsidies largely fail to achieve their goal of improving the accessibility and affordability of piped water for poor households. Instead, the majority

of subsidies in all 10 countries are captured by the richest households. This is in part because the most vulnerable population segments typically face challenges in accessing and connecting to piped water services. The paper also reveals shortcomings in the design of the subsidies, which are conditional on poor households being connected to a piped network.

This paper is a product of the Water Global Practice. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at <http://www.worldbank.org/prwp>. The authors may be contacted at Landres@worldbank.org.

The Policy Research Working Paper Series disseminates the findings of work in progress to encourage the exchange of ideas about development issues. An objective of the series is to get the findings out quickly, even if the presentations are less than fully polished. The papers carry the names of the authors and should be cited accordingly. The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. They do not necessarily represent the views of the International Bank for Reconstruction and Development/World Bank and its affiliated organizations, or those of the Executive Directors of the World Bank or the governments they represent.

Study of the Distributional Performance of Piped Water Consumption Subsidies in 10 Developing Countries

Laura Abramovsky, Luis Andrés, George Joseph, Juan Pablo Rud,

Germán Sember, and Michael Thibert*

JEL Classification: D3, H220, L95, O13, O2

Keywords: Distributional performance of subsidies, consumption of piped water, developing country.

* Laura Abramovsky: Institute for Fiscal Studies (IFS) and MacroConsulting (labramovsky@gmail.com, corresponding author), postal address: 7 Ridgmount Street London WC1E 7AE; Luis Andrés: World Bank (WB) (landres@worldbank.com), postal address: World Bank, 1818 H Street, NW, Washington, DC 20433 USA; George Joseph: WB (gjoseph@worldbank.org), postal address: World Bank, 1818 H Street, NW, Washington, DC 20433 USA; Juan Pablo Rud: Royal Holloway University of London and IFS (Juan.Rud@rhul.ac.uk), postal address: Royal Holloway University of London Egham Hill, Egham TW20 0EX, UK; Germán Sember: MacroConsulting (gsemer@macroconsulting.net), postal address: Lavalle 190, Piso 5° Oficina I, Buenos Aires, Argentina; and Michael Thibert: WB (mthibert@worldbank.org), postal address: World Bank, 1818 H Street, NW, Washington, DC 20433 USA.

1. Introduction

Universal access to water and sanitation is a stated international development goal (UN 2015).² Well-designed subsidies—along with investment, technological innovation, and better governance and planning—stand out as a key instrument to reach this objective. In the context of high levels of poverty, where markets alone do not result in the desired levels of service provision and consumption, targeted subsidies can help address affordability and equity issues without necessarily jeopardizing the objectives of cost recovery or economic efficiency (WWAP 2019). Additionally, water and sanitation subsidies are advocated because greater access to and consumption of water and sanitation services are associated with rising productivity and living standards, and positive externalities related to public health.

The design and performance of subsidies hinges on the structure and technology of piped water production and delivery. But it is difficult to design subsidies. The water and sanitation sector involves large up-front (fixed) costs, long-lived assets, and network characteristics that make it difficult to estimate marginal costs, and thus to recover costs through efficient pricing. Instead, services often receive a blanket subsidization that may not increase either accessibility or affordability, and is likely to undermine the financial sustainability of the system. It is recommended that tariffs at least cover the operating expenditures incurred by suppliers, but even this minimal objective is rarely achieved. In this paper, we consider the extent to which subsidies meet equity objectives and affect providers' ability to recover service costs. In the process, we provide new evidence of the distributional performance—and, specifically, the pro-poor targeting—of subsidies for piped water consumption in 10 developing countries, and document the gap between estimates of actual tariffs and cost-recovery tariffs.

We consider 10 low- and middle-income countries around the world: Ethiopia, Mali, Niger, Nigeria, Uganda, El Salvador, Jamaica, Panama, Bangladesh, and Vietnam. This sample is relatively heterogeneous in terms of gross domestic product per capita, connection rates, tariff structures, and cost-recovery tariffs. Our analysis is founded upon data from household surveys that capture water expenditure, utility providers' administrative reports, and a novel estimation of country-specific costs of service.³

Our results suggest that, in all the countries analyzed, the mean unit prices charged are, on average, lower than the overall cost of producing and distributing piped water (that is, lower than would be needed to cover both capital and operating expenditures), resulting in substantial subsidies. Having said this, in some countries the average prices charged are higher than the tariffs that would be needed to cover operating expenditure. In addition, subsidies are regressive, with the amount of resources allocated to water consumption subsidies increasing over the expenditure distribution, and richer households in the top five deciles usually capturing the lion's share. The results also suggest that, in most countries, subsidies are regressive due to a combination of factors that are not related to their design: (i) poor households are located in areas not covered by piped water networks, (ii) poor households are in areas that are covered,

² The United Nations' Sustainable Development Goals (SDGs), adopted in 2015, include the aims to "achieve universal and equitable access to safe and affordable drinking water" and to "achieve access to adequate and equitable sanitation and hygiene for all" by 2030.

³ These estimates are calculated using an improved methodology and new data presented in Andres et al. (2019).

but are not connected to the network themselves, and (iii) poor households that are connected to the network appear to be consuming smaller quantities of water than the general population. This means that there are high errors of inclusion (rich households receiving subsidies) and even higher errors of exclusion (poor households not receiving subsidies). This issue is particularly pronounced in the African countries considered, where errors of exclusion fall between 90 and 100 percent.

Our findings are consistent with a small number of previous studies that also find that water consumption subsidies in developing countries are not reaching the poor as intended. Key examples of this literature—such as Komives et al. (2005) and Angel-Urdinola and Wodon (2007b)—have shown that quantity-based, targeted subsidies in Nicaragua, Cabo Verde, Sri Lanka, and the cities of Kathmandu (Nepal) and Bangalore (India) are usually regressive, with a smaller share of benefits accruing to the poor than the general population. These studies indicate that this problem is mostly associated with low rates of access to water networks in poor neighborhoods, as well as low connection rates among poor households in neighborhoods with access. More recently, the World Bank (2017) found that Tunisian households in the bottom quintile of the income distribution receive 11 percent of water subsidies, while those in the top quintile receive 27 percent.

Our findings may be used to inform a long-standing policy debate that is particularly heated where resources to fund water infrastructure are scarce. Despite evidence that poor households' need for affordable, high-quality services remains unmet, and that wealthier segments of the population benefit most from subsidies, countries find it challenging to introduce policy reforms. This can be due to political economy constraints but also due to lack of technical and institutional capacity.

The rest of the paper is structured as follows: section 2 presents the data used, related statistics, and our methodology; section 3 presents our findings; and the final section summarizes these findings and discusses their policy implications.

2. Data and methodology

A subsidy represents the difference between the cost of providing a service and the actual price, or tariff, paid by a user. In practice, water consumption subsidies can take different forms. They may be untargeted (e.g., due to the general underpricing of water supply); implicit (e.g., because of inadequate metering or low rates of bill collection); or explicit (e.g., the setting of higher tariffs for larger consumers, using increasing block tariffs). The funding for these subsidies comes from one or a combination of the following sources: government transfers, cross-subsidies (i.e., money taken from other consumer segments of the same or another sector), or simply the money freed up in the short term by, say, a lack of maintenance or service interruptions.

Estimating subsidies for piped water at the household level requires calculating the efficient economic cost of delivering a unit (cubic meter, m³) of piped water and the unit price paid. In order to do this, we use a methodology that closely follows Komives et al. (2005) and Angel-Urdinola and Wodon (2007a) and that we describe below. It is worth noting that the estimates

of subsidies' distributional and targeting performance are arithmetic, nonbehavioral, and express a partial equilibrium.⁴

2.1 Data sources

As no single data source provides all the information needed to compute the efficient economic cost of service, which is needed to estimate efficient subsidies at the household level, we use several data sources combined with a series of assumptions to construct the variables for our analysis.

Household surveys

We estimate piped water access, connections, and expenditure using information self-reported during national household-level surveys (see the appendix for details). These surveys also provide, with varying degrees of quality across countries, the information necessary to construct total expenditure (and/or income) variables for each household. The quantities of water consumed, and the prices or tariffs paid by each household, are usually not reported in household surveys. We therefore estimate these by complementing the household-level surveys with administrative data from service providers and government programs detailing tariff structures.

Administrative data on tariff structures

We gathered information about tariff structures from the International Benchmarking Network for Water and Sanitation Utilities (IBNET) database. Some countries list most of their water providers in IBNET, while others list only a few. For example, IBNET includes data on the tariff structures of all water providers in Mali and Niger, each of which has only one piped water provider. Meanwhile, for countries such as Ethiopia, Nigeria, Uganda, and Bangladesh—where the provision of services is decentralized and a multitude of utilities provide piped water—IBNET covers only a sample of providers.

Data on cost-reflective tariffs

Cost-reflective tariffs cover the costs of providing service, including not only the efficient economic cost but also the costs arising from the inefficiencies of the service provider. The *efficient economic cost*, meanwhile, covers all the economic resources required for efficient service delivery. These include operation and maintenance expenses and also all capital costs such as depreciation and return on capital. Estimating cost-reflective tariffs is a data-intensive endeavor.

For our purposes, cost-reflective tariffs are taken from a novel data set provided by Andres et al. (2019). The alternative approach followed by Andres et al., despite its assumptions and simplifications, improves on the existing estimates. In a nutshell, this approach entails answering the following question: “What is the long-run incremental cost of providing water and sanitation services for a given company?” It is based on a simple, utility-wide, bottom-up model, drawing

⁴ See, for instance, Abramovsky and Phillips (2015) for a description of different microsimulation models for taxes and benefits using household survey data.

from estimates of the capital stock per customer for an efficient firm plus information on operation and maintenance costs and efficiency levels (in terms of losses and employees) for the period 2010–15, derived from the IBNET data set. A total cost-reflective tariff that covers both operating expenditure (OPEX) and capital expenditure (CAPEX) (defined as CRT) and a cost-reflective tariff that covers only OPEX (defined as CRT_{opex}) are estimated.⁵

2.2 Descriptive statistics

Table 1 presents some descriptive statistics of the rates of households connected to piped water in each country analyzed; countries are listed in descending order by gross domestic product (GDP) per capita. These statistics are country-wide, and outline the areas covered by each household survey and not only those served by utility companies.⁶ Column 1 shows the proportion of all households (regardless of whether they have access or not) that report using piped water as their main source of drinking water.⁷ Column 2 shows the same figure for rural households, column 3 for urban households, and column 4 for poor households. Despite wide variations in coverage rates across countries, connection levels are consistently higher among urban households than both rural and poor ones.⁸ The African countries in our sample with the lowest GDP per capita (Ethiopia, Mali, Niger, and Uganda; column 5) also have the lowest connection rate, at below 5 percent among rural and poor households. Bangladesh, a relatively poor country, presents a similar pattern. Nigeria’s connection rates are quite low given the country’s income per capita, but disparities among different population segments are smaller. The three Latin American countries have substantially higher connection rates, between 70 and 95 percent for the general population, and around 50 percent or over for rural and poor households. Vietnam falls in the middle, with a connection rate of 53 percent for the whole population, and reaching 70 percent for urban households.

Table 1. Households connected to piped water

Country	Households connected to network water (piped water) (%)				GDP per capita in USD PPP 2016
	(1)	(2)	(3)	(4)	
	Total	Rural	Urban	Poor	(5)
Panama	93.2	80.4	98.7	84.6	21,335
Jamaica	69.7	49.0	88.1	56.2	8,180
El Salvador	79.3	64.1	88.0	67.9	7,990
Vietnam ^a	53.0	28.8	70.2	50.4	5,838
Nigeria	13.6	9.9	19.0	10.5	5,435

⁵ Estimated cost-reflective tariffs exclude environmental costs due to data constraints. For Ethiopia, we use averages across the 24 Sub-Saharan African countries considered in Andres et al. (2019), which excludes Ethiopia, since otherwise the values for cost-reflective tariffs in this particular country are unrealistically high.

⁶ For most countries, the surveys are nationally representative. In Vietnam, the survey includes only five regions: Hanoi City, Da Nang, Dak Nong, Thu Dau Mot City and Binh Duong Province, and Ho Chi Min City.

⁷ Country estimates might differ slightly from those of the Joint Monitoring Programme (JMP) of the World Health Organization and United Nations Children’s Fund (UNICEF), due to some minor differences in variable definitions and sources. One common difference between our computation and JMP’s is that we define a household as connected to piped water if it uses piped water as its main source of drinking water either in the dry or wet season. The JMP also includes public standpipes as part of its piped water definition in some countries such as Ethiopia and Mali, whereas we include only household connections. Thus, our figures may be easily compared against the JMP’s for household connections only. For example, figures for Ethiopia and Nigeria are slightly higher in table 1 (19.8 percent and 13.6 percent, respectively, in column 1) than those presented by the JMP (15.2 percent and 12.2 percent, respectively).

⁸ As one might expect, there are also wide variations across the administrative geographic areas covered by the household surveys in each country, variations that are not shown in this paper.

Bangladesh ^b	13.6	2.8	41.3	4.7	3,319
Mali	11.1	2.2	29.6	0.9	1,971
Uganda	8.7	1.8	29.1	0.9	1,687
Ethiopia	19.8	3.5	63.9	2.4	1,608
Niger	9.1	0.8	49.7	0.1	914

Source: Original calculations using data from several household surveys.

Note: These are countrywide figures. Poor households are defined as belonging to the first four deciles of the expenditure (or income) distribution in each country. All figures are calculated using sample weights. Water connection is derived from questions about main source of drinking water—but some countries have information about sources of water for other uses (like Bangladesh), which are then also used to construct water connection. More information can be found in the appendix. Column 5 refers to GDP per capita, PPP (constant 2011 international U.S. dollars). GDP = gross domestic product; PPP = purchasing power parity.

^a The figures for rural Vietnam, using the 2015 Vietnam Household Registration Survey (VHRS), are much higher than the figures presented in JMP, using the Household Living Standards Survey (HLSS) 2012 that shows a rural rate of 13 percent. This is likely due to differences in the regional coverage of each survey. The VHRS 2015 has a sample that is representative of the population in five provinces—Ho Chi Minh City, Ha Noi, Da Nang, Binh Duong, and Dak Nong—while the HLSS 2012 is supposed to be nationally representative.

^b The figures for urban and total are higher than the figures published in JMP for the latest year. The data for Bangladesh used in this analysis differ from the data used in JMP. We use the Household Income and Expenditure Survey 2016, and the figures presented here are consistent with the official figures published in the Preliminary Report on Household Income and Expenditure Survey 2016, page xiii (BBS 2016).

Table 2 summarizes the number of providers (as listed in the IBNET dataset) whose service areas are also covered in the household surveys, the average cost-reflective tariffs, and imputed unit prices (conditional on the reporting of positive expenditure on water). (More information about IBNET data for each country can be found in the appendix.) Most countries in the sample try to target subsidies using increasing block tariff structures, though two African countries, Nigeria and Uganda, have fixed rates. In Bangladesh, some service providers charge a flat consumption rate while others use increasing block tariffs. El Salvador is the only country that has a volume-differentiated tariff structure. Some countries or providers also place a value-added tax on tariffs. For the analysis carried out in the following section, we use all the households surveyed in each country, and information from the utilities serving them. As explained earlier in this section, when a household is located in an area or region with no available tariff structure, we use information from other households in that country to impute quantities and unit prices paid.

Remarkably, all countries show higher cost-reflective tariffs than the average unit price paid by all households that report paying a positive amount for piped water. This already shows that all countries operate in a way that on average subsidizes residential consumers. However, six of the ten countries show a unit price higher than the estimated CRT_{OPEX} , suggesting that they can cover at least operating expenditures.

Table 2. Tariff data and estimated unit costs and prices

Country	Number of providers covered in the analysis ^a	Type of tariff structure	Estimated cost-reflective tariff (unit cost/m ³) CRT (\$ 2017)	Estimated OPEX cost-reflective tariff (unit cost/m ³) CRT _{OPEX} (\$ 2017)	Estimated effective average price/m ³ (\$ 2017)
---------	--	--------------------------	--	---	--

Ethiopia ^b	9	IBT	3.68	0.67	0.23
Mali	1	IBT with fixed charge + VAT	2.29	0.37	1.04
Niger	1	IBT	3.97	0.48	0.37
Nigeria ^c	10	Fixed rate/m ³ , some with a fixed rate	2.05	0.40	0.80
Uganda	1	Fixed rate/m ³	1.89	0.37	0.86
El Salvador ^d	1	VDT, with fixed charge for 10 m ³ or less	0.85	0.19	0.32
Jamaica ^e	1	IBT	2.51	0.55	1.69
Panama ^f	1	IBT	1.18	0.26	0.20
Bangladesh	23	Depends on utility (IBT, 16 with flat rate)	0.49	0.12	0.26
Vietnam	3	IBT (+ VAT for some)	2.70	0.62	0.38

Source: IBNET database, World Bank, and other resources.

Note: Since there are no available data on OPEX cost-reflective tariffs for El Salvador and Jamaica, we use the value for the total cost-reflective tariff, multiplying it by 0.22, which is the ratio of the average OPEX cost-reflective tariff to the average total cost-reflective tariff from Andres et al. (2019). The far-right column shows the unit price conditional on paying for water services (i.e., self-reported expenditure on water greater than zero). The figure is calculated using sampling weights. CRT = cost-reflective tariff; CRT_{opex} = OPEX cost-reflective tariff; IBT = increasing block tariff; m³ = cubic meter; OPEX = operating expenditure; VAT = value added tax; VDT = volume-differentiated tariff.

^a These are providers that cover areas included in the household surveys and for which there are available data online. Most of the data come from IBNET.

^b Data are from 2007 for Dire Dawa, and 2014 for Addis Ababa. The cost-reflective tariff includes both OPEX and CAPEX and is estimated using averages across 24 Sub-Saharan African countries in Andres et al. (2019), since the values otherwise presented for Ethiopia seem unrealistically high.

^c Data come from Abubakar (2016).

^d Data come from the state-owned piped-water provider, Administración de Acueductos y Alcantarillados (ANANDA).

^e Data are from the National Water Commission.

^f Data from the Autoridad Nacional de Servicios Públicos are used for OPEX cost-reflective tariffs for the year 2015 in U.S. dollars and divided by 0.22, which is the relationship between the average of the OPEX cost-reflective tariffs across countries from Andres et al. (2019), and the average of total cost-reflective tariffs across countries from the same paper.

2.3 Definition of variables of interest

In the following subsections we describe how we classify households by economic status (i.e., poor or not), identify whether they benefit from water consumption subsidies, and estimate the magnitude of the subsidies they receive. (Further information on how each variable is constructed for each country is provided in the appendix.)

Poor households (P) and all households (H)

Although we conduct our analysis at the household level, we construct deciles of expenditure (or income) on the basis of per capita expenditure (or income). Poor households are defined as belonging to the first four deciles of the national distribution of expenditure (or income) per capita in each country, and denoted by the subscript *P*. All households in each country are denoted by the subscript *H*.

Sampling weights were used to correct for the bias inherent in representative household surveys, which tend to underrepresent poorer households in low-income countries. Because we

conducted our analysis of expenditure at the household level—and average household size may vary across deciles, particularly in Africa—average total expenditure at the household level may not increase as expected when moving across the household per capita expenditure distribution.

Service area (SA)

Following Angel-Urdinola and Wodon (2007a), households are considered to have potential access to a network if they are located in a service area (SA_h),⁹ which takes the value of 1 if other households in their neighborhood reported having water connections in a household survey. We assume that households in a SA_h have the option of connecting to the piped water network present in their neighborhood. The neighborhood is proxied by the enumeration area where the household is located, according to household surveys. However, this assumption may not always be correct. If a neighborhood covers a large geographical area, or if the presence of an adjacent water main varies by household, the survey figures may overestimate the actual number of households with potential access to the piped water network.

We can define the ratio of all households that have potential access ($SA_H = \sum_{h=1}^H 1(SA_h = 1) / H$) and the equivalent ratio for the poor, which is defined as the number of poor households that have potential access divided by the total number of poor households ($SA_P = [\sum_{h=1}^P 1(SA_h = 1)] / P$).

Connected (C)

We set this variable to 1 if a household is connected to and drawing from the water network, and to zero otherwise. This is determined by the main source of drinking water, as self-reported in household surveys.

We then define $C_{H|SA}$, as the share of households that are connected to the network among those with potential access (i.e., located in a service area), which is a subset of all households H . Hence, $SA_H \times C_{H|SA}$ is equal to the actual connection rate among all households. Analogously, $C_{P|SA}$ is the proportion of poor households that are connected, conditional on their having potential access (or being located in a service area) or, equivalently, the number of poor households that are connected divided by the number of poor households that have potential access to the network.

Quantity of water consumed among those connected (Q)

We construct this variable by imputing water consumption volumes from self-reported household water expenditure, $E_{H|T}$, conditional on being connected to the network. The conversion is undertaken using the corresponding tariff structure from the IBNET data.¹⁰

In the first round of calculations, we impute quantities for households for which (i) the total bill for water consumption depends on the quantity consumed, (ii) the value of self-reported

⁹ The variable *service area* (SA) is equivalent to the variable *access* (A) in Komives et al. (2005) and Angel-Urdinola and Wodon (2007a). In this paper we prefer the phrase *service area* because it better reflects the variable we are measuring.

¹⁰ Information on how this match is made for each country is provided in the appendix.

expenditure on water is greater than zero, and (iii) there is a specific provider for which we have tariff structure information. For households that pay a fixed rate per cubic meter, the monthly quantity of water consumed equals the total expenditure on water divided by the rate. For households facing unit prices that vary by quantity consumed (such as increasing block or volume-differentiated tariffs), each block within the tariff structure is assigned a maximum expenditure level and associated quantity of water consumed. Then quantities are assigned to the household sample by matching self-reported household water expenditure with the corresponding level of the tariff structure. For the remainder of households, for which (i) the bill is a flat rate unrelated to water quantities consumed or (ii) self-reported expenditure on water equals zero,¹¹ we assume consumption quantities at the median of those households in the same country for which we could assign quantities. For those households that report a positive expenditure on piped water but are located in areas where they cannot be mapped to a specific provider, we use a median unit price derived from households with data, and recover the quantity of water consumed.

We then define $Q_{P|T}$ as the average quantity consumed by the poor, conditional on receiving a subsidy and being connected, and $Q_{H|T}$ as the analogous measure for the population as a whole. This variable is related to the subsidy design because the quantity of water consumed by subsidy recipients determines the total value of the subsidy each recipient will receive.

Average unit price of water paid among those connected (UP)

We define this variable as the ratio of (i) water expenditure (as self-reported in household surveys) to (ii) assigned quantities, as described above. For a household with a water expenditure of zero, the unit price would also be zero.

Subsidy beneficiaries among those connected (B), and targeting measures (T)

We define variable B as equal to 1 if a household is connected and pays a unit price (UP) for water that is lower than the cost-reflective tariff (CRT , as defined in above).

We then define B_H as the total number of households that receive water consumption subsidies, B_P as the total number of poor households that receive water consumption subsidies, and B_{NP} as the total number of non-poor households that receive water consumption subsidies.

We then define $T_{H|C}$ as the share of households that receive a subsidy (or are targeted) conditional on C (that is, being connected to the network within a service area). Analogously, $T_{P|C}$ represents the share of poor households that receive a subsidy conditional on C . Therefore, the beneficiary incidence of the consumption subsidy is determined by SA , C , and T . The share of all households receiving the subsidy is equal to $SA_H \times C_{H|SA} \times T_{H|C}$.

¹¹ In many countries, and particularly Ethiopia and Nigeria, many households appear to be connected to the network and use piped water as their main source of drinking water but report paying zero for their water. Anecdotal evidence indicates that many households are connected illegally to the network or that utilities do not invoice and collect payments as they should.

Value of the subsidy (S)

This number is constructed using the variables described above; for each household, this is equal to $S = Q_{P|T} \times (CRT - UP)$, conditional on $UP < CRT$ (i.e., $B = 1$).

Then, S_P is the value of the subsidies accruing to the poor, and S_H is the total value of the subsidy accruing to the population as a whole.

Rate of subsidization (R)

The average rate of subsidization is $R_{H|T} = 1 - E_{H|T} / (Q_{H|T} \times CRT) = 1 - UP / CRT$.

2.4 Distributional performance of subsidies

Having identified beneficiary households (B) and the size of subsidies (S) they receive, we estimate the share of subsidies accrued to each decile of the national expenditure (or income) distribution, and consider whether subsidies are progressive or not.

- i. *Progressive subsidies*: Subsidies are considered progressive when the share of subsidies accrued to each decile decreases over the expenditure (or income) per capita distribution. This means that poor households capture a higher portion of the subsidy pie.
- ii. *Regressive subsidies*: Conversely, subsidies are considered regressive when the share of subsidies accrued to each decile increases over the expenditure (or income) distribution.

We also estimate the share of overall countrywide household-level expenditure captured by each decile, and contrast this with the share of subsidy captured by each decile. This helps understand whether the subsidy in effect reduces inequality—that is, whether a greater percentage of subsidies is allocated to households in poorer deciles than is the case for countrywide expenditure. When the subsidy distribution is more skewed toward richer deciles than is the distribution of expenditure or income, the subsidy is regressive and increases inequality. However, if subsidies are less regressive than the distribution of expenditure or income, they can serve to reduce inequality.¹²

2.5 Performance of subsidies' targeting and underlying mechanisms

Following Angel-Urdinola and Wodon (2007a), we define the targeting performance indicator (Ω), which relates to a subsidy's distributional performance, as the share of subsidy benefits received by the poor (S_P/S_H), divided by the proportion of poor households in the total population (P/H).

The targeting performance indicator (Ω) can be split into factors related to water network access and factors related to subsidy design, using the variables defined in the previous section:

¹² These measures are simple statistics that can be easily displayed in bar charts, and are conceptually similar to the quasi-Gini coefficients described, for example, in Komives et al. (2005: 140–41).

$$\Omega = \frac{\frac{S_P}{P}}{\frac{S_H}{H}} = \frac{SA_P}{SA_H} \frac{C_{P|SA}}{C_{H|SA}} \frac{T_{P|C}}{T_{H|C}} \frac{R_{P|T}}{R_{H|T}} \frac{Q_{P|T}}{Q_{H|T}} \quad \text{(Equation 1)}$$

Where:

SA_P/SA_H is the ratio of (i) the share of poor households located in a service area (SA_P) to (ii) the share of all households located in a service area (SA_H) (access related);

$C_{P|SA}/C_{H|SA}$ is the ratio of (i) the proportion of poor households located in any given service area that are connected ($C_{P|SA}$) to (ii) the proportion of *all* households located in any given service area that are connected ($C_{H|SA}$) (access related);

$T_{P|C}/T_{H|C}$ is the relative proportion of (i) poor households with a subsidy, conditional on connection (subsidy design related) to (ii) all households with a subsidy, conditional on connection (subsidy design related);

$R_{P|T}/R_{H|T}$ is the relative rate of subsidization of poor households or all households, respectively, conditional on receiving a subsidy (subsidy design related); and

$Q_{P|T}/Q_{H|T}$ are relative quantities consumed by poor households or all households, respectively, conditional on being subsidized (subsidy design related).

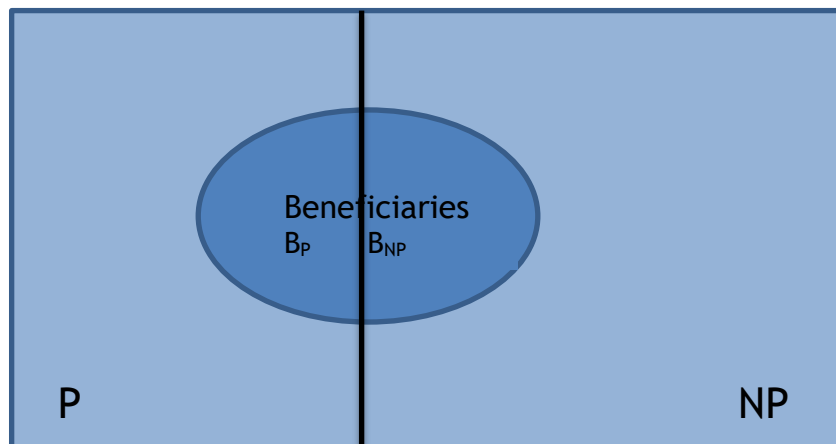
Access factors are fixed in the short term, since they are determined by network expansion and households' decisions, and will affect the distributional performance of a consumption subsidy, regardless of its type or structure.

Two additional measures used to assess subsidies' targeting performance are errors of inclusion and exclusion.

The error of exclusion (EE) is the share of households in poverty that are not benefiting from the subsidy: $EE = 1 - (B_P/P) = A_P \times U_{P|A} \times T_{P|U} = (P - B_P)/P$.

The error of inclusion (EI) is the share of beneficiary households that are not in poverty: $EI = B_{NP}/B_H = B_{NP}/(B_P + B_{NP})$. Figure 1 shows graphically how these errors are defined.

Figure 1. Illustration of the errors of inclusion and exclusion



Note: B_P = share of households in poverty; B_{NP} = share of households not in poverty; P = poor; NP = not poor.

3 Findings

3.1 Distributional performance of existing subsidies

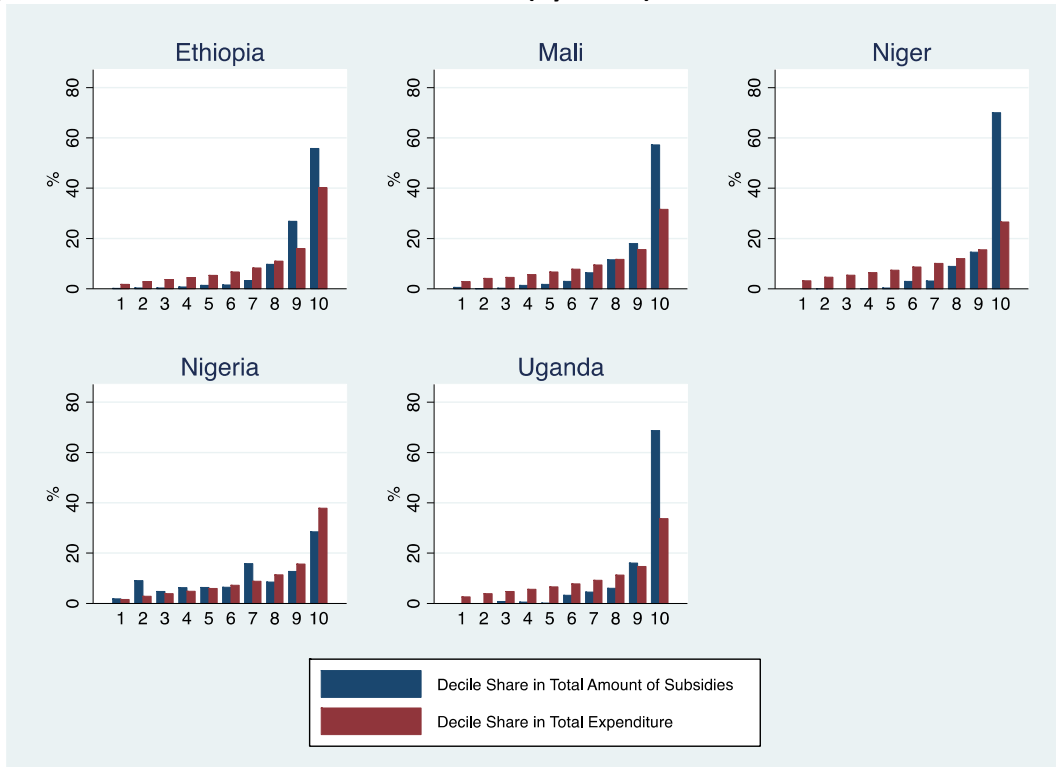
In this section we show the overall distributional incidence of water consumption subsidies across households by expenditure decile (or income decile for El Salvador and Panama).

As explained in section 2, each figure shows the percentage of subsidy captured by each decile (i.e., percentage of money spent on subsidies accruing to all households in the given decile). In addition, we present the share of total expenditure or income in the economy accruing to each decile, to show if the subsidy reduces inequality (i.e., is less concentrated in top deciles than is the overall expenditure or income distribution) or not.

As presented in figure 2, the results for the five African countries demonstrate a common trend: richer households enjoy a greater share of subsidies since the poor have less access to piped water and, even when connected, consume less water generally. In all countries, richer households receive the lion's share of subsidies. In Niger and Uganda, households in the top decile receive over 60 percent of all water consumption subsidies. In Mali, Niger, and Uganda, the poorest do not benefit from the subsidy at all. Nigeria is the only country where subsidies reduce rather than increase inequality.

Figure 3 shows the distribution of beneficiaries (households that receive the subsidy) across expenditure deciles for the same five countries. It complements the picture painted by the distributional incidence of the amount of subsidies. Wealthier deciles included the largest share of total subsidy beneficiaries (blue bars) and the largest share of all households within each decile that are beneficiaries (red bars). The differences between the top three deciles and the remaining ones are remarkable in all countries, although less pronounced in Nigeria. As noted above, in Niger, the poor (i.e., the first four deciles) do not benefit from the subsidy at all; Uganda shows a similar pattern, and in Mali only the fourth decile shows a very small amount of beneficiaries. We conclude that in the five African countries analyzed, and using the household data, tariff data, and the methodology described, consumption subsidies are regressive (albeit relatively less so in Nigeria).

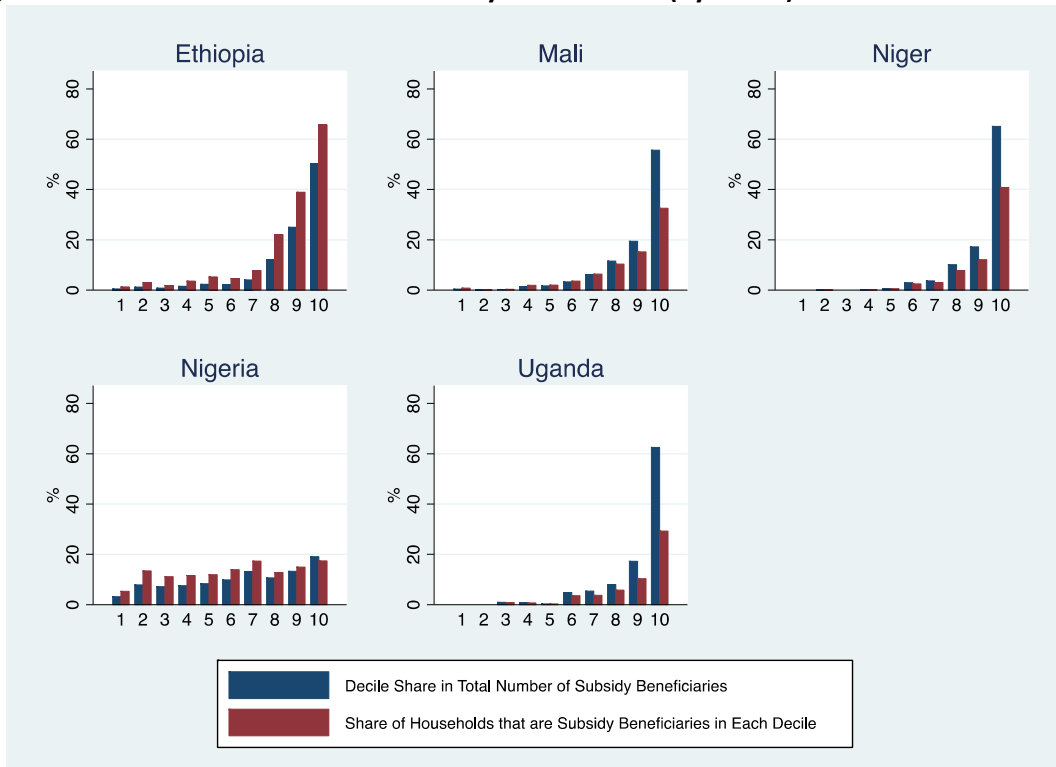
Figure 2. Distributional incidence of subsidies (by decile) in five African countries



Source: Original calculations using data from household surveys, IBNET, and national utilities and programs. See the data and methodology section, and the appendix, for more detail.

Note: All figures are calculated using sample weights. Total expenditure is total household expenditure in all categories. The distribution of expenditure refers to the countrywide distribution of expenditure per capita, i.e., households are ranked according to their expenditure per capita.

Figure 3. Distributional incidence of subsidy beneficiaries (by decile) in five African countries

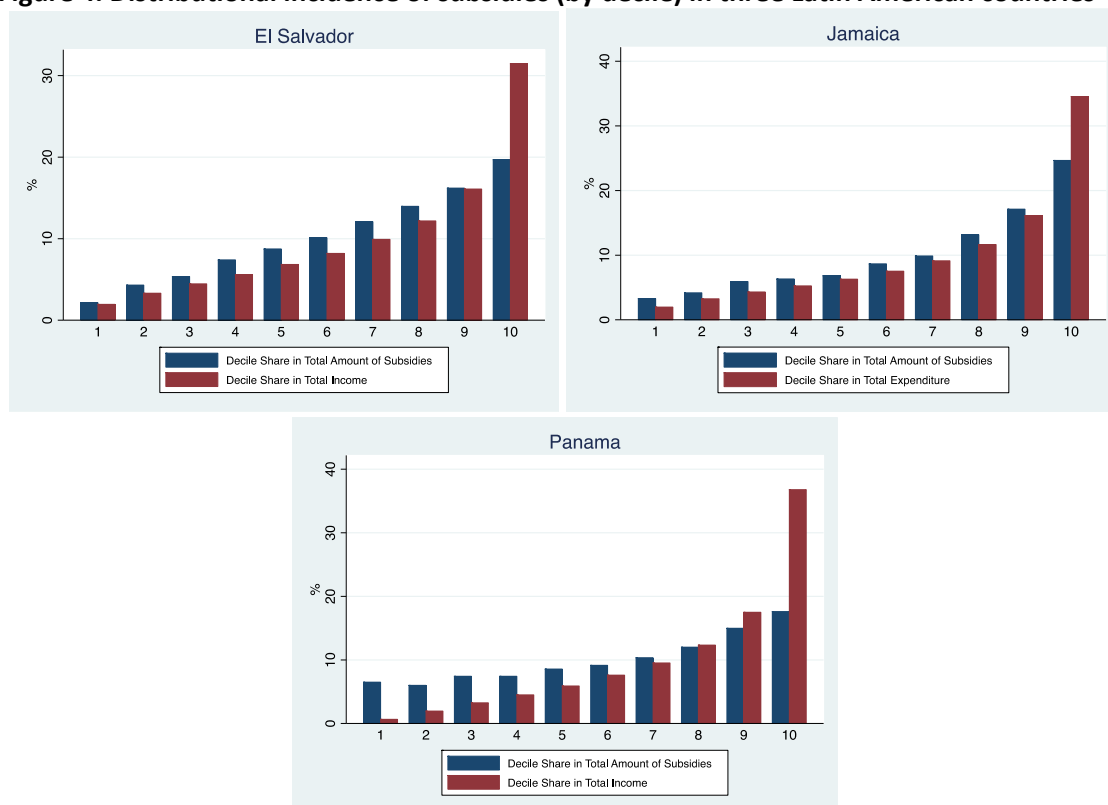


Source: Original calculations using data from household surveys, IBNET, and national utilities and programs. See the data and methodology section, and the appendix, for more detail.

Note: Subsidy beneficiaries are households. All figures are calculated using sample weights. Total expenditure is total household expenditure in all categories. The distribution of expenditure refers to the countrywide distribution of expenditure per capita, i.e., households are ranked according to their expenditure per capita.

Presented in figure 4, the results for Panama, Jamaica, and El Salvador have a similar pattern, demonstrating subsidies' regressivity. However, the degree of regressivity in Latin American countries is lower than in African countries. As shown in the next subsection, this is partly because both a greater number of poor households reside in service areas, and, conditional on this potential access, a greater percentage of poor households are connected to the network. The figures suggest that subsidy schemes in all three Latin American countries reduce inequality.

Figure 4. Distributional incidence of subsidies (by decile) in three Latin American countries

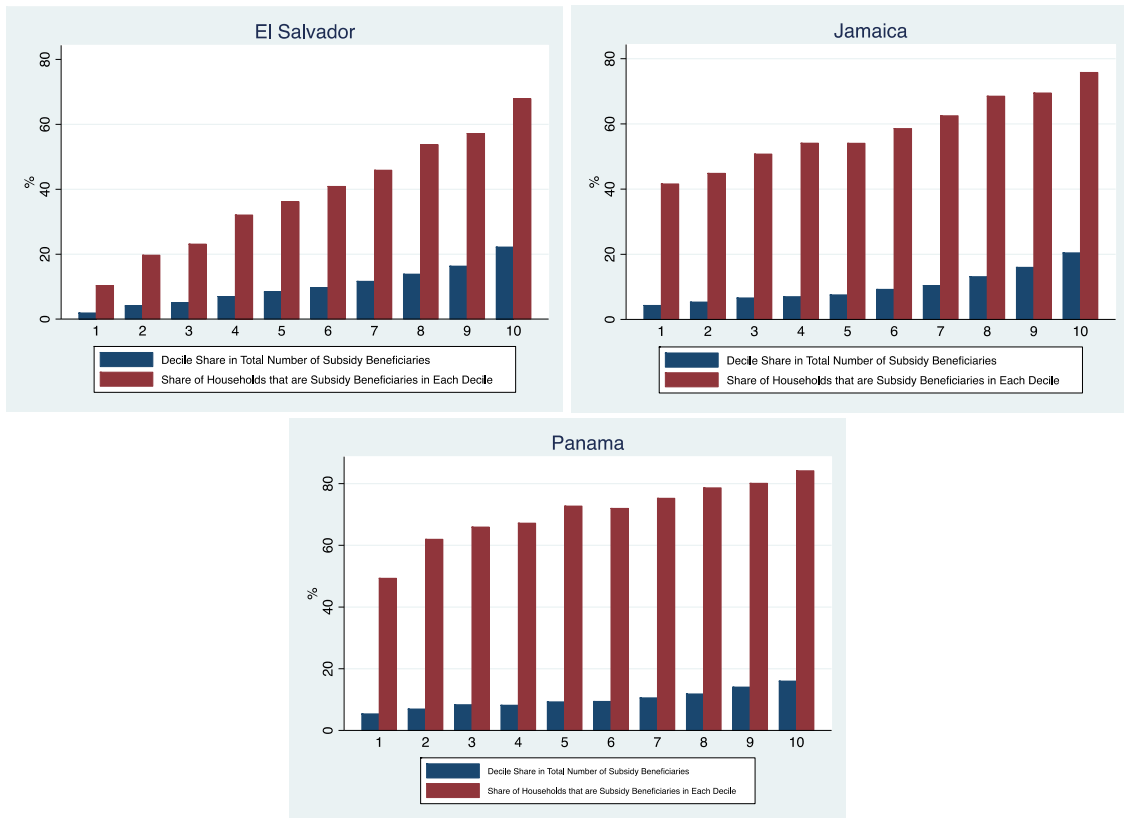


Source: Original calculations using data from household surveys, IBNET, and national utilities and programs. See the data and methodology section, and the appendix, for more detail.

Note: All figures are calculated using sample weights. Total expenditure is total household expenditure in all categories. The distribution of expenditure (Jamaica) or income (El Salvador and Panama) refers to the countrywide distribution of expenditure/income per capita, i.e., households are ranked according to their expenditure/income per capita.

Figure 5 shows the distribution of beneficiaries (households that receive the subsidy) across expenditure or income deciles for the three countries. As with the African countries, it complements the picture painted by the distributional incidence of the amount of subsidies. Richer deciles feature the largest share of total subsidy beneficiaries (blue bars) and the largest share of all households within each decile that are beneficiaries (red bars), although in Panama the pattern is less pronounced.

Figure 5. Distributional incidence of subsidy beneficiaries (by decile) in three Latin American countries



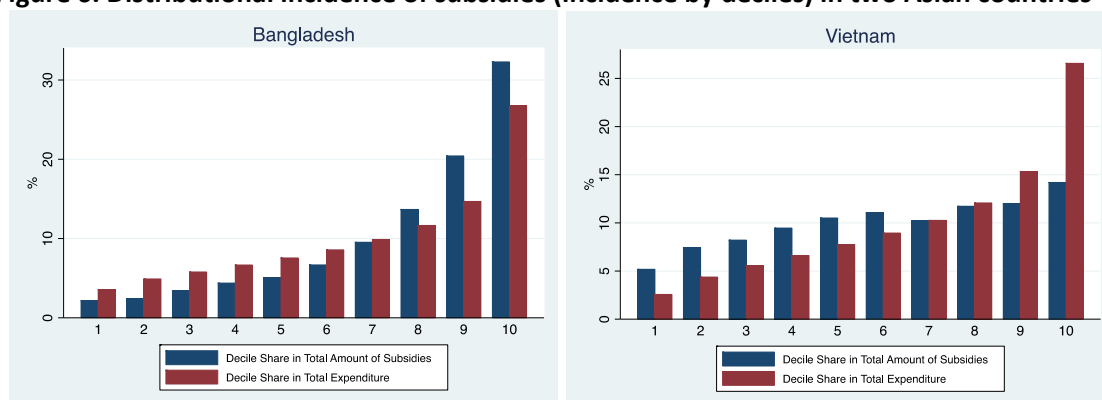
Source: Original calculations using data from household surveys, IBNET, and national utilities and programs. See the data and methodology section, and the appendix, for more detail.

Note: Subsidy beneficiaries are households. All figures are calculated using sample weights. Total expenditure is total household expenditure in all categories. The distribution of expenditure (Jamaica) or income (El Salvador and Panama) refers to the countrywide distribution of expenditure/income per capita, i.e., households are ranked according to their expenditure/income per capita.

Figure 6 shows the results for two Asian countries, Bangladesh and Vietnam. In Bangladesh, water consumption subsidies are strongly regressive and increase inequality. While subsidies in Vietnam are still regressive, albeit less so, they are actually reducing inequality, suggesting slightly better targeting than in Bangladesh. Figure 7, which depicts the distribution of beneficiary households across deciles, shows strong regressivity in Bangladesh but a more even distribution across expenditure deciles in Vietnam, once again suggesting better targeting.

In the next subsection, we look at a more synthetic measure of targeting performance that complements this analysis and consider both access and subsidy design factors driving this performance.

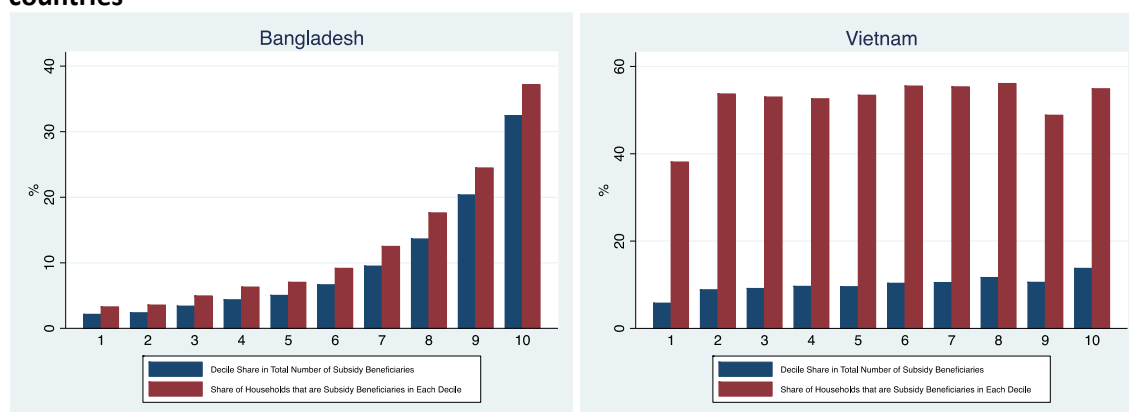
Figure 6. Distributional incidence of subsidies (incidence by deciles) in two Asian countries



Source: Original calculations using data from household surveys, IBNET, and national utilities and programs. See the data and methodology section, and the appendix, for more detail.

Note: All figures are calculated using sample weights. Total expenditure is total household expenditure in all categories. The distribution of expenditure refers to the countrywide distribution of expenditure per capita, i.e., households are ranked according to their expenditure per capita.

Figure 7. Distributional incidence of subsidy beneficiaries (incidence by deciles) in two Asian countries



Source: Original calculations using data from household surveys, IBNET, and national utilities and programs. See the data and methodology section, and the appendix, for more detail.

Note: Subsidy beneficiaries are households. All figures are calculated using sample weights. Total expenditure is total household expenditure in all categories. The distribution of expenditure (Jamaica) or income (El Salvador and Panama) refers to the countrywide distribution of expenditure/income per capita, i.e., households are ranked according to their expenditure/income per capita.

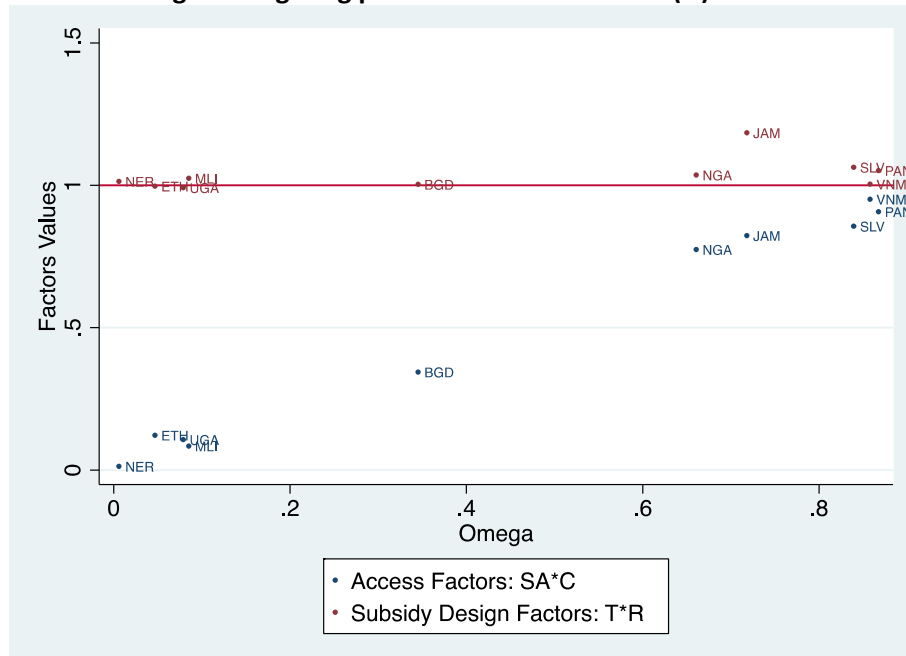
3.2 How well are existing subsidies targeting the poor?

Table 3 and figure 8 show the targeting performance of water consumption subsidies in the 10 countries under analysis. Figure 8 shows how access factors ($SA \cdot C$) and subsidy design factors ($T \cdot R$) drive the omega (Ω) value across countries. Table 3 presents the values of each factor for each country. A value below 1 indicates that the factor lowers performance, whereas a value above 1 indicates that the factor boosts performance.

As shown in figure 8, all African, Latin American, and Asian countries present Ω values below 1, demonstrating that water consumption subsidies are poorly targeted to the most vulnerable populations. Access factors (blue dots) are the driving force explaining low Ω values in most

countries. Subsidy design factors (red dots) are in general around or above 1. These indicators suggest that policy makers should mainly focus on increasing access to services, although enhancing subsidy design could also be beneficial.

Figure 8. Factors driving the targeting performance of subsidies (Ω) across countries



Source: Original calculations using data from household surveys, IBNET, and national utilities and programs. See the data and methodology section, and the appendix, for more detail.

Note: Of access factors, $SA = SA_P/SA_H$ is the share of households located in a service area for the poor relative to the population as a whole; $C = C_{P|SA}/C_{H|SA}$ is the relative share of households that are connected to the service conditional on potential access (being located in a service area). Of subsidy design factors, $T = T_{P|C}/T_{H|C}$ is the relative proportion of households with a subsidy conditional on usage; $R = R_{P|T}/R_{H|T}$ is the relative rate of subsidization. Factor values below 1 indicate that the factor lowers targeting performance, whereas factor values above 1 indicate that the factor boosts targeting performance. BGD = Bangladesh; ETH = Ethiopia; JAM = Jamaica; MLI = Mali; NER = Niger; NGA = Nigeria; UGA = Uganda; PAN = Panama; SLV = El Salvador; VNM = Vietnam.

Various factors influence the degree to which targeting performance is inadequate across countries. In table 3 we explore relevant access and subsidy design factors in more detail.

Four African countries—Ethiopia, Mali, Niger, and Uganda—show an estimated value of Ω lower than 0.1. In all four the main factors that decrease the efficiency with which subsidies target poor households relative to all households include (i) poor households’ lower probability of being located in a service area and (ii) their lower probability of being connected to a water network, conditional on being located in a service area. Additionally, in Ethiopia and Niger, the relatively low water quantities consumed by the poor significantly decrease targeting performance.

Nigeria shows an Ω above 0.5, revealing a significant problem, although it is less acute than in Ethiopia, Mali, Niger, and Uganda. SA , C , and Q are closer to 1, and $T = 1$ and $R = 1.03$. This is consistent with the evidence in the previous subsection, which shows that Nigeria’s distributional incidence of subsidies by decile is regressive, although to a less pronounced degree than in the other four African countries.

In order to improve the targeting performance of water consumption subsidies, these governments should expand the service area (i.e., SA) of their utilities and connect more households within this service area (i.e., C) to the water network. Additionally, these countries should improve the design of their water consumption subsidies to better target poor households (increasing T to values over 1).

In El Salvador, Jamaica, and Panama, the problem is less acute, with an Ω of 0.84, 0.69, and 0.87, respectively. In these countries the factors lowering Ω to below 1 are different. In all three, the probability of living in a service area is high for both types of households, poor and non-poor (SA is close to 1). However, connection rates conditional on location in a service area and water quantities consumed are both significantly lower for poor households, driving Ω to below 1. These countries would benefit from increasing service connection rates, as well as improving subsidy design to better target the poor (resulting in the increase of variables T and R further above 1).

Bangladesh falls in between African and Latin American countries, with an Ω of 0.35. Both the variables SA and C are low in general, and particularly low for poor households. Water quantities consumed by the poor are similar to those of other households, but this is potentially driven by the lack of information on households' expenditures and the flat rates being charged, which complicates imputing Bangladesh's household-specific water consumption (therefore, a median consumption quantity is assumed for most households). A parameter Q close to 1 is potentially reasonable given that any connected household, regardless of its consumption level, pays a flat rate. Nonetheless, potentially all factors (SA , C , T , R), in addition to the tariff structure, could be improved. In Vietnam, the value for Ω is much higher, though still below 1, and a focus on subsidy design (T and R) could increase targeting performance.

Table 3. Decomposing the targeting performance of water consumption subsidies

	Ω (1)	SA (2)	C (3)	T (4)	R (5)	Q (6)
	$\Omega > 1$ \square pro-poor	Potential access to water connection (service area)	Connection rate (for those with access)	Receipt of subsidy (for those connected)	Rate of subsidization (for those with a subsidy)	Quantities (for those connected)
Ethiopia	0.047					
Poor		0.255	0.095	1.000	0.957	3.275
All		0.446	0.444	0.996	0.964	8.567
Poor/All		0.571	0.214	1.004	0.993	0.382
Mali	0.085					
Poor		0.036	0.263	0.907	0.858	14.491
All		0.239	0.467	0.958	0.793	14.751
Poor/All		0.150	0.563	0.948	1.081	0.982
Niger	0.006					
Poor		0.030	0.040	1.000	0.921	10.453
All		0.209	0.433	1.000	0.909	23.651
Poor/All		0.141	0.093	1.000	1.014	0.442
Nigeria	0.661					
Poor		0.507	0.208	0.997	0.929	3.270
All		0.585	0.233	0.993	0.900	3.972
Poor/All		0.867	0.894	1.004	1.032	0.823
Uganda	0.079					
Poor		0.204	0.045	1.000	0.544	5.173
All		0.332	0.261	1.000	0.549	6.965
Poor/All		0.610	0.17	1.00	0.99	0.74
El Salvador	0.839					
Poor		0.945	0.719	0.996	0.679	19.230
All		0.966	0.821	0.983	0.647	20.863
Poor/All		0.977	0.876	1.013	1.050	0.922
Jamaica	0.690					
Poor		0.998	0.563	0.969	0.773	10.318
All		0.998	0.698	0.955	0.653	14.456
Poor/All		1.000	0.806	1.015	1.183	0.714
Panama	0.867					
Poor		1.000	0.846	1.000	0.872	40.453
All		1.000	0.932	1.000	0.829	44.484
Poor/All		1.000	0.907	1.000	1.052	0.909
Bangladesh	0.345					
Poor		0.286	0.164	0.998	0.999	36.555
All		0.384	0.355	0.998	0.995	36.579
Poor/All		0.745	0.462	1.000	1.003	0.999
Vietnam	0.858					
Poor		0.804	0.627	1.000	0.861	13.863
All		0.840	0.631	1.000	0.858	15.430
Poor/All		0.958	0.993	1.000	1.004	0.898

Source: Original calculations using data from household surveys, IBNET, and national utilities and programs. See the data and methodology section, and the appendix, for more detail.

Note: Access factors: $SA = SA_P/SA_H$ is the share of households located in a service area for the poor relative to the population as a whole; $C = C_{P/SA}/C_{H/SA}$ is the relative share of households that are connected to the service conditional on potential access (being located in a service area). Subsidy design factors: $T = T_{P/C}/T_{H/C}$ is the relative proportion of households with a subsidy conditional on usage; $R = R_{P/T}/R_{H/T}$ is the relative rate of subsidization; $Q = Q_{P/T}/Q_{H/T}$ are relative quantities consumed. A factor value below 1 indicates that the factor contributes to reduced targeting performance, whereas a value above 1 indicates that the factor contributes to increased targeting performance. All figures are calculated using sample weights. Poor households are defined as belonging to the first four deciles of the expenditure (or income) distribution in each country.

Table 4 shows the errors of inclusion (the proportion of beneficiary households that are in the top six deciles, or relatively rich) and the error of exclusion (the proportion of poor households that do not receive a water consumption subsidy). These errors are not conditional on location in a service area or connection, so they differ from those in table 3. The estimates show that in most countries covered here, the errors of exclusion range from 78 percent to nearly 100 percent, except for Jamaica, Panama, and Vietnam (column 2). This is consistent with the very low levels of Ω presented in table 3. The countries on the lower end of this spectrum exhibit errors of exclusion around 50 percent, suggesting that their level of outreach to the poor could still be improved.

Inclusion errors (column 1 of table 4) are extremely high in all countries, suggesting a wide margin for the improvement of targeting, consistent with the analysis presented so far. The inclusion errors are particularly high in African countries, with figures close to 100 percent in all countries except Nigeria. Bangladesh also stands out with figures close to 90 percent.

Table 4. Water consumption subsidies, and errors of inclusion and exclusion

	Error of inclusion (%)	Error of exclusion (%)
	(1)	(2)
Ethiopia	96.01	97.57
Mali	97.82	99.15
Niger	99.73	99.93
Nigeria	74.35	89.59
Uganda	98.28	99.60
El Salvador	82.01	78.27
Jamaica	51.78	51.78
Panama	71.14	38.56
Bangladesh	87.67	95.45
Vietnam	66.51	50.28

Source: Original calculations using data from household surveys, IBNET, and national utilities and programs. See the data and methodology section, and the appendix, for more detail.

Note: Poor households are defined as belonging to the first four deciles of the expenditure (or income) distribution in each country. Error of inclusion is measured by the percentage of all beneficiary households that are rich; error of exclusion is measured by the percentage of poor households that do not get a subsidy. All figures are calculated using sample weights.

4 Conclusion

This paper offers a methodology to both estimate the amount of subsidy resulting from piped water consumption tariffs and assess the resulting subsidy's efficacy in improving the accessibility and affordability of service for the poor. In an analysis of 10 low- and middle-income countries, we find that piped water is substantially subsidized, as existing tariffs do not fully recover the costs of service provision. Moreover, these consumption subsidies fail to efficiently address service gaps among the poor due to ineffective targeting. Our analysis reveals remarkably consistent findings across countries, despite their great diversity in terms of economic development, national income levels, piped water coverage, and the costs of producing and distributing piped water.

Overall, we find that water consumption subsidies in all 10 countries are regressive and therefore do not adequately target the poor (Ω has a value under 1 in all cases, with an average value of 0.45 across all 10 countries). We also find that the severity of regressivity varies significantly (from 0.006 in Niger to 0.87 in Panama).

Only a very small number of poor households benefit from subsidies, particularly among the African countries in our sample. This is because poor households are less likely to be located in areas serviced by utility providers (the variable *SA* in the analysis), and even where they are, they are less likely to be connected and consuming piped water (variable *C*) than the general population.

This suggests that subsidies insufficiently target the poor primarily because of access factors (*SA* takes a value of 0.7 and *C* takes a value of 0.6 on average across all 10 countries). This problem is particularly pressing in the African countries (with an average *SA* of 0.47 and average *C* of 0.39 across the sample) and Bangladesh (which has an *SA* of 0.75 but a *C* of 0.46).

Aside from improving access for the poor, subsidy design could also be improved to better target the poor. As shown, the share of poor households that receive a subsidy conditional on being connected to the network—relative to the equivalent share for the whole population (*T*)—averages 0.99. The rate of subsidization conditional on receiving a subsidy for the poor—relative to the equivalent rate for the whole population (*R*)—averages 1.02 across all 10 countries. This signals a need for improved subsidy design that reflects current network coverage and connection rates. This trend is observed in all countries.

All in all, this means that in the 10 countries considered here—and, perhaps, in most developing countries—improving the targeting of current subsidy schemes to the poorest households will primarily require improving these households' access to service. Therefore, network expansion into poorer neighborhoods and policies that facilitate household connections should be pursued. In countries where water access is no longer a significant issue, modifying a subsidy's design could itself improve how well the subsidy targets the poor.

References

- Abramovsky, L., and D. Phillips. 2015. "A Tax Micro-Simulator for Mexico (MEXTAX) and Its Application to the 2010 Tax Reforms." IFS Working Paper W15/23, Institute for Fiscal Studies, London.
- Abubakar, I. R. 2016. "Quality Dimensions of Public Water Services in Abuja, Nigeria." *Utilities Policy* 38 (February): 43–51.
- Andres, L. A., M. Thibert, C. Lombana Cordoba, A. V. Danilenko, G. Joseph, and C. Borja-Vega. 2019. *Doing More with Less: Smarter Subsidies for Water Supply and Sanitation*. Washington, DC: World Bank. <https://openknowledge.worldbank.org/handle/10986/32277>.
- Angel-Urdinola, D., and Q. Wodon. 2007a. "Do Utility Subsidies Reach the Poor? Framework and Evidence for Cape Verde, Sao Tome, and Rwanda." *Economics Bulletin* 9 (4): 1–7.
- . 2007b. "Does Increasing Access to Infrastructure Services Improve the Targeting Performance of Water Subsidies?" <https://ssrn.com/abstract=1133125> or <http://dx.doi.org/10.2139/ssrn.1133125>.
- Komives, K., V. Foster, J. Halpern, Q. Wodon, and R. Abdullah. 2005. *Water, Electricity, and the Poor: Who Benefits from Utility Subsidies?* (English). Directions in Development. Washington, DC: World Bank. <http://documents.worldbank.org/curated/en/606521468136796984/Water-electricity-and-the-poor-who-benefits-from-utility-subsidies>.
- NWC (National Water Commission). 2013. *NWC Tariff Submission for the Period 2013 to 2018*. Jamaica: NWC. https://www.our.org.jm/ourweb/sites/default/files/documents/sector_documents/nwc_tariff_submission_for_2013_-_2018.pdf.
- UN (United Nations). 2015. "Sustainable Development Goals." <https://sustainabledevelopment.un.org/?menu=1300>.
- World Bank Group. 2017. *Reducing Inequalities in Water Supply, Sanitation, and Hygiene in the Era of the Sustainable Development Goals: Synthesis Report of the WASH Poverty Diagnostic Initiative*. Washington, DC: World Bank. <https://openknowledge.worldbank.org/handle/10986/27831>.
- WWAP (World Water Assessment Programme). 2019. *The United Nations World Water Development Report 2019: Leaving No One Behind*. Paris: United Nations Educational, Scientific, and Cultural Organization (UNESCO).

Appendix:

Table A.1 Household surveys and sample sizes

Country	Survey	Year	Sample of households			
			Total	Rural	Urban	Poor
1. Ethiopia	Ethiopian Socio-Economic Survey	2015/16	4,954	3,272	1,682	1,353
2. Mali	Enquête Modulaire et Permanente Auprès des Ménages (EMOP)	2014	5,462	3,081	2,381	1,265
3. Niger	National Survey on Household Living Conditions and Agriculture	2014	3,617	2,319	1,298	808
4. Nigeria	General Household Survey (GHS) Panel Wave-3 Survey	2015/16	4,560	3,112	1,448	1,718
5. Uganda	The Uganda National Panel Survey	2013/14	3,117	2,302	815	1,003
6. El Salvador*	Encuesta de Hogares de Propósitos Múltiples	2016	20,609	9,561	11,048	8,058
7. Jamaica	Jamaica Survey of Living Conditions	2012	6,579	3,688	2,417	2,074
8. Panama*	Encuesta de Hogares de Propósitos Múltiples	2015	11,502	5,040	6,462	4,694
9. Bangladesh	Household Income and Expenditure Survey (HIES)	2016	46,034	32,067	13,967	18,323
10. Vietnam	Household Registration System Survey	2015	5,000	2,100	2,900	1,232

Source: Original compilation based on sources listed in column 2.

Note: Poor households are defined as belonging to deciles one to four of the expenditure per capita (or income per capita if marked with *) distribution, depending on the country (see below).

Construction of water connection variables at the household level

1. *Ethiopia*: Connected to piped water is defined as hh_s9q13 = 1 or 2, or hh_s9q14 = 1 or 2.
2. *Mali*: Connected to piped water is defined as L08_E = 1, 2 (inside or outside dwelling).
3. *Niger*: Connected to piped water is defined as MS06Q13 = 1.
4. *Nigeria*: Connected to piped water is defined as s11q33a = 1 or 2 (in dry season) or s11q33b = 1 or 2 (in wet season).
5. *Uganda*: Connected to piped water is defined as H9q7 = 10 (piped water into dwelling), or H9q7 = 11 (piped water to the yard).
6. *El Salvador*: Connected to network water services (piped water) is defined as r312 = 1, 2, 3, 4, 4.1, 6. (ANDA [Administración de Acueductos y Alcantarillados] is the state-owned piped-water provider that directly serves around 30 percent of the households in the sample.)
7. *Jamaica*: Connected to piped water is defined as i22 = 1 or 2.
8. *Panama*: Connected to piped water is defined as v1i_agua_b = 1 or 2. There was no information on the enumeration area (EA) in 2015, but in 2014 there was information about access and EA (but no information on expenditure, so 2015 is used). Water access is equal to 1 for all households, so we assume access is equal to 1 for all households in 2015 as well.

9. *Bangladesh*: Connected to piped water (supply water) is defined as s6aq12 = 1, s6aq15 = 1, or s6aq16 = 1.
10. *Vietnam*: Connected to piped water is defined as m6c10 = 1.

Tariff structure and imputation of quantities, unit prices, and subsidies

As explained in section 2 of this report, the tariff data are taken from the International Benchmarking Network for Water and Sanitation Utilities (IBNET) in most cases, and the year corresponds to the closest available to when the household survey was conducted. It is worth noting further specificities for each country when imputing quantities, unit prices, and subsidies:

1. *Ethiopia*: Each city or region has its own provider. There is only information on tariff structure for nine areas, so we compute the unit price paid by all households in areas we have information for and use this unit price for other households connected to water, and then combine this information with expenditures to impute quantities and calculate subsidies. Information from IBNET was used for the utilities listed in table A.2.

Table A.2 Utilities and tariff structure used in Ethiopia

Utility	Year of tariff structure used
Addis Ababa Water and Sewerage Authority	2014
Ambo Water Supply	2013
Dire Dawa Water Supply and Sewerage Authority	2007
Debremarkos Water Supply and Sewerage Service Office	2013
Dessie Water Supply	2013
Gondar Water Supply and Sewerage Service Office	2013
Shashemene Water Supply and Sewerage Service Enterprise	2013
Mekelle Water Supply Service Office	2013
Wukro Water Supply Service Office	2013

Source: IBNET database.

2. *Mali*: There is only one water supplier, Société Malienne de Gestion de l'Eau Potable, in the country and we have information on the tariff structure from IBNET for the year 2013.
3. *Niger*: There is only one water supplier, Societe De Patrimoine Des Eaux Du Niger, in the country and we have information about the tariff structure from IBNET for the year 2009.
4. *Nigeria*: IBNET covers nine utility providers in the states of Ekiti, Enugu, Kaduna, Kano, Katsina, Niger, Oyo, Plateau, and the city of Lagos. Data on Abuja has been sourced from Abubakar (2016). There are many other providers in each of the 37 regions covered by the household survey, but tariff structure data are not accessible. Hence, we impute the fixed rate as the average of the effective fixed rate charged in each of the states we do have information for, using the few households for which self-reported water expenditure is positive (202 nairas per cubic meter). Around 75 percent of connected households report zero expenditure on water.

Table A.3 Utilities and tariff structure used in Nigeria

Utility	Year of tariff structure used
---------	-------------------------------

Ekiti State Water Corporation	2018
Enugu State Water Corporation	2008
Kaduna State Water Board	2018
Kano State Water Board	2013
Katsina State Water Board	2015
Niger State Water Board	2018
Oyo State Water Corporation	2018
Plateau State Water Board	2012
Lagos Water Corporation	2017

Source: IBNET database.

5. *Uganda*: There is only one provider of piped water in the IBNET data, Uganda National Water & Sewerage Corporation, and there is no information to identify which households in the survey get piped water from this provider. Hence, we use the tariff structure of this provider to impute quantities and subsidies paid by all households connected to piped water. The tariff structure is from the year 2017.
6. *El Salvador*: There is one big public provider of piped water, Administración de Acueductos y Alcantarillados (ANDA), and many other local suppliers. However, we only have information on the tariff structure for ANDA clients for the year 2015, and hence we use this tariff structure for households connected to ANDA to get parameters T , R , and Q to analyze the distributional performance of subsidies. The tariff structure is a volume-differentiated tariff with extra charges for sewerage. In addition, most of the ANDA-connected households have a toilet connected to sewerage services so we assume that all pay the extra charge, and calculate quantities based on the complete tariff structure for water and sewerage services.
7. *Jamaica*: Tariffs are increasing block tariffs with a fixed cost. However, around 70 percent of the water supply was free of charge (nonrevenue water) in 2013 according to the National Water Commission (NWC 2013: 57). Many of the households that reported having access to piped water report zero expenditure, contributing to nonrevenue water.¹³ For those households that are connected but report no expenditure on water, we impute an average water consumption of 16 m³ and unit price of zero.¹⁴ We use tariff structure data from IBNET for the National Water Commission for the year 2016.
8. *Panama*: Tariffs are increasing block tariffs with an initial fixed charge for consumption under 30 m³. There are different providers, but all have the same tariff structure and levels and by law utility companies have to charge cost-reflective tariffs and avoid cross-subsidies, to promote rational and efficient water consumption and efficient supply and demand.¹⁵ We use tariff structure data from IBNET for the Instituto de Acueductos y Alcantarillados Nacionales (IDAAN) for 2016.

¹³ The National Water Commission (NWC 2013: 152) proposes that one of the main reasons that households report being connected but making zero expenditure is due to illegal connections.

¹⁴ According to NWC (2013), the average consumption per residential connection per month is around 16 m³ (see figure 7.4 in NWC [2013], which reports 3,600 imperial gallons per residential connection per month, equivalent to 16 m³).

¹⁵ See Article 32 of Republic of Panama Government Decree No. 2 of 1997: https://www.asep.gob.pa/?page_id=14202

9. *Bangladesh*: Most households report water expenditure equal to zero, even if connected to piped water. In addition, many of the utility providers charge a flat rate (16 out of the 23 with available data in IBNET). Hence it is difficult to calculate the quantity consumed and the unit price. Of the seven districts with providers that charge a nonflat rate (Brahmanbaria, Chittagong, Dhaka, Jhalokati, Lakshmipur, Manikganj, and Sherpur), only households in Chittagong, Dhaka, and Manikganj report positive values of expenditure on water; the rest report zero expenditure. We calculate the quantity consumed and unit price for households that report positive expenditure in areas where there is a nonflat rate, so that quantity can be estimated. This is a very restrictive sample, but it is the only way to get an approximation of the quantities consumed and the price paid and hence of the Ω indicator, assuming all households that are connected consume the average quantity of those households with positive expenditure for which quantities can be estimated. In practice, we use the tariff structure for the seven utilities listed in table A.4, which do not charge a flat rate, to calculate unit prices and quantities consumed.

Table A.4 Utilities and tariff structure used in Bangladesh

Utility	Year of tariff structure used
CWASA, Chittagong	2015
DWASA, Dhaka and Naryanganj	2015
MaP, Manikganj	2015
Lakshmipur	2015
Jhalakathi Pourashava	2015
SHP, Sherpur	2015
Brahmanbaria Pourashava	2015

Source: IBNET database.

10. *Vietnam*: We have information about the tariff structure for only three utility providers serving some of the largest of the five provinces covered by the household survey. We use that information for households, plus impute unit prices and quantities for the other two areas using the median of the estimated price and quantities for those for which we have area-specific information. Vietnam has a large number of utility providers (around 180) scattered over the roughly 60 provinces in the national territory. Table A.5 lists the information from IBNET that we use in practice in the analysis.

Table A.5 Utilities and tariff structure in Vietnam

Utility	Year of tariff structure used
Hanoi Water Supply Co. Ltd, Ha Noi City	2015
Sai Gon Water Supply Corporation, Ho Chi Minh City	2013
Binh Duong Water Supply, Sewerage and Environment Co. Ltd, Thu Dau Mot City	2016

Source: IBNET database.