

”Low-level” versus ”high-level” equilibrium:
A theoretical framework for analysis of urban water markets
in developing countries

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Abstract

The paper provides a theoretical analysis of (absolute and relative) performance of three alternative types of water management in city regions in developing countries, namely central-government and local-government agencies, and private monopoly firms. The two former types are subject to median-voter political decision making, and central-government agencies are assumed to suffer from serious organizational slack. We find that central-government agencies then provide too low levels of both service quality and system expansion to new customers. Local-government agencies are more efficient with respect to service quality but not necessarily system expansion, and generally set lower water prices. A private monopolist provides good service but high water prices, and may do well in terms of system expansion given that (near) cost recovery for such expansion from new customers is allowed. The model may also yield multiple equilibria when the degree of slack in the public-agency cases is endogenous. The model explains several important phenomena, associated with "low-level" and "high-level" equilibria in the water market, and forms a basis for empirical work on the political economy of water management in developing countries.

1. Introduction

The purpose of this paper is to present a theoretical framework for analysis of some key urban water market issues in developing countries, with special reference to Latin America. The water allocation problems encountered in cities in this region are largely threefold: 1) Low coverage levels, whereby many households are not covered by regular water service, and where those not covered must rely on other more expensive and less reliable sources. 2) Low service quality level for households covered by the regular system. E.g., water service may be provided only during part of the day or sometimes not at all, water pressure is often poor, and the water may have low quality. 3) Low overall supply of water to many individual urban regions, resulting from a failure to make required water system expansion investments.

Problems of water supply are exceedingly important for many developing countries. In particular, our own data (as presented in Walker et.al. (2000) and elsewhere) show that water service improvement is the overwhelmingly most important public-service issue to survey respondents in many cities.¹ While piped water access is high in many cities in Latin America, in a large number of other cities 20-40 % of the urban population lack such access, and most of those served in these cities have inferior service, by being served only during part of the day or by having low water pressure. Estache et.al. (2000) moreover find that providing piped water access, in addition to increasing the level of welfare directly, may significantly raise household income e.g. by freeing time for market work or education among household participants.² This implies the potential for enormous overall benefits from improvements in this area.

Our discussion will focus on the first two of these three problems, as on short- and medium run local-level water administration issues. The third problem is admittedly important, but is

¹ E.g. in Tegucigalpa, almost 25 % of surveyed households rated water issues as most important, with sewerage service as a distant number 2 (at about 10 %).

largely a long-run issue and can often be viewed as outside of the direct control of the local-level water administrations. In many cases investments for overall system expansion will be undertaken according to central-level plans, and largely funded by outside sources. A failure in this area can consequently often be viewed as not so much a failure of local water administrations, as that of higher bodies.

We will consider three different, and quite simple, institutions for organizing the local urban water sector, and with emphasis on how they solve the first two efficiency problems presented above. These three institutions are, first, a water administration operated by a central-government agency; secondly, operation by a local-government agency; and thirdly, operation by a private firm subject to public regulation of its water-related charges. These institutions are also compared to a "first-best" case for a given total supply of available water.

The purpose of our exercise is twofold. First, we claim that a fundamental theoretical understanding of main implications of particular institutions on water sector performance is essential for identifying possible fruitful reforms of the sector. In our opinion no satisfactory such theoretical framework exists to date. Secondly, such a framework is needed as a starting point for empirical analysis of urban water sector performance, by identifying key parameters that need to be estimated, and by providing interpretations of estimated parameters. Such empirical work we intend to do in the future, in the extension of the current work.

Essential to our model is the concepts of "low-level" versus "high-level" equilibrium in the urban water sector in developing countries. This dichotomy has been pointed out by a number of authors and appears to be a notion which applies to a variety of such markets, in various parts of the developing world.³ In short, a "low-level" equilibrium is a situation where performance is low on most relevant counts: service quality and coverage are both low, the

² Overall, their estimates indicate that the resulting increase in household income is approximately 10 %, although the figure is uncertain due to possible selection problems.

water authority has low net revenues, and there are severe organizational inefficiencies, with few incentives to maintain existing facilities or improve services. Moreover, this situation implies an "equilibrium" in the sense that there are inherent forces tending to maintain the current state. A "high-level" equilibrium by contrast implies higher service quality and coverage, higher water revenues, and greater intrinsic incentives for maintaining and improving the system. A main objective of our analysis is to provide a basis for understanding to what degree and under what circumstances a "low-level" equilibrium can be the result of particular institutional arrangements, and what are the requirements for breaking out of an initial "low-level" equilibrium.

Much of the essence of our argument is likely to carry over to other utility services, notably the electricity market where similar coverage rates are experienced in many cities, and where many of the incentive problems dealt with below are similar. We also note that an analysis of such issues have become more pertinent over the last 10 year period, with a great wave of regulatory changes sweeping over the Latin American continent, largely in the electricity and telecommunications sectors but also increasingly in water and sanitation. This has largely taken the form of privatization of various sorts, at least in telecommunications and power but also to some extent in water and sanitation.⁴ In the latter sectors public operation is however still often the most realistic alternative, thus justifying our inclusion of two public operation alternatives in our theoretical discussion.

In section 2 below we present our main model framework, and in section 3 we derive the optimal (first-best efficient) allocation of water for the urban sector in question. We then go on to study the performance of this water sector when it is run by different types of

³ Our concrete point of departure for the project was the study by Walker et.al. (1999), of the Honduran case; see here also Strand (2000). See however also e.g. Singh et.al. (1993), and Altaf et.al. (1993), for similar analyses and concepts, applied to respectively India and Pakistan.

⁴ See Estache, Foster and Wodon (2000) for a discussion and overview of privatization of utilities in Latin America over this period, covering all basic utility services. They point out that most of the privatization within the water and sanitation sectors have been of the management contract and concessions type.

institutions. These are central-government management (in section 4), local-government management (in section 5), and a private monopoly firm subject to possible charge regulations (in section 6). Section 7 sums up and concludes.

2. Model of the urban water sector

Consider an urban water market where the public comprises two basic groups of households, namely those connected to the water system, and those not connected.⁵ Assume that the demand relationships and valuations of water are principally the same for both groups, and for all households within each group. Such a focus implies that distributional issues among connected households, often central to policy discussions over water sector reform, are played down.⁶ Assume also that those connected are in a majority such that if e.g. the political decisions concerning the water sector are decided by majority voting, only those connected will affect such decisions. Each connected household initially consumes an amount A_1 of water, while unconnected ones consume an amount A_2 , where $A_2 < A_1$, and this difference can be large.⁷ Assume that the marginal valuation of water for connected households is affected by the quality of service, $v_1(q)$, with positive first derivative and negative second derivative. The total utility derived from water for a connected household can be written as

$$U(A_1) = v_0 A_0 + v_1(q) A_1 - p A_1 + \pi, \quad (1)$$

⁵ In reality this is more complicated in many cases. Importantly, many of those connected often have good service even though most do not. If those with good service at the same time have high political influence, outcomes may be different from those derived here in particular under the public management systems.

⁶ We will however have certain distributional issues in mind in the following. In particular, the issue of water coverage is strongly distributional since those initially not covered are typically in the poorest groups.

⁷ E.g. in Tegucigalpa, low-income connected households consume about 30 m³ per month, and pay about 0.10 USD per m³, while unconnected ones consume about 3.5 m³ per month and pay about 2.5 USD per m³; see Strand (2000).

where p is the unit price paid by regular water consumers, and π represents households' share of possible net revenues created by the water sector, distributed back to the public (e.g. in the form of tax reductions or improvements in other services). v_0A_0 can be taken to represent the value of the water connection itself, for a connected household, here for simplicity represented by a constant marginal value v_0 of water in an amount $A_0 < A_1$, which comes in addition to the marginal value v_1 of water when already connected. We may here think of v_0 as substantially higher than $v_1(q)$ for relevant levels of q .⁸ The value of current water consumption for an unconnected household is similarly:

$$U(A_2) = v_0A_2 - p_2A_2 + \pi, \quad (2)$$

where p_2 can be "high" relative to p . We may reasonably view p_2A_2 as the social cost of providing water to unconnected households (which may involve purchasing water from vendors or hauling water from wells or taps), where p_2 is assumed constant.

Assume now that the total amount of ("basic") water is fixed at W .⁹ The amount of water available to those with connections can then be written as

$$W_1 = N_1A_1 = W - (N - N_1)A_2, \quad (3)$$

⁸ Thus $v_0 > v_1$ can be taken simply to represent the property that the demand function for water is downward sloping, and that a household which is not connected (and has very little water), has a much higher marginal water value than a household which is connected, regardless of the "quality" of service in the latter case.

⁹ The assumption that the total amount of water available to customers is a constant need not be taken literally. One aspect of improved service quality is namely likely to be greater efficiency in the utilization of the total available water resource, in the form of less wasted water (through leakage or spills). If this were the only aspect of quality, the product $v(q)A_1$ would represent the actual amount of water available to customers as "quality" changes. The only difference this would make for the subsequent analysis is that the price per unit of actual water received would be represented by $p/v(q)$, instead of by p as below.

where N_1 and N_2 are the numbers of connected and unconnected customers, respectively, and the total number $N (= N_1 + N_2)$ of households is a constant. We then find

$$\frac{dA_1}{dN_1} = -\frac{A_1 - A_2}{N_1}. \quad (4)$$

Thus when new customers are connected to the water system, and the total amount of water available in the system is constant, the amount of water available to each connected customer must fall, and more so the greater the difference in consumption between connected and nonconnected customers.¹⁰

The local water agency is assumed to take three different possible forms:

- a) Central-government water administration, with the basic aim of covering costs. Here little incentive is assumed to be present for cost reductions or recovery. Part of gross revenue is eaten up by administration and overstaffing/spending or used to pay off old water-sector debts, and there is a high rate at which customer payments are avoided or evaded. Any possible surplus is spent on various investment costs, to be discussed below.
- b) Municipal water administration. This is assumed to operate in a similar way to a central-government administration, with the difference that incentives for cost recovery are greater, and there is less slack.
- c) A private firm which aims to maximize profits, under certain constraints. One constraint may be water price regulation by either a government agency or a political decision-making body.

¹⁰ In our discussion below we assume that the water agency is allowed and able to allocate water directly to connected households, in amounts A_1 to each, and independently of the water price charged. This is of course simplistic. In practice realized water demand will be a function of the (marginal and average) water price, at least for unrationed households. We may however think that the water administration partly allocates the water by rationing (in particular when there is no metering and the effective marginal price is zero), or that block rate structures are used to loosen up the tie between the average and the marginal water price. See e.g. Whittington

Assume that the water administration in the region is in the position to make two types of investments, namely in improving service to regular customers, and in providing connections to previously unconnected households. Assume also that both these variables are initially below their first-best levels (in particular, not all households are at the outset connected to the water system). Total investment costs are assumed to be as follows:

$$TC = c(q)N_1 + I \Delta N_1. \quad (5)$$

Here $c(q)$ is the cost of improving service to quality level q (starting at some initially lower level), per (already existing and new) customer, while I is the investment cost of expanding service to each new customer. Assume that the current cost associated with this investment equals r TC , where r is an interest rate associated with this investment (which may represent the market rate plus a depreciation rate on the investment). Assume also a fixed cost B of running a public water agency of the relevant dimension, which is considered constant (i.e. B is the cost of running the utility efficiently).

We will in the following four sections consider different solutions to this problem, namely the first-best solution, and the three institutional solutions presented in the introduction.

3. Analysis of the first-best solution

To derive the first-best solution with respect to service quality and coverage, we assume that the total amount of basic water available for consumption in the urban region in question is given (i.e., system expansion is not an issue), that investment costs are represented by (5),

and Swarna (1994), Barrett (1996), Webb and Iskandarani (1998), Renwick and Archibald (1998), Boland and Whittington (2000) and Hewitt (2000) for further discussion.

and that the cost of running the water agency is a constant, B . Then the sum of utilities to all households in the community, from the water services provided, can be written as

$$NU = N_1[v_0A_0 + v_1(q)A_1] + (N-N_1)(v_0 - p_2)A_2 - B - r[N_1c(q) + I\Delta N_1]. \quad (6)$$

The first-best solution to this problem can be found by maximizing (6) with respect to q and N_1 , yielding

$$\frac{dNU}{dq} = N_1[A_1v_1'(q) - rc'(q)] = 0 \quad (7)$$

$$\frac{dNU}{dN_1} = v_0(A_0 - A_2) + p_2A_2 + v_1(q)A_2 - r[c(q) + I] = \delta. \quad (8)$$

We will here assume that an internal solution obtains with respect to q , resulting in the derivative being set equal to zero, and thus the optimality condition (7).¹¹ This condition states that service be provided up to the point where the marginal benefit of additional service equals its marginal cost. δ is the optimal shadow value of a new connection, which may in principle take any sign. We here utilize (4) to derive the third term on the right-hand side of (8), and (for given q and I) all terms on the right-hand side of (8) are constants. If the sign of this expression then is positive, $\delta > 0$ and it is consequently optimal to connect all households. We will here and later assume that $v_0(A_0 - A_2) + p_2A_2 > rI$, which implies that the basic utility value of connecting to the water system for an initially unconnected household, including the cost of providing water to an unconnected household, together exceed the connecting costs. This assumption will imply $\delta > 0$. It is then efficient to connect all households.

¹¹ Reasonably the investments associated with quality q are irreversible. Then the (7) implies that the "starting value" of q is lower than or equal to its optimal value, and the investment necessary to implement (7) is nonnegative.

The solution implied by the conditions (7)-(8) is "real" in the sense that it only specifies properties of the optimal allocation and does not tell us how it can be achieved. In particular, no prices are involved in deriving the solution, nor any other institutional framework for implementing it. Sections 4-6 below will analyze alternative implementing institutions.

4. Analysis of water allocation under central-government water management

We now consider a water system run by a central-government agency. Assume that TC in (5) must be borne fully by the agency, or alternatively that some fraction of such costs may be charged directly to customers. We then focus on the possibility that new customers may be charged a fraction θ of the connecting costs, where $\theta \in (0,1]$, i.e., new customers can never be charged with more than the full connection cost. We also assume that they cannot directly be charged with costs of improving service above the initial level (such charges are assumed to be reflected in the water price). The water administration has gross revenues from the sale of water, equal to GR given by

$$GR = p[W - (N - N_1)A_2]. \quad (9)$$

The agency is thus assumed to sell all available water except that going to unconnected customers (each of whom always consumes A_2 of water by assumption), at the given water price p .¹² Assume that the agency has a fixed operating cost B , and in addition a variable cost

¹² We here do not specify exactly how unconnected households obtain their water. One possibility is that the water agency by law is required to make a minimum amount of water available for free to those who are not connected, e.g. by public wells. Another possibility is that water is supplied to the unconnected by vendors, who in turn obtain their water from the regular system for free, e.g. through illicit tapping or by the use of unmetered

amounting to a fraction $1-\beta$ of GR. This variable part of costs has three alternative interpretations. First, B may as before be viewed as the minimum cost of running a water utility of this size, while the fraction $1-\beta$ of GR is "organizational slack" caused by an excessively expensive organization, resulting from "employee capture" or from lack of organizational checks or interest to maximize net revenue.¹³ Secondly, there may be evasion of payments among customers, such that only a fraction β of these actually make their required payments, when the water agency is a central-government operated.¹⁴ Thirdly, a fraction $1-\beta$ of GR may be transferred to the central government (which owns and runs the water system). In the latter case the corresponding resources are not lost, but they are made unavailable to the parties in our analysis, and this affects their incentives in the same way as under the first interpretation.

Assume that the water agency considers making investments in service improvements and connections and has current costs r on these investments. After making the investments, the net surplus of the water agency is given by

$$R = \beta p[W - (N - N_1)A_2] - B - r[N_1 c(q) + (1 - \theta)I \Delta N_1]. \quad (10)$$

The agency is here assumed to be subject to political decisions with respect to its main variables. Assume that the actual decisions with respect to the water price p , the service level

connections. In neither of these cases does the water agency obtain any revenue for water supplied to unconnected households.

¹³ "Employee capture" is a likely outcome in particular when there is a strong local labor union which organizes most of the water agency employees, and would be an example of a "holdup problem", analyzed in related contexts by Grout (1984) and others. A relevant example familiar to the current authors is the situation in Tegucigalpa, Honduras, where a strong union organizes the employees of the water agency, SANAA, which is central-government run. Here, increases in the local water price customarily translate into almost equally large salary increases for water-agency employees (of whom there are far too many), thus resulting in the type of slack assumed here.

¹⁴ This interpretation is a little problematic since those evading payments of course are likely to gain from evasions, something that should be reflected in their total utilities. The simplest interpretation is that payment evasion involves rent-seeking expenses of "almost" the same magnitude as the amounts evaded. This would leave households who evade payment with little net surplus from the evasion.

q , and the number of new connections ΔN_1 , are all made at by majority voting in the local community in question. This implies that the relevant decisions will be taken by the median voter in the community.¹⁵ By assumption, the median voter represents a household with a water connection.¹⁶ Assume also that any net revenue R of the water utility is distributed equally back to the households, i.e such that each receives an amount $\pi = R/N$.¹⁷ The relevant Lagrangian for the median (connected) household may be formulated as follows:

$$L = [v_1(q) - p]A_1 + \frac{\lambda}{N} [\beta p(W - (N - N_1)A_2) - r(N_1c(q) - B - (1 - \theta)I\Delta N_1)], \quad (11)$$

where λ is a lagrange multiplier associated with a possible zero-profit constraint of the utility, assuming that the utility is not allowed to have negative profits. Note that when the zero-profit constraint is not binding (and the utility in general has positive profits), $\lambda=1$. For the case where it is not efficient to expand service to new customers, the first-order (Kuhn-Tucker) conditions for this problem are:

$$\frac{dL}{dp} = -A_1 + \frac{\lambda}{N} \beta(W - N_2A_2) = \delta_p \quad (12)$$

$$\frac{dL}{dq} = v_1'(q)A_1 - \frac{\lambda}{N} rN_1c'(q) = 0 \quad (13)$$

¹⁵ The median voter assumption is analytically convenient and has been subject to a large amount of economic analysis; see e.g. the extended discussion in Persson and Tabellini (2000). It may be interpreted either in terms of political competition between parties for majority power, as in Downs (1957), or in terms of a decision making organ such as a regulatory board, which is elected or appointed locally according to majority criteria. Note that our assumption rules out political influence on the final decisions at stake here, e.g. through lobby groups or representation of special interest groups in relevant decision-making bodies. In our context it means that unconnected groups have no political influence, which they often may have even on a regulatory board. Modifying our assumptions on this point is however not likely to alter our conclusions fundamentally; see the final section for further discussion.

¹⁶ This is based on two, reinforcing, arguments. First, more than half of the population is connected. Secondly, those connected are more politically active than those not connected, implying e.g. that their voting propensities are higher.

$$\frac{dL}{dN_1} = -[v_1(q) - p] \frac{A_1 - A_2}{N_1} + \frac{\lambda}{N} (\beta p A_2 - r(c(q) + (1 - \theta)I)) = \delta_N. \quad (14)$$

Here δ_p and δ_N represent the marginal values of the value function L with respect to p and N_1 at the optimal solution, which here both are assumed to be nonpositive. We assume the initial level q to be so low that a majority always wants it improved, represented by an internal solution with respect to q and thus equality in (13). We may however have corner solutions with respect to p and N_1 , implying negative δ_p and δ_N respectively. This in turn has the implications that, respectively, that the price will be kept at its lowest allowable level compatible with nonnegative R (when $\delta_p < 0$), and that no new customers are being connected (when $\delta_N < 0$). Using that $W - N_2 A_2 = N_1 A_1$, we find from (12) setting $\delta_p = 0$:

$$\lambda = \frac{N}{\beta N_1} > 1. \quad (15)$$

This implies that the zero-profit constraint on the water utility must bind (since setting $\lambda=1$ in (12) would yield a strict negative inequality). The water price is then set at its minimum possible level. There are two factors responsible for this principle of water pricing. First, part of the money paid by customers in the form of higher water prices is wasted by the utility, represented by the parameter β being less than one. Secondly, part of the excess revenue from water charges would in case benefit all households, and not only those current connected (who are the ones that must pay the water price). This is represented in (15) by $N/N_1 > 1$.

Inserting for λ from (15) in (13) yields

¹⁷ This revenue may be viewed as distributed to households in the form of tax reductions (relative to taxes otherwise), improvements in other services, or a combination of these, today or in the future.

$$v_1'(q)A_1 = \frac{r}{\beta}c'(q). \quad (16)$$

Comparing (16) to the first-best condition (7), the only difference is the slack factor β appearing in (16). This factor is responsible for increasing v_1' relative to c' , in (16) relative to (7), and this contributes to reducing q below its first-best level. The reason is that the marginal gain to connected consumers, in terms of increased quality when the price they pay for water increases, is low relative to the marginal cost when a large fraction of revenues are wasted. The equilibrium choice will then be a too low service level.

Using the condition $R=0$ we may derive an expression for the water price, as follows:

$$p = \frac{1}{\beta A_1} \left[rc(q) + \frac{B}{N_1} \right]. \quad (17)$$

Here we have taken as given that $\Delta N_1 = 0$ (as derived below), i.e. no new connections are added. $c(q)$ is here small if we are initially close to an equilibrium situation, and q represents possible improvements over this. Setting $c(q)=0$, we have $p = B/\beta N_1 A_1$, where B as noted is the minimum cost of running the utility. This implies that the required water price is higher the greater the amount of organizational slack in the water utility (β lower).

When $\beta < 1$ is interpreted as delinquency of payment, there is an additional, interesting and important, implication for the model. The reason is that a high price level is likely to be resisted more than a low level, at least for a given service quality level. Then β will generally be endogenous and a function of p , and lower then higher is p . At the same time q will vary with β , from (13). One easily realizes that this may lead to multiple equilibria in the model, i.e. multiple combinations of β , p and q that may all fulfill the first-order conditions (12)-(14)

(and (17)). In such cases the "worse" equilibria are clearly those with low β and q , and high p levels, which provides a somewhat different story than that behind the more standard "low-level" versus "high-level" dichotomy (where, traditionally, "low-level" is associated with low water prices). We will comment further on this in the final section below.

Consider next dL/dN_1 in (14). Using (15) and (17), (14) can be written as follows:

$$\frac{dL}{dN_1} = \frac{1}{N_1} \left[-v_1(q)(A_1 - A_2) + \frac{1}{\beta} \left(\frac{B}{N_1} - r(1 - \theta)I \right) \right]. \quad (18)$$

Since A_1 is (much) larger than A_2 by assumption, the first main term is negative. Intuitively, more new customers reduce the amount of water available to each of the old ones, something that is valued negatively by old customers. The second main term is however ambiguous. $B/\beta N_1$ represents the average cost of running the water service, which as noted translates into a minimum water price paid to cover this cost. A high water price is in this context viewed positively by already connected customers, since those that are connected additionally must also pay the required price and thus make a contribution to total water payments. This factor makes new customers "attractive" to old ones. A low level of cost recovery θI , from new customers for their own connections, works in the opposite direction, and reduces incentives to provide new connections. We then have no unambiguous conclusion with respect to the sign of dL/dN_1 , without knowing the value of the parameters, hereunder θ .

A "high" water price in such a system, relative to a "low" service level, could easily lead to political resistance against a high own-payment share for new connections (and thus against a high θ). A low θ in turn makes a negative inequality in (14), and thus the low-level equilibrium itself, more likely, by making existing connected households more hostile toward connecting new ones.

Three salient features of a local water agency run by a central-government utility, where central decision variables are set through a local political (median voter) process, stand out from the above discussion, namely:

1. Low service quality, represented by a "low" value of q .
2. A tendency for no or few new connections to be made, and for unconnected households to be required to pay a small share of their own possible new connections.
3. "As low as possible" water price, represented by a minimum price required to run the utility, at low service quality, and with no system expansion. The required water price is however higher than the price required under a system with less slack.

Our solution is derived under the assumption that the central government is not willing to let the water agency run a current deficit. If a deficit is allowed, and the water price is set at the local level by majority rule as here, the consequence is likely to be pressure in the direction of a lower water price than that derived above (due to the negative inequality in (12)).

The institutional setup assumed here need not be realistic. "The public" is likely to influence the water price of a central-government water agency (through a pricing board or something similar), but may not necessarily be able to control the setting of service levels or the adding of new connections. Instead the water agency may itself have authority to decide on the two latter variables, possibly subject to price setting by a body representing the median voter, and subject to a revenue break-even condition as above. Such an alternative setup however in fact strenghtens the case for our proposed solution. First, it is at least as likely (or more) to create slack since the water agency is still assumed to have no intrinsic interest in maximizing the population's utility from water service.¹⁸ Whatever resources that have to be

¹⁸ The reason why slack may be more likely is that the utility may be subject to much more direct control and pressure to fulfill particular targets with respect to service quality and system expansion, when these targets are set by a body representing broad population groups, than when the targets are set by the agency itself. Pressure to fulfill targets may create pressure to reduce slack in the agency organization, which may not be present in the case we are just considering.

spent on service improvements, may however be allocated efficiently.¹⁹ Secondly, the service quality and expansion levels will then be characterized by (13)-(14), as before.

5. Water allocation under local public water administration

We now consider a water system run by a local-government agency. We assume that the institutional setup is largely the same as before. The main difference is much more efficient cost control than under central-government management. In the context of the above model, the slack parameter β is then much closer to one (or in the limit, equal to one). Under median-voter decision making as before, the analysis above still largely applies, except that now (in the limit) $\beta=1$. One easily finds that $\delta_p < 0$ in (12) still holds, i.e. a majority still opts for a minimum-level water price. This is seen from (15), where $\lambda > 1$ still. Given a high initial coverage rate N_1/N , however, λ is now just "slightly" higher than one, implying that the majority of households is "almost" indifferent toward raising the water price above the minimum level, and not. The reason is that (practically) all of the revenue from water charges now benefits these households themselves, and does not go to waste in the form of "slack". Existing customers however still prefer lower p over net water administration profits, since the latter must be shared among all households, also those who are not yet connected.

Concerning service provision levels, inserting $\beta=1$ in (16) now simply yields (7), i.e. the first-best service level, and consequently higher service than under central-government administration.

The optimality condition with respect to new connections can now be represented by (18) setting $\beta = 1$ and using the new value of q . Seemingly, dL/dN_1 is smaller in the present case

¹⁹ Of course, there may be slack also on this end, something that may further exacerbate the inefficiency problem.

than with a central-government water agency analyzed above. Two factors are responsible for this. First, q is now higher, which makes the congestion effect of additional connections on old customers more severe, in utility terms. Secondly, the water price is lower when $\beta = 1$, thereby reducing the positive cost sharing effect of additional paying customers. On the other hand θ could be higher in the present case, due to less political resistance to a high own-share of new-connection payments when the water price is lower relative to the service level (from (17)). Taking this factor into consideration, it is not obvious whether dL/dN_1 is higher or lower here when compared to the central-government agency case.

Note that the difference between a central and local government water administration in our model is represented only by the parameter β and not in other, perhaps equally obvious, ways. One alternative (or supplementary) way to represent this difference could be to let households without water connections have some political influence in the local but not the central case. This would change local preferences in the direction of more new connections being established.

6. Private water administration

Our final case is a water administration run by a private profit-maximizing, monopolistic, firm. We assume at that this firm can freely determine its service quality levels. We also assume that the utility cannot price discriminate, i.e. it must set a common price for all water charged, and may or may not be subject to price regulation by (local or central) authorities. Moreover, all available water must be sold in the market (the water agency cannot artificially restrict supply in order to raise prices). The private water agency can only charge a given fraction θ of connection costs to new customers, and may or may not be able to set its water price (this may be subject to regulation).

Assume that the private firm seeks to maximize net profits, which are now given by R in (10), only setting $\beta = 1$, and subject to a given level of θ and given that the water price cannot exceed the marginal water value for connected workers, i.e. $v_1(q) \geq p$. A profit-maximizing firm would then set p at the highest level obeying this condition, i.e., $p = v_1(q)$.²⁰ We may then form the following Lagrangian:

$$H = p[W - (N - N_1)A_2] - r[N_1c(q) + (1 - \theta)\Delta N_1] + \mu[v_1(q) - p], \quad (19)$$

where μ now is a Lagrange multiplier associated with the worker utility constraint. First-order conditions with respect to p , q and N_1 are now:

$$\frac{dH}{dp} = W - N_2A_2 - \mu = 0 \quad (20)$$

$$\frac{dH}{dq} = -rN_1c'(q) + \mu v_1'(q) = 0 \quad (21)$$

$$\frac{dH}{dN_1} = pA_2 - rc(q) - r(1 - \theta)I = \delta_1, \quad (22)$$

where δ_1 represents the marginal value the private water agency of increased coverage, which could be either a positive or negative (but since all terms on the right-hand side of (22) can be regarded as constants, generally not zero). (20) can be viewed as solving for μ . Combining

²⁰ Note that the water agency is here assumed to be able to extract all the consumer surplus of connected customers except for the component v_0A_0 , from (1), which represent the basic value of a water connection (it is in fact by definition that part of the consumer surplus of a connection, that cannot be extracted by a private monopolistic water agency). In our case this is simple since all consumers are assumed to have the same preferences for water, and the marginal value of water is constant over the relevant consumption ranges. The water agency then always has incentives to set a given water price which is equal for all customers. It would be more complicated if instead different consumer groups have different, and downward sloping, demand functions for water.

(20) and (21) we derive the efficient service quality level, implied by (7), in the same way as under local public administration. Inserting for $p = v_1(q)$ yields $\delta_1 > 0$ whenever

$$v_1(q)A_2 > r[c(q)+(1-\theta)I]. \quad (23)$$

In general (23) differs significantly from the corresponding condition (14) under a central-government water administration, or the condition equivalent to (18) under a local-government water administration (where β is set equal to one). The left-hand side of (23) expresses the increased value of water revenues for the private utility, which here are equivalent to the gross value to consumers of the amount of water shifted from the "illegal" to the "legal" market, when one new connection is established. The right-hand side expresses the net current costs to the utility of establishing one new connection. Whenever A_2 is not too small and θ close to one (such that new customers are charged a high share of their connection costs), (23) may hold, in which case new connections will be provided by the water agency. In particular, this is always the case whenever new customers are required to pay all their connection costs, i.e., $c(q) + I$.

A comparison between (23) and the equivalent condition (18), under local public water agency, can be found from a rewriting of the condition under which new connections will be added in the latter case, as follows:

$$-[v_1(q)-p]A_1 + v_1(q)A_2 > r[c(q)+(1-\theta)I]. \quad (24)$$

Since $v_1(q) > p$ under a local-government water administration (since the water price is then set to maximize the utility of connected consumers), the left-hand side of (24) must be smaller than the left-hand side of (23). This represents the effect of less water being available to old

customers when service is expanded to new ones, as reflected in the majority decision of connected customers in the local government case. This implies that it is more likely for new connections to be made under a private water management than under local-government management, given that new customers make the same private payment for their new connections in both cases. On the other hand, it is possible (as in the case of central-government water management case above) that when a private water agency is allowed to charge a high water price, it may make government regulators less willing to at the same time let the agency charge all connection costs to the new customers themselves. This implies that the right-hand side of (24) is greater under private water management, than the equivalent expression under local public management. No unambiguous conclusion can then be reached with respect to the relative propensity to create new connections.

Alternatively, the private water agency could be subject to government price regulation, and such that the regulated price is less than $v_1(q)$. The main effect of this is to reduce the term pA_2 in (22), which makes it less likely that new connections are added. Note however again that whenever the private agency is allowed to (at least partly) make up a reduction in revenues from such price regulation, in the form of higher self-payment by connecting customers, this effect can easily be overturned, and a negative inequality in (22) shifted to a positive one.

7. Overall conclusions

We will now sum up the above analysis, with the main aim of predicting important differences in performance between the three types of water agency studied above.

First, with regard to water service quality, we predict a central-government agency to be significantly worse than the other two. In our model service quality is efficiently provided by

both local-government and private water agencies, while the central-government agency provides suboptimal service. This is based on the assumption of much greater deadweight loss created in the latter type of organization relative to the other two. It is then more costly, in terms of higher water prices, for connected customers to demand better service in the latter case compared to the two former. The median voter (who is connected) will then consequently opt for lower service in the central-government case.

Our second prediction is with regard to incentives to connect new households to the water system. Here the private agency appears to be superior to the other two, while we predict little difference between the local- and central- government agencies. All three agency types however generally produce suboptimal performance in this respect.

The third important policy issue studied in our model is incentives for setting the water price, and the relationship between water pricing and the other performance variables (service quality and coverage). We find, naturally, that a private water agency has a strong incentive to set a high water price, and higher than the other two types of agency. Since private management appears to yield the highest efficiency with respect to quality and coverage, this translates into an overall positive relationship between water pricing and performance. The theoretical analysis does not give us strong clues to relative water prices under central-government versus local-government management; this is largely an empirical matter.

Our overall conclusion, that public water agencies are never efficient within the institutional settings considered, is hardly surprising. Two different features contribute to this. First, operating (central-government) public water agencies implies slack which is not experienced in private agencies (nor here, by assumption, in locally operated public agencies). Secondly, both the publicly-operated agency types are subject to a median voter decision making process, while the private agency operates autonomously, only subject to price regulation. It is well known that median-voter decision making is generally inefficient when

preferences are not symmetrically distributed.²¹ In our context there is an extreme asymmetry of preferences, in the sense that some minority group (of unconnected households) has a very strong special interest in being connected. In practice unconnected households are however likely to have some political power, perhaps more so in the local-administration than in the central-administration case. This may counteract the inefficiency associated with the median-voter outcome, and could provide better incentives for system expansion under local-level administration.

Another overall conclusion is that we do not find any strong or unambiguous relationship between water prices and performance. In particular, we cannot say that higher prices always imply better performance, as is often the assumed implication using the simplistic dichotomy between low- and high-level equilibrium solutions, in the literature cited above. This issue depends heavily on the main reason or reasons why the price is "high". If one main reason is that the (public-sector) water agency is run very inefficiently (due to overstaffing, corruption and/or low revenue recovery), the water price may have to be quite high just to cover the agency's operating costs, and little will be left for (and done with) service improvements or extensions. This will imply a sort of "worst of all worlds", with high consumer costs and poor coverage and service. If by contrast the agency is an unregulated private monopoly, the water price may easily be set higher than the efficient price (this may also happen when the monopoly practices profit-maximizing price discrimination between consumer groups, something that may have more adverse efficiency consequences than those explored here).

Our main contention is however that the "worst of all worlds" case is not very relevant empirically. In fact, the low-level versus high-level dichotomy discussed in the introduction, and which is referred to by several independent observers worldwide, departs from a premise that "low-level" equilibria are associated with low water prices. This also appears to apply to

²¹ See the seminal work by Black (1948), subsequent applications to tax and macroeconomic policy by Meltzer and Richard (1981) and Roberts (1977), and the general discussion in Persson and Tabellini (2000).

the cases with which we are familiar, at least those in the Central American region. This at the same time implies certain checks on the degree of inefficiency of public water systems; in particular, such systems cannot be so inefficient that the water price required to finance running the system (at some minimum activity level) is higher than the efficient price.

A number of issues have been ignored in our analysis. First, we ignore issues related to water system expansion. When the water system is in need of expansion, with large investments being planned or undertaken, the water price facing consumers should at the same time preferably reflect the basic scarcity of water, such that these investment costs are also included in what is paid for by consumers. Such a perspective is important for making sure that the scale of such investments is socially efficient, and the water produced is efficiently utilized.

Secondly, our focus in terms of distributional implications of water provision has been on the distribution between those with and those without regular water access. Distributional concerns among connected households (which often after all is the overwhelming majority) have however been ignored. One way of dealing with distributional concerns among those with regular water access is to consider the use of increasing block-rate tariffs, which implies rebates for low consumption levels and perhaps punitively high prices at high levels of consumption. This may imply aspects of efficient cost recovery in that high-income consumer groups can be "milked" without devastating the poorer groups. Great rebates for low consumption (or even free consumption up to, say, 20 m³ per household per month as is customary in many cities) however of course works to undermine the principle of revenue recovery. Note also that block rate systems break with the basic efficiency principle of long-run marginal cost pricing, discussed in the previous paragraph.

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