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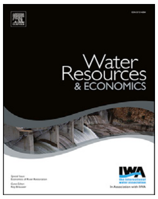

The externality from communal metering of residential water: The case of Tehran

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A B S T R A C T

Many countries use a single water meter for multiple units within a building. This creates a cost externality where the cost of water consumed is spread over all units. Using administrative data from Tehran Water and Wastewater Co. for 2013 and 2014, we find an increase in the number of units on a communal meter on average increases per unit use by 0.4%. Estimation at different levels of units reveals that almost all communal meters have higher per unit water use. The results suggest that removing this externality could save 2.7% water consumption in our sample.

1. Introduction

Many countries use a single water meter for multiple apartments within a building. Boston, New York, Paris, and Berlin traditionally had a single meter per building [2]. Under communal metering the cost of water consumed by a unit is borne by all units served by the same meter. This cost externality creates an incentive for multi-unit subscribers to increase their consumption. In response to this problem in some Australian states, sub-metering of individual apartments has been made compulsory to allow landlords charge tenants based on consumption [3].

Given the high cost of residential water supply and potential water savings from installing individual meters, it is important to quantify the magnitude of the cost externality arising from multi-unit metering. There is, however, little empirical evidence on this issue. To the best of our knowledge, the only study that tries to estimate the impact of moving to individual metering is [4]. This paper studies Seville metropolitan area using aggregate data and finds that installation of individual metering is responsible for 1.5% reduction in water consumption. Our paper is the first empirical study that uses billing data to measure this cost externality.

In Iran almost all residential water consumption is metered. However, multi-unit meters are quite common and only recently some new developments started to install individual meters. In Tehran multi-story buildings containing several apartments are common. Quite often the water consumption of a whole building is measured via a single mechanical meter. In our data we observe all bills issued to water subscribers in two districts of Tehran over a period of two years. A subscriber is equivalent to a meter that is installed on the water pipe that enters the property. The water bill registers the number of separate apartments (units) served through a meter. Our results show that an increase in registered number of units results in 0.4% increase in monthly per unit water use. This effect is significant at 1% level and is quite robust to several specification tests.

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Once we allow for a flexible specification, we observe that moving from a single-unit meter to a two-unit meter increases per unit water consumption by 1%. Similarly per unit water use for seven-unit subscribers is on average 4% higher than single-unit users. Adding up the extra consumption due to the cost externality we observe that 4.1 million cubic meters of water could be saved over a month by a move to individual metering. This constitutes 2.7% of total monthly water use in our sample.

The remaining of the paper is structured as follows. In next section we provide a brief review of the literature. Section 3 formulates a simple model to better explain the cost externality from multi-unit metering. In section 4 we explain the data. Section 5 discusses the research method and regression results. Section 6 concludes.

2. Literature review

This paper is influenced by the extensive research that studies water resources from the perspective of a common good. [8] coined the term "tragedy of commons" to highlight the race to use shared and unregulated resources which leads to overuse and depletion. There are, however, abundant examples where communities voluntarily cooperate to organize and regulate common resources to avoid depletion [11]. Common pool resources (CPRs) are defined as assets where exclusion of others is costly and exploitation by one user reduces available resources to others. A group can own and manage CPRs, while excluding others from the resources[1]. The externality we identify in this paper is somewhat similar to the tragedy of commons except that households residing in adjacent units might have long-run relationships and hence better incentives to share costs.

Our paper also speaks to the literature on the impact of non-price variables on water demand. For example, [13] study residential water demand in California and examine the impact of non-price "demand side management" policies across eight urban water agencies. They attempt to capture the endogeneity of marginal price and virtual income by estimating two reduced form price equations. [9] discuss that the simple OLS cannot address the price endogeneity, and propose a structural estimation approach. Information on household consumption and other characteristics including wealth, income, family size, age, and numbers of bedrooms allow them to estimate deep parameters and to conduct several counterfactual scenarios.

The final branch of the literature that our paper relates to is the set of papers that try to come up with optimal metering strategies in urban areas. These studies are primarily motivated by new initiatives to introduce full water metering in England and Wales[2]. [5] studies the optimal number of meters and pricing schemes under various systems including rateable value, universal metering, optimal metering, and decentralized metering. His main finding is that in all types of metering, bar rateable metering, the optimal price has to equal marginal cost and the optimal number of meters would be determined endogenously. Similarly, [6] analyzes the provision of free meters in England and Wales. He finds that the social benefit of meters is higher the higher the elasticity of demand. Furthermore, he concludes that metering should be compulsory when the regulator has limited information on household characteristics and when large households are reluctant to install meters. An empirical example that tests these theories is [7]. They compare the distributional impact of eleven hypothetical water tariff options for high and low income households. Our paper sheds new light on the externality that might arise if households do not face the price of what they consume.

3. Conceptual model

We define the total volume of water consumed by all users served by a meter as a common pool where none of the users can be excluded from[3]. In contrast to the literature that exploitation by a user reduces available resources to others, in our case the consumption of a unit increases the cost of other units and there is no limitation on total resources. Notwithstanding, we do not need to take into account the dynamic nature of the water reserve because consumption of a resident is unlikely to exploit total water resources in a city.

In our model there are n units (households[4]) served by a single water subscription (i.e. use the same meter). Take $u(q_i, x_i)$ to be the utility function of household i, where q_i is water use and x_i is consumption of other goods. We assume a differentiable increasing concave utility function, i.e. $u_q, u_x > 0 > u_{qq}, u_{xx}$ (the subscripts show derivates with respect to the subscripts). We further assume that the cross derivative is positive ($u_{qx} \geq 0$). The household maximizes utility subject to her budget constraint:

$$\max_{q_i,x_i} u(q_i,x_i) \quad st. \quad p(\overline{q})\frac{q_i+(n-1)\overline{q}_{-i}}{n}+x_i=y_i \tag{1}$$

where $\overline{q}_{-i}$ is average water consumption of other households excluding i under the same subscription, and y_i is household income. Price of other goods is normalized to one and $p(\overline{q})$ is the relative price of water which is a function of average water consumption, $\overline{q} = \frac{q_i+(n-1)\overline{q}_{-i}}{n}$, and is differentiable[5]. Household i treats consumption of others as given in this optimization but takes into account the impact of a change in her water quantity on prices. The first order condition of optimization is therefore:

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[1] Several papers study the CRPs and focus on the governing institutional frameworks: for example [12] in water supply [10], in coal industry [1], in forest management.

[2] Two third of homes in England and Wales are unmetered by 2011 [2].

[3] Exclusion of a unit from water use requires court order and joint action by all other residents. Therefore, in our context exclusion is too costly and rarely takes place.

[4] We have no information on the number of households/individuals served by a meter. But most often a single household lives in a unit (apartment/house). We use the term household and unit interchangeably.

[5] We have an increasing block pricing for water in Iran. While price is a step function, in expectation we can think of expected price as a differentiable function of quantity.