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Do Utility Subsidies Reach the Poor? Framework and Evidence for Cape Verde, Sao Tome, and Rwanda

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Abstract

This article provides a simple framework to analyze the determinants of targeting performance of utility tariffs and applies it to data on electricity in Cape Verde, Rwanda, and Sao Tome and Principe. While most indicators of benefit incidence are silent as of why subsidies are targeted the way they are (they only give an idea as to whether they reach the poor or not and to what extent), we develop a simple decomposition that allows analyzing both "access" and "subsidy-design" factors that influence the targeting performance of subsidies. Our findings suggest that consumption subsidies for electricity in Cape Verde, Rwanda, and Sao Tome and Principe are regressive in large part due to access factors that prevent the poor from using the services. We then conduct simulations to quantify how much targeting performance could be enhanced by changing tariff-structures as well as subsidizing connections instead of consumption.

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1. Introduction

Given the budget constraints faced by many governments a good targeting performance of public subsidies (whether in cash or in kind) is important for the reduction of poverty. Several studies have been devoted to assessing the targeting performance of a wide range of programs in developing and transition economies (e.g., Grosh 1994; Subbarao et al. 1997; Braithwaite et al. 2000; Coady et al. 2004). In the case of utilities such as water and electricity, while subsidies are very widespread, it is not clear that they are well targeted (Wodon et al., 2003; Komives et al., 2005; Angel-Urdinola et al., 2006)[1]. This is problematic given that in developing and transition economies, utility subsidies are often more costly than other transfer programs (Alderman 2002).

The objective of this note is to provide a framework to analyze the determinants of the targeting performance of social programs and transfers, with an application to electricity subsidies in three African countries. While most indicators of benefit incidence are silent as of why subsidies are targeted the way they are (they only give an idea of the targeting performance of the subsidies)[2], we develop a simple decomposition that allows analyzing both "access" and "subsidy-design" factors that affect the overall targeting performance of subsidies. Section 2 describes the framework, which is then applied to electricity subsidies in Section 3.

2. Framework

In what follows, we use capital letters to denote means across the population as a whole or the poor, and lower case letters to define household level variables. Define by S_P and S_H the amounts of subsidies granted to the poor and to the population as a whole respectively. While we consider electricity subsidies here, the framework can be applied to any other type of subsidy. Our benefit targeting performance indicator Ω is defined as the share of the subsidy benefits received by the poor (S_P/S_H) divided by the proportion of the population in poverty (P/H), where H denotes all households and P denotes the households who are poor. A value that is lower (greater) than one implies that the average subsidy for the poor is lower (greater) than the average subsidy received in the population as a whole. The parameter Ω can be computed from household surveys with data on expenditure or consumption of utility services provided that information is also available on tariff structures. The value of Ω is:

$$\Omega = \frac{S_P}{S_H}\frac{H}{P} = \frac{\sum_{i=1}^{P} q_i(p_i - C)}{\sum_{i=1}^{H} q_i(p_i - C)}\frac{H}{P}, \tag{1}$$

where q_i is the quantity consumed by household i and $p_i - C$ is the unit subsidy for household i (i.e., the difference between average unit price for the household and unit cost of service C assumed constant across households.)

The parameter Ω can be decomposed in five key factors affecting its value: access, take-up, targeting, rate of subsidization, and quantity consumed. The first factor is access to networks in the neighborhood where the household lives, denoted by A, with typically access for the poor

[1] There are some exceptions to this when subsidies are allocated according to proxy-means testing as in the case of Colombia and Chile (e.g., Gomez-Lobo and Contreras, 2003), yet when compared to other targeted subsidies, utility subsidies typically are less well targeted than these other subsidies (e.g., Wodon and Yitzhaki, 2002). On tariff design more generally, see among others Whittington (1992) and Boland and Whittington (2000).

[2] For a good discussion of standard benefit incidence analysis, see for example Demery (2003).

lower than for the population as a whole ($A_P<A_H$). The second factor is take-up or usage of service when households have access, with often lower usage among the poor than the population as a whole conditional on access ($U_{P|A}<U_{H|A}$). The product of A and U is the connection rate (share of households using network water or electricity). The variables A and U affect the targeting performance of subsidies since in order to receive a subsidy households must first consume the good that is subsidized. The third factor is subsidy targeting (conditional on usage), which takes a value of one for households who receive a subsidy, and zero otherwise. When utility consumption is subsidized for all users we have $T_{P|U}=T_{H|U}=1$. Beneficiary incidence (the probability of receiving or not the subsidy among a specific population group) is:

$$B_H = A_H U_{H|A} T_{H|U} \tag{2.1}$$

$$B_P = A_P U_{P|A} T_{P|U} \tag{2.2}$$

To estimate benefit incidence (as opposed to beneficiary incidence), two more factors must be taken into account: the rate of subsidization and the quantity consumed among those who benefit from the subsidy. If the average quantity consumed by subsidy recipients in the population as a whole is $Q_{H|T}$, and the average expenditure on the good is $E_{H|T}$, the average rate of subsidization is $R_{H|T} = 1 - E_{H|T} / (Q_{H|T} C)$. The average value of the subsidy received among subsidy recipients is then $R_{H|T}\, Q_{H|T}\, C$. For the poor, the average subsidy received among those who benefit from the subsidy is $R_{P|T}\, Q_{P|T}\, C$. Overall, the average subsidy benefits in the population as a whole and among the poor are:

$$\frac{S_H}{H} = B_H R_{H|T} Q_{H|T} C\ . \tag{3.1}$$

$$\frac{S_P}{P} = B_P R_{P|T} Q_{P|T} C\ . \tag{3.2}$$

This implies that:

$$\Omega = \frac{A_P}{A_H}\frac{U_{P|A}}{U_{H|A}}\frac{T_{P|U}}{T_{H|U}}\frac{R_{P|T}}{R_{H|T}}\frac{Q_{P|T}}{Q_{H|T}}\ . \tag{4}$$

Thus Ω is the product of five ratios for access, uptake, targeting, rate of subsidization, and quantity consumed. In most cases, the ratio of access rates will be lower than one (the poor tend to live in areas with lower access rates than the population as a whole), and the ratio of usage or take-up rates for the service will also be lower than one (when access is available in a neighborhood or village, the poor are less likely to be connected to the network than the population as a whole due to high costs of connection). Also, the quantities consumed in the population as a whole tend to be larger than those consumed by the poor. This means that the design of the subsidy mechanisms (through the values of T and R for the poor and the population as a whole) must be pro-poor if overall targeting is to be pro-poor (value of Ω larger than one).

To better understand the design of typical subsidy mechanisms for water and electricity, denote as before by q_i the quantity consumed by a particular household i and by e_i the expenditure for that household. Consider first a benchmark case corresponding to an inverted block tariff (IBT) structure with two price levels: Π_A and Π_B, with $\Pi_A < \Pi_B$. The reasoning can easily be extended to more blocks. The variable L denotes the consumption threshold (in kilowatt-hours or cubic meters per month) at which the unit price for the good shifts from Π_A to Π_B. In IBTs, L is often considered as a "lifeline", that is a level of consumption needed for a household to meet its basic needs. If we denote by t_i a dummy variable taking a value of one for a household eligible to benefit from the lifeline rate (and a value of zero otherwise), the expenditure of household i is:

$$[IBT] \qquad e_i = \begin{cases} q_i \Pi_A & if \quad q_i \le L \\ L\Pi_A + (q_i - L)\Pi_B & if \quad q_i > L \end{cases}, \text{ with } t_i = 1 \text{ if } \{ q_i > 0 \}. \tag{5}$$

In (5), all households pay a unit price of Π_A per quantity consumed below the lifeline L, and for those who consume more than L, the price per unit consumed above that threshold is Π_B. Household wither higher consumption will pay a higher average price per unit consumed, but since all households with a positive consumption benefit from the lower unit prices for quantities below L, the targeting indicator t_i is equal to one, meaning that every household consuming some quantity benefits from a lower unit price for at least part of the quantity consumed.

An alternative tariff structure is to grant the lower price Π_A only to those households consuming less than L. This is referred to as a Volume Differentiated Tariff (VDT) as follows:

$$[VDT] \qquad e_i = \begin{cases} q_i \Pi_A & if \quad q_i \le L \\ q_i \Pi_B & if \quad q_i > L \end{cases}, \text{ with } t_i = 1 \text{ if } \{ q_i > 0 \text{ and } q_i \le L \}. \tag{6}$$

In (6), if total quantity consumed is above L, the unit price is Π_B, and this price applies to the total quantity consumed. In turn, since only the households who consume less than L benefit from the lower price Π_A, the targeting indicator takes a value of one only for those households.

Equations 5 and 6 enable us to compute subsidy rates for the poor and the population as a whole under alternative tariff designs. If we denote the average subsidy rate for the poor R_P (among poor households who benefit for at least part of their consumption from a lower tariff rate as compared to the average cost for the utility), we have:

$$R_P = \left(1 - \frac{\sum_{i=1}^{P} e_i 1(p_i = 1) 1(t_i = 1)}{C \sum_{i=1}^{P} q_i 1(p_i = 1) 1(t_i = 1)} \right), \tag{7}$$

where p_i takes a value of one for a household in poverty and zero otherwise, and $1(p_i = 1)$ and $1(t_i = 1)$ are indicator functions taking a value of one if the conditions are met (i.e., the household is poor in the first function, and the household benefits from a lower tariff rate on at least part of its consumption in the second function), and zero otherwise. Thus only households verifying these conditions are included in the estimation of the ratio of expenditures to costs. The subsidy rate at the national level R_H is calculated likewise among all households who benefit from the subsidy:

$$R_H = \left(1 - \frac{\sum_{i=1}^{H} e_i 1(t_i = 1)}{C \sum_{i=1}^{H} q_i 1(t_i = 1)} \right). \tag{8}$$

A similar framework can be applied to connection subsidies. Even if we do not have information in the household survey on who benefited from a connection subsidy (for example because no such subsidies already exist), we can still assess the potential value for Ω under various scenarios. Denote the average subsidy rate for a connection subsidy received by a household in the overall population obtaining subsidized connections by $R^C_{H|T}$. This rate depends on the difference between the average cost of a connection (C^C), assumed constant for all households for simplicity, and the connection fee paid (F^C_H). The rate of subsidization $R^C_{H|T}$ among beneficiaries is then $R^C_{H|T}=1–F^C_{H|T}/C^C$. For the poor $R^C_{P|T} = 1 – (F^C_{P|T}/C^C)$.

Three stylized scenarios for connections subsidies can be considered. First, assume that connection subsidies will be distributed in the same way as existing connections. This is a pessimistic assumption from a distributional point of view since it tends to favor better off households, but it could be realistic if access rates to the network are low. Then:

$$\Omega^{C1} = \frac{A_P}{A_H} \frac{U_{P|A}}{U_{H|A}} \frac{R^C_{P|T}}{R^C_{H|T}} \tag{9}$$

Second, new connections could be distributed randomly among households who are currently not connected, but live in a neighborhood where connections are available. Then:

$$\Omega^{C2} = \frac{A_P}{A_H} \frac{(1-U_{P|A})}{(1-U_{H|A})} \frac{R^C_{P|T}}{R^C_{H|T}} \tag{10}$$

Third, new connection subsidies could be randomly distributed among all households who do not currently have access (an optimistic assumption given that many of these households do not live in neighborhoods where access is available). This would lead to:

$$\Omega^{C3} = \frac{(1-A_P U_{P|A})}{(1-A_H U_{H|A})} \frac{R^C_{P|T}}{R^C_{H|T}} \tag{11}$$

We should typically observe that $\Omega^{C1} < \Omega^{C2} < \Omega^{C3}$.

3. Empirical Illustration

The framework is applied to household survey data from Cape Verde, Sao Tome and Principe and urban Rwanda, using in each country a nationally representative household survey implemented circa 2001 (the exact dates of the surveys are 2001-2002 for Cape Verde, 2000-2001 for Sao Tome and Principe, and 1999-2001 for Rwanda). In each of the three countries, for comparability purposes, we consider that the bottom 40 percent of the population in terms of consumption per capita is poor. In the case of Rwanda, we restrict the analysis to urban areas because access to electricity is virtually inexistent in rural areas. The tariff structures for water and electricity in Cape Verde and Sao Tome are IBTs. In Cape Verde, households paid 20.5 CVE (Cape Verde Escudos) per kilowatt-hour (kWh) consumed above the lifeline of 40 kWh and 16.5 CVE below that threshold. In Sao Tome and Principe, households paid 601.31 Dobras per kWh under 100 kWh, 1000.68 Dobras per kWh between 100 kWh and 300 kWh, and 1519.97 Dobras/kWh above 300 kWh. For simplicity, tariffs in the top blocks of the IBTs for Cape Verde and Sao Tome and Principe are assumed to represent average cost, which is close to available estimates for Cape Verde (in Sao Tome, we do not have good data on true costs). In Rwanda, households paid a flat rate of 42 Rwanda Francs per kWh whatever their level of consumption, but the cost of providing service was estimated at 81.25 Rwanda francs per kWh.

In order to facilitate comparisons with Cape Verde and Sao Tome and Principe, we will simulate the targeting performance of an IBT structure in Rwanda according to which households would pay 42 Rwanda Francs per kWh for their consumption below 40kwh, and 81.25 Rwandan Francs for their consumption above that level. This improves a bit the targeting performance versus the actual flat rate, but not by very much[3].

Results for the decomposition of the determinants of subsidy performance are provided in Table 1. Consider for example the case of Cape Verde where Ω takes a value of 0.48. This implies that electricity subsidies are not pro-poor, since the share of the subsidies that goes to the poor is almost three times lower than the share of the poor in the population. Even lower values are observed for Sao Tome and Principe (Ω=0.40) and for urban Rwanda (Ω=0.30).

The low values for Ω are due in large part to access factors. In the case of Cape Verde for example, access is lower for the poor (A_P=0.71) than the population as a whole (A_H=0.82).[4] Within areas with access, uptake is also lower for the poor ($U_{P|A}$=0.29) than for the population as a whole ($U_{H|A}$=0.54). All households receive the subsidy (since electricity pricing follows an IBT structure), hence $T_{P|U}=T_{H|U}=1$. The rate of subsidization is greater for the poor than for all households ($R_{P|T}$=0.11, versus $R_{H|T}$=0.06), but the average quantity in kWh per month consumed by poor households connected to the network is less than half the quantity consumed in the population as a whole ($Q_{P|T}$=49.31, versus $Q_{H|T}$=111.72).

Similar results are obtained for the other two countries. In Sao Tome access to the network is lower for the poor (A_P=0.73) than in urban areas as a whole (A_H=0.85), and so is uptake ($U_{P|A}$=0.32 versus $U_{H|A}$=0.50). All households again receive the subsidy ($T_{P|U}=T_{H|U}=1$) but the rate of subsidization is slightly better for the poor ($R_{P|T}$=0.45, versus $R_{H|T}$=0.40). Yet the average quantity in kWh consumed by the poor is more than 50 percent higher for the population as a whole than for the poor. Finally in the IBT simulated for urban Rwanda, the value of the access and uptake parameters are A_P=0.78, A_H=0.86, $U_{P|A}$=0.18 and $U_{H|A}$=0.37. In the simulated IBT, $T_{P|U}=T_{H|U}=1$. As for the rates of subsidization and quantity consumed, the values obtained are $R_{P|T}$=0.24, $R_{H|T}$=0.19, $Q_{P|T}$=63.01, and $Q_{H|T}$=92.49.

Could targeting performance be improved under an alternative tariff structure? Simulations have been conducted for VDTs under which the pricing for each block is applied to the total consumption of the households in that block[5]. In the case of Cape Verde, as shown in Table 2, the targeting performance indicator Ω increases dramatically, from 0.48 to 1.06. In the Sao Tome and Principe, the increase is smaller, from 0.40 to 0.47, while in Rwanda, the increase

[3] In urban Rwanda, Ω takes a value of 0.30 under the flat rate, and 0.39 under the simulated IBT, holding household consumption constant. Given that the key messages from the decomposition of the value of Ω are very similar for the flat rate and the IBT, we focus on the IBT results, for comparison purposes with the other two countries.

[4] Households are considered to have access to the network if other households in their neighborhood reported having either water or electricity connections. This might overestimate the share of households with access if a neighborhood as defined by the Primary Sampling Unit in the household survey covers a large geographical area.

[5] We assume for simplicity that different tariff structures do not change the total consumption of households (i.e., q_i remains constant), nor do they change the average cost production, transmission and distribution for the utility.

is from 0.39 to 0.63. Thus, while shifting from an IBT to a VDT might not make electricity subsidies pro-poor, this would nevertheless help in improving targeting performance. As to the reason for the higher performance, it is associated with better values for the *T* and *Q* ratios (recall that quantities consumed are estimated among those who benefit from the subsidy). As to the *R* ratio, it is equal to one under VDTs since all of those who consume less than the lifeline pay the same reduced unit price for the service.

An alternative to consumption subsidies would be to implement instead connection subsidies. Table 2 provides estimates of Ω under the three scenarios considered in the methodological discussion in Section 2 of this note. In all three countries, the value of Ω^{c1} and Ω^{c2} are similar, ranging from 1.16 to 1.35. This suggests that well designed connection subsidies could show good potential targeting performance. However, if new connections were distributed in a similar way to existing connections, targeting performance would remain poor, as suggested by values for Ω^{c3} in the 0.44-0.56 range.

4. Conclusion

Several clear messages emerge from the decomposition presented in this paper and its application to electricity subsidies in three African countries. First, access factors are important in determining the potential beneficiaries of consumption and connection subsidies. As poor households tend to live in areas without electricity service, or far from electric lines where service exists, it is difficult for them to benefit from electricity subsidies simply because they are not connected to the network. In order to compensate for the negative impact of access factors on targeting performance, good subsidy design mechanisms are required. Yet the IBT tariff structures that prevail in many countries tend to be poorly targeted. One alternative to traditional IBTs would be to shift to VDT tariff structures. Another alternative would be to provide connection as opposed to consumption subsidies. The simulations implemented in this paper suggest that these two alternatives could help in improving targeting performance.

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Table 1: Determinants of consumption subsidy performance in Cape Verde, Sao Tome and Principe and Rwanda

	IBT						VDT			
	Omega Ω	*Ratio share of hhs with community access to service* **(A)**	*Ratio of share hhs with access who use service* **(U|A)**	*Ratio of share of users who receive the subsidy* **(T|U)**	*Ratio of subsidization* **(R|T)**	*Ratio of average quantity consumed* **(Q|T)**	*Omega* Ω	*Ratio of share of users who receive the subsidy* **(T|U)**	*Ratio of subsidization* **(R|T)**	*Ratio of average quantity consumed* **(Q|T)**
Cape Verde Electricity										
Poor households		0.72	0.34	1.00	0.11	56.83		0.47	0.20	20.33
All households		0.82	0.54	1.00	0.06	111.72		0.24	0.20	21.15
Ratio	0.48	0.88	0.63	1.00	1.70	0.51	1.06	1.99	1.00	0.96
Sao Tome Electricity										
Poor households		0.73	0.32	1.00	0.53	84.65		0.97	0.45	76.95
All households		0.85	0.50	1.00	0.46	138.20		0.91	0.40	109.67
Ratio	0.40	0.86	0.65	1.00	1.16	0.61	0.47	1.07	1.11	0.70
Rwanda Electricity										
Poor households		0.78	0.18	1.00	0.24	63.01		0.45	0.48	21.99
All households		0.86	0.37	1.00	0.19	92.49		0.28	0.48	25.11
Ratio	0.39	0.91	0.49	1.00	1.31	0.68	0.63	1.62	1.00	0.88

Source: Authors’ estimation.

Table 2: Simulated connection subsidy performance in Cape Verde, Sao Tome and Principe and Rwanda

	Ω^{C3} **Subsidy recipients taken randomly from set of all unconnected households**	Ω^{C2} **Subsidy recipients taken randomly from household with access in their area but no yet connected**	Ω^{C1} **Subsidy recipients similar in characteristics to households already connected to the network**
Cape Verde Electricity	1.35	1.25	0.55
Sao Tome Electricity	1.32	1.16	0.56
Urban Rwanda Electricity	1.27	1.18	0.44

Source: Authors' estimation.