The impact of cross-subsidies on utility service quality in developing countries

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\section*{ABSTRACT}

Low service quality in the utility sector (electricity, water, natural gas, etc.) is a major obstacle to economic advancement in developing countries. This paper provides an explanation for low quality of service through examining the rational responses of firms (utility providers) to subsidy policy. Cross-subsidies are widely applied to spur poor households’ consumption of utility services. This raises the issue of whether charging lower prices to poor households, while boosting their consumption, induces firms to lower the quality of service received by these households. We specify an analytical model in which the government may not fully cover the firm’s deficit from subsidizing poor households. Our main findings are: 1) when government transfers fail to cover this deficit, the firm reduces quality for subsidized consumers; 2) the difference in quality across consumer income groups might be reduced by an increase in the amount of government transfers. This paper also identifies several directions for future research, including the impacts of cross-subsidies on social welfare and a better design of subsidy funding mechanism.

1. Introduction

In developing countries, consumers are often subsidized for utility services—including electricity, water, natural gas, and telecommunication. Such subsidies are implemented to redistribute utility services to the poor by reducing the cost of consumption. One widely adopted subsidy design is the cross-subsidy system, whereby a utility service provider (referred to as a firm throughout the rest of the paper) charges higher prices to high-income residents to subsidize lower prices for low-income residents. Ideally, cross-subsidies raise consumption (through lowering the price) and provide adequate quality utility services in poor neighborhoods. However, many subsidized households receive significantly low-quality service; for example, low voltage and abrupt changes in voltage for electricity supply, abnormal color and taste for water supply, weak signals for telecommunications, and a surplus of impurities for natural gas. This paper aims to provide an explanation for low quality service received by the poor under the background of cross-subsidies.

Two important issues of cross-subsidies are how the subsidy recipients are targeted and how the subsidy is funded. The eligibility of subsidy recipients can be determined based on a household survey of socioeconomic circumstances. To avoid the cost of doing a household survey, some subsidies are based on a cost-effective alternative: geographical targeting, whereby residential consumers living in a selected region receive subsidies.\textsuperscript{1} One example is the Colombian utility sector, which employs the residential dwelling as the only factor in identifying the poor. Within each municipality, all residential districts are divided into six strata, from poor to rich. Households living in strata 1–3 receive subsidies. While these two schemes apply different mechanisms to identify the poor, the recipients of subsidies are geographical clustering for both. This permits a firm to identify consumer types (whether eligible or ineligible for subsidies) and even vary service qualities across these consumer types at low cost.

Subsidy funds can either come directly from government fiscal transfer or can be financed by other consumers. The first option is generated through a lump sum transfer from tax revenues (Churchill and Yew, 2017). Conversely, the second option is generated within a firm by charging high-income consumers a higher price. In practice, some existing subsidy systems apply a combination of both options. A firm charges a higher price for surcharged consumers to subsidize a lower price for subsidized consumers.\textsuperscript{2} If the firm fails to reach a financial balance on its own, the scheme in place calls for the
government to cover the resulting deficit via a transfer. However, government funds are often unreliable in developing countries. Accordingly, a firm may still have a financial deficit after government transfers. This raises the issue of whether segmenting markets geographically induces firms to vary the service across consumer types when facing a deficit from subsidizing the poor.

It might seem that the provision of low-quality services to the poor arises naturally from standard supply and/or demand factors (the poor are less desirable customers, and quality is a superior good). This paper argues that this is not completely accurate. The provision of low-quality services to poor neighborhoods may be due to the unreliable funding mechanism of subsidy policy. If the firm’s deficit is not fully covered by government transfers, the firm has incentives to reduce the amount of subsidy and increase the amount of surcharge to lower its financial deficit. This can be achieved by reducing service quality for subsidized consumers, while improving service quality for surcharged consumers, which, in turn, causes consumers to adjust their consumption of the firm’s products.

Formally, we develop a theoretical framework that allows the firm to provide services with different qualities to neighborhoods that have different income levels. Different types of consumers pay different prices for utility services: low-income consumers receive a subsidy, middle-income consumers pay a standard price, and high-income consumers pay a surcharge. The standard price, subsidy rate, and surcharge rate are regulated by the government, and a government transfer is incorporated to fund any deficit that the firm incurs. The causal effect on service quality is derived by comparing the benchmark case, where the transfer completely covers the deficit, with the case of partial funding, where the firm has a deficit even after the transfer. In the benchmark case, the firm provides identical service quality across consumer types. Under partial funding, the firm provides higher quality service to surcharged consumers but lower quality service to subsidized consumers. Comparison of service qualities between these two cases implies that the underfunded cross-subsidy system will cause the firm to reduce service quality in poor neighborhoods to reduce its losses. Thus, the provision of low quality service to the poor may arise from the firm having a deficit, rather than from the low price under a cross-subsidy background.3

This research is related to literature on the effect of cross-subsidies and quality regulation. Most theoretical models related to quality of utility service have focused on the design of quality regulation. Sappington (2005) summarizes the current progress on this issue. Following this line of research, Laffont (2005), and Estache et al. (2006) analyze quality regulation in developing countries. This type of literature does not address quality regulation in the context of subsidies, although this topic has received more attention recently. Laffont and N’Gho (2000) use a social welfare maximization model to discuss the financing of utility network expansion in developing countries and show that firms reduce service quality to the poor under cross-subsidies. Their model, however, relies on the strong assumption that the poor devote a fixed portion of their income to utility services, something that is not assumed here.

A few recent empirical studies provide some evidence on the effect of cross-subsidies on quality of utility service. McRae (2015) estimates the Colombian household demand for electricity and then uses it to calculate the change in firms’ profits from quality upgrades. He finds that cross-subsidies deter firms’ investments to improve service quality, but he does not distinguish the effects on service qualities across different consumer income groups. Extending his work, Li et al. (2016) finds similar evidence in the Colombian drinking water sector.

The remainder of the paper is organized as follows. Section 2 describes a profit maximization model, including the benchmark case and the partial funding case. After presenting the main implications of the theoretical model, Section 3 describes comparative statistics in the general case. Section 4 introduces an extension to the theoretical model. Section 5 concludes with policy implications of these results and suggestions for future research.

2. Theoretical framework

2.1. Setup

To simplify the problem, we consider a model where a single firm provides service to three different types of consumers: subsidized consumers (type 1), standard consumers (type 2) and surcharged consumers (type 3). Consumer type is determined by whether the consumer receives a subsidy, pays a standard price, or pays a surcharge for the utility service. Under cross-subsidies, the government sets the standard price \( p \), the subsidy rate \( s \), and the surcharge rate \( t \), where \( p, s, t \) and \( f \) are exogenous for the firm. Accordingly, the price \( p_i \) charged by the firm to type \( n \) consumers is \( p_i = p - s_i \), where \( i = 0 \), \( 1 \), and \( 2 \) respectively, where \( n \) is the consumer type. Besides paying different prices, consumers of different types differ in their incomes and the service qualities that they receive. Let \( J_n \) denote the income of type \( n \) consumers. Assume \( J_1 < J_2 < J_3 \), to allow a higher income for surcharged consumers. With the ability to provide multiple levels of service quality and identify consumer types, the firm can deliver services with different levels of quality across consumer types. Let \( q_i \) denote the service quality that type \( n \) consumers receive.

For type \( n \) consumers, an individual’s demand depends on price \( p_n \), income \( J_n \), and quality \( q_i \). Specifically, assume that individual demand function of type \( n \) consumers is given by \( d_n = f(p_n, J_n, h(q_n)) \), with \( f_n > 0, f_n > h > 0, J_n > 0 \), and \( h > 0 \), where subscripts denote partial derivatives. This representation has quality affecting an individual’s demand proportional to the effects of price and income. That is, a change in quality affects the demands of high users more than it affects the demands of low users.1 For example, the demand for electricity services is derived through the use of energy using appliances (Dubin and McFadden, 1984; Pourazarm and Cooray, 2013). Appliance ownership and use depend on consumer income. Intuitively high-income consumers own more appliances than do low-income consumers. Accordingly, given identical electricity prices, as outages and frequency of electricity interruption decline (i.e., service quality improves), the high-income consumers increase their consumption of electricity by more than do the low-income consumers. This is consistent with the Colombian household electricity demand estimated by McRae (2015). In accordance with this, the demand functions have a multiplicative relation between quality and a function of income and price. Using individual demand functions, the firm’s output for each consumer group is \( d_n J_n \), where \( N_n \) denotes the number of type \( n \) consumers. Assume that \( N_n \) is constant.

For simplicity, the short-run model excludes the fixed cost.5 Assume that the marginal cost of providing the service is \( c(q_n) \), which depends on quality but remains the same across different consumer types. Hence, the total cost for serving type \( n \) consumers with quality \( q_n \) is \( C_n(q_n) = c(q_n) + (c(p_n, J_n) h(q_n) N_n) \), where \( d > 0 \) and \( c > 0 \). This representation emphasizes that quality enters the cost function \( C_n(q_n) \) by both changing the constant marginal cost \( c(q_n) \) and changing individual demand through \( h(q_n) \). Since \( f(p_n, J_n) N_n \) is not affected by quality, we factor it out from \( C_n(q_n) \), for simplicity. Then, let the unit marginal cost of increasing service quality at \( q_n \) be \( MC(q_n) \equiv c(q_n) h(q_n) + c(p_n, J_n) h(q_n) \).

3 If the government sets a more suitable subsidy and surcharged rates by solving an optimization problem of social welfare, then there may be no deficit for firms. However, if the government fails to set up an appropriate price, the subsidy may be either underfunded or overfunded. In developing countries, underfunded subsidies are more realistic social issues. Thus, this paper focuses on the impact of an underfunded subsidy system on service quality.

4 When we use a more general demand function \( d_n = f(p_n, J_n, q_n) \) with additional constraints to reflect similar relationship between quality and demand, the key results still hold.

5 In the long run, the fixed cost should be included in the model. Moreover, a high level of financial deficit may cause firms to stop supplying the service.
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