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Low-Level Versus High-Level Equilibrium in Public Utility Services

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Abstract

Heterogeneity of public utility services is common in developing countries. In a "high-level" equilibrium, the quality of utility services is high, consumer willingness to pay for services is high, the utility is well funded and staff well paid in order to induce high quality of performance. In a "low-level" equilibrium the opposite is the case. Which alternative occurs depends on both the quality of utility management, and public perceptions about service quality. If a utility administration has the potential to offer high-quality service, and the public is aware of this, high-quality equilibrium also requires the public's service payments to be high enough to fund the needed pay incentives for the utility staff. When the public lack knowledge about the utility administration's quality, the public's initial beliefs about the utility administration's quality also will influence their willingness to make adequate service payments for a high-quality equilibrium. This paper shows that, with low confidence, only a low-level equilibrium may exist; while with higher initial confidence, a high-level equilibrium become possible. "Intermediate" (in between the low- and high-level) outcomes also can occur in early periods, with "high-level" outcomes later on.

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Low-Level Versus High-level Equilibrium in Public Utility Services

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1. Introduction

This paper presents a theoretical framework for analyzing some key issues related to urban public utility services in developing and emerging economies, with specific reference to Latin America, South Asia, and Africa. The allocation problems for utility services including household water and electricity access and service, encountered these regions are threefold: 1) Low service quality levels for households covered by the regular system. Water or electricity service is often provided only during part of the day or sometimes not at all (including frequent outages); water may have low quality or pressure, and power may have incorrect and variable voltage. 2) Low coverage levels of households, with many households not having access to regular service, and where those without access must rely on other more expensive and less reliable sources. 3) Inadequate long-run overall supply (of water and electricity).

Water and electricity supply are crucial services in many developing countries. Surveys have shown that water service improvement is the most important public-service issue for urban residents in many developing countries.[1] While piped water access is now high in Latin America, in many cities 20-40 % of the urban population still lacks such access, and service is inferior to many, only during part of the day or by having low water pressure. Estache et.al. (2000) find that providing piped water and electricity access, in addition to increasing the level of welfare directly, may significantly raise real household income in many Latin American countries e.g. by freeing time for market work or education among household participants.[2] This implies the potential for enormous overall welfare gains from improvements in these areas, in both the short and long run. The situation may be even worse in Africa and South Asia, where coverage rates for tap water and electricity are lower, and

[1] An example is Tegucigalpa, Honduras, where almost 25 % of surveyed households (in 1995) rated water issues as the single most important issue, with sewerage service as a distant number 2 (at about 10 %).

[2] Overall, their estimates indicate that the resulting increase in household income is approximately 10 % from water access alone, although the figure is uncertain due to possible selection problems. See also Estache et al (2006).

other public goods such as roads of lower quality. In India, surveys reveal that overwhelming majorities of respondents cite either water or other local infrastructure as the top problem for their village.[3] This is in spite of infrastructure spending having a much lower priority than other spending categories (including education), with lower attention by households.[4]

My discussion in the following focuses on the first two of the three mentioned problem areas, as applied to short- and medium run local-level water and power administration issues, with emphasis on the first (supply quality) area at least in the formal model. The two other problems are also important, but are more long-run issues requiring model set-ups that are alternative to that adopted here. The problem of long-run supply can also, arguably, often be viewed as outside of the direct control of local-level water and power administrations. In many cases investments in system expansion are undertaken according to central-level plans, and largely funded by outside sources (central-government budgets, or donors). A failure in this area can consequently often be viewed less as a failure of local administrations, than that of higher bodies.

This exercise has two main objectives. The first is to achieve a better basic understanding of main implications of particular institutions on water and electricity sector performance, and how incentives work within such institutions, which are are essential for identifying possible fruitful reforms of the sector. In the view of this author, no satisfactory such theoretical framework exists to date. I here seek to provide such a framework. This is also needed as a starting point for empirical analysis of urban water, sewerage and electricity sector performance, by identifying key parameters to be quantified, and providing interpretations of estimated parameters.

The second and related (and more specific) objective is to explore the theoretical possibility of simultaneous existence of ”low-level” and ”high-level” equilibria in markets

[3] See e g Besley (2004), Chattopadhyay and Duflo (2004), Banerjee et al (2007).
[4] See Khemani (2010).

for public utility services in developing and emerging economies. The distinction between these two types of equilibria, and an understanding of the possibility of their simultaneous occurrence, are in my view keys to understanding the functioning of such markets. The dichotomy between a "low-level" and a "high-level" equilibrium has been pointed out by a number of authors and applies to a variety of such markets, in the developing (as well as developed) world.[5] In the current jargon, a "low-level" equilibrium denotes a situation where performance is low in most respects: service quality and coverage are low, the service utility has low net revenues, and there are severe organizational inefficiencies and incentive problems, with few incentives to maintain existing facilities or improve services. This constitutes an "equilibrium" in the sense that no inherent forces tend to change the current state.[6] A "high-level" equilibrium by contrast implies higher service quality and coverage, higher revenues to the utility, and greater intrinsic incentives for maintaining and improving the system. In such an equilibrium, a high level of service is supported by high public willingness to pay for the same services, and where the public recognizes this positive relationship between service payment and quality. A main objective of this analysis is to provide a basis for understanding the circumstances under which a "low-level" equilibrium can be an outcome of particular institutional arrangements, where the prior history of the utility can play a major part in perpetuating a particular (often inefficient) solution. This leads to a next natural question, namely, what are the conditions that make it possible to break out of an initial "low-level" equilibrium, and instead move toward a higher-level and more efficient solution.

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[5] See the general discussion related to water markets in Central America in Walker et.al. (1999). For the Honduran case, see here also Strand (2000). Singh et.al. (1993), and Altaf et.al. (1993) discuss similar issues for, respectively, India and Pakistan.

[6] Note that I do little in the paper to explain why the "low-level" equilibrium arises in the first place; my main concern is to explain why such a situation can be sustained as an equilibrium once having arisen. Following Bardhan (2006), factors conducive to such an initial situation are 1) a "weak state" whereby government commitment to long-run policies is difficult; and 2) a lack of a broad range of credible instruments for income redistribution, making redistribution via low commodities prices virtually the only option.

In the formal analysis I am less concerned with the issue of public versus private utility administration, but rather *"high-quality" versus "low-quality"* utility management. High-quality management is taken to mean that service delivery responds positively to economic incentives provided via higher prices of utility services. Under low-quality utility management, by contrast, service quality does not respond to price incentives. In principle, a publicly-run utility could be of high quality and a private-run utility of low quality; the opposite constellation is however more customary to face, and to assume.

At least equally important for this story is however the *public's perception* of whether future service delivery quality can be expected to be "high" or "low". In many cases, the public has incomplete information on which to judge the quality of a given utility administration. This, I argue, can be crucial in (at least) two main situations: when the utility is initially stuck in a low-level equilibrium; and when the utility's management is in a process of change. The key to multiple equilibria (where both high-level and low-level equilibria exist simultaneously for given economic fundamentals) can be found just here: pessimistic beliefs may be self-perpetuating; while optimistic beliefs may break an evil circle of "low-quality" equilibria.

In my model I assume that a utility administration can provide service at a "basic" level, or in excess of this "basic" level, but that the latter requires the ability to induce staff to put up excess effort (above a minimum), through a system of incentive (bonus) payments. I assume that when only a minimum price is paid for the service, only a minimum productivity level is implemented, regardless of administration quality. When income recovery is above minimum, incentives can be provided through bonuses, given that the quality of the utility administration is high (it is "non-corrupt"). When the utility administration has low quality (is "corrupt"), I assume that pay does not affect service delivery. I also assume that the price charged for utility services is decided in a public decision-making process (possibly, voting), and is set by the public on the basis of an anticipated relationship between price and service quality. I first explore how such a relationship between pay and service quality may lead to either a “low-level” or a “high-level” equilibrium, or possibly the co-existence of both. I then go on to demonstrate that when the public is uncertain about the true type of the utility administration (whether it is “corrupt” or “non-corrupt”), the utility market described by my model tends to exhibit multiple equilibria, in the sense that a “low-level” (“high-level”) equilibrium obtains when the (Bayesian) prior probability of “non-corrupt” is low (high).

The issues I describe by my model are highly relevant for describing actual public utility markets in several world regions. One is Latin America, where a great wave of regulatory changes has swept over the region largely in the electricity and telecommunications sectors but increasingly in water and sanitation. This has largely taken the form of privatization, so far more in telecommunications and power than in water and sanitation.[7] In the latter sectors public operation is however still often the most realistic alternative.

Another region where endemic inefficiency problems in both the electric power and water sectors take similar forms is South Asia. A main case in point is the market for electricity to households and farmers in India. This market is plagued by a chronic “low-level equilibrium” where willingness to pay for electricity supply is low (often zero at the margin for farmers, and typically determined at the state level through a political process), service quality is poor with frequent power outages and voltage distortions (leading to damaged equipment), and there are large system losses.[8] Surveys have indicated substantial willingness to pay for more reliable service, which could also raise more revenue so as to solve some of the problems). There is however a lack of political will to increase electricity prices in part because consumers do not trust the power utilities to actually deliver higher-quality services. The

[7] See Estache, Foster and Wodon (2000) for an early discussion and overview of privatization of utilities in Latin America over this period, and World Bank (2009) for a more recent discussion, covering all basic utility services.
[8] Such issues are discussed e g in World Bank (2010).

potential, and reachable, “high-level equilibrium” is thus then not reached, and due to processes very similar to those invoked in my model.[9]

To my knowledge, no satisfactory and directly comparable analysis of multiple equilibra in infrastructure delivery markets currently exists in the literature. My model still relates rather closely to various supporting strands of literature. One is the literature on more general “low-level” equilibrium in developing countries; see Nelson (1956) for a seminal contribution. The “entrapment” mechanisms are similar in my model and his, namely an inadequate level of funds to free the economy from the trap (in Nelson for investment; here for rewarding utility staff to take effort). But there are also more substantive differences, in particular when the “trap” in my model has an informational basis, as I discuss in section 5. Then escaping the “trap” is in a real economic sense easier here; and, arguably a more natural basis for the notion of multiple equilibria (for given fundamental values) is achieved. Another related strand of literature deals with centralization versus decentralization of utility services; a prominent example is Bardhan and Mookherjee (2006).[10] A focus in their paper, similar to ours, is on the potentially positive relationship between the ability to implement user fees, and service delivery, which they argue is more likely to be successful under a decentralized system, in particular since asymmetric information problems, and tensions related to potentially adverse distributional impacts of service user charges, then are minimized. To connect my model to theirs, note that a system with gradually higher user payments in my model can in principle be interpreted as one with gradually greater local autonomy and less central control in theirs (considering a system where the balance of utility revenues are obtained from central funds).

[9] A similar but slightly less dire situation exists in the household power sector in India, where the norm also is under-pricing, poor supply quality, and an anemic rate of system expansion.
[10] For further discussion and elaboration of such issues, see Bardhan and Mookherjee (2005), and World Bank (2003).

2. Basics

Consider the following basic model. A given group of served customers with "regular service"[11] have the following utility function related to their utility services:

(1) $$U(q,W) = qV(W) - pW \ .$$

U is net welfare to the customers ("the public") from the utility service, W is the amount of the good provided (which could be water as our main example, or electricity), V is a "basic utility function" (in "basic water", or "basic electricity"), q is a "quality outcome" variable for the public, that takes a minimum value of unity, and p is the price charged by the utility per unit of the good delivered. We assume that q is a function, q(E), of utility employee and management effort, E, so that q(0) = 1, while q'(E) > 0, q''(E) < 0 throughout. We assume that V is increasing and strictly concave in W.

Consider initially that both p and q are given, at "basic" levels: q = 1, while p is some minimum price required for recovery of the utility's basic operating cost. Assume that the utility has a (minimum) initial staff of size N, where each is paid a minimum unit salary, and assume that the utility has a fixed per-period capital cost of C. The total minimum per-period *short-run* cost of the utility is then SC(0) = N. But, I assume, this does not service any of the utility's current capital costs, denoted C, and would thus result in a deficit being accumulated given that these costs are not serviced. Define minimum total costs by TC(0) = N+C (where the "zero" denotes that total costs are minimized).

We can think of this in two ways. First, we could assume that this deficit is simply being accumulated and the water utility is falling farther and farther into debt. The other, and more reasonable, possibility is that an additional accumulated deficit is covered ("bailed out") through alternative funding.[12]

[11] By this we here simply mean that, in the case of electricity or water, they are actually connected to the standard (power or tap) delivery system.
[12] Funding sources for long-run capital cost service could be general (local or central) taxation; the central government budget; or donors.

Either way, start by assuming that the utility is responsible only for short-run cost recovery. Assume that the number of regular customers is M. Then the basic price of water per unit, that exactly covers the utility's cost (and is the minimum necessary price for operation) equals SC(0)/M = p(0). At this cost, the average household would select (vote in favour of) a level of W so as the maximize (1) (assuming that W is metered and subject to marginal pricing), yielding the following first-order condition solving for W:

(2) $$V'(W) = p(0).$$

Consider a quadratic V function:

(3) $$V(W) = aW - \frac{1}{2}bW^2$$

For this case, the optimal W and V(W) are:

(4) $$W(0) = \frac{a - p(0)}{b}$$

(5) $$V(W(0)) = \frac{a^2 - (p(0))^2}{2b}.$$

Define also per-unit utility of the service by v(W), which is given by

(6) $$v(W(0)) = \frac{a + p(0)}{b} > \frac{p(0)}{q(0)}.$$

For (1) to be meaningful, U(q(0), W(0)) > 0, requiring the last constraint in (6) to hold.

The above solution may be considered as an "equilibrium", in two different situations. In the first, there is no available alternative (or the public perceives no such). In the second, there are available alternatives but they are (viewed as) inferior to the low-level "status quo".

3. Endogenizing q with High-Quality- Utility Management

3.1 Locally optimal q for low- (L) and intermediate-efficiency (M) solutions, 1 < p < p*.

I will now seek to endogenize the parameter q, the "quality" of service delivery. When the water price p is kept at the basic level of p(0), there is no surplus by which to reward good service that could raise q above zero. I will consider mechanisms by which q can be determined, endogenously and above the minimum level of unity, when p can be raised above the basic level of unity, and the service utility management can take on either of two different types: non-corrupt, and corrupt.

Assume a high-quality ("non-corrupt) service utility. Funding, through higher a p > 1 will then go toward either service improvements, or increased servicing of existing debt, or a combination of the two. Assume that these take the form that utility employees are paid bonuses (beyond a basic compensation of unity). Assume in the following here that the amount of water sold is a constant (and equal to the optimal amount given p = 1, from (4)). Then an increase in the unit price will lead to a proportional increase in utility revenue.

When the utility however recovers more cost, some part of capital costs are assumed to be serviced out of user fees. Assume that when a higher price is charged for water, a fraction α is used toward higher pay for staff, and a fraction 1-α used for servicing of the debt.

Assume, alternatively, that the service utility could be corrupt. I will assume that low service quality (or "corruption") takes the form that, regardless of additional funding through excess water price, service will not improve. This money now instead disappears in the pockets of utility management and staff.[13]

We will in this section concentrate on the "non-corrupt" case. For this case we can formulate a function relating higher payments of the public per unit of water, to service quality in the form of higher values of the quality parameter q. The wage of staff, w, is then determined from (as long as not all capital costs are yet paid)

(7) $$\alpha(p-1)W = (w-1)N$$

[13] Alternatively, service quality could be only a very weakly increasing function of unit price in this case. A number of such examples can be found.One case is the water utility administration, SANAA, in Tegucigalpa, Honduras, during the 1990s. Being initially stuck in a "low-level" equilibrium, there was on a few occasions attempts to raise water prices in order to improve service levels. On those occasions, however, the SANAA employee union was able to capture virtually the entire increased cash flow to SANAA, without any noticeable service improvements taking place. For further discussion of this case, see Strand (2000).

where w(0) = 1 is a minimum wage to be paid to utility staff. Service of capital costs, γC, are correspondingly given by the fraction 1-α of excess water revenue:

(8) $$(1-\alpha)(p-1)W = \gamma C$$

which holds up to the upper limit for γ (= 1). This occurs when p reaches the level

(9) $$p^* = 1 + \frac{C}{(1-\alpha)W} = 1 + \frac{c}{1-\alpha}$$

where we have set c = C/W. c can be interpreted as the ratio of capital costs to minimum or basic labor costs in the public utility's budget. Alternatively, c is the ratio of capital costs to the utility's gross receipts from the public at the minimum price (= 1).

Any increase in p beyond its level given by (9) is expended toward higher wages and bonuses to staff. From (6) we now have the following relationship between the wage of utility staff, w, and the price paid by customers, p, as follows:

(10) $$w = 1 + \frac{\alpha(p - p(0))W}{N}.$$

Let us now normalize further and set p(0) = 1, which in turn implies W = N. Assuming still that W is a constant given by (4), we can then write (10) in the following simplified way, given that $1 < p \le p^*$:

(10a) $$w = 1 + \alpha(p-1),$$

or when written inversely, as the price as function of the wage:

(11) $$p = \frac{1}{\alpha}(w - 1 + \alpha)$$

Consider now incentives of water utility staff to put up effort to improve on the delivered service quality parameter q. We assume that management of the water utility can reward employees according to q (which is assumed to be publicly observable), according to a linear payoff function of the following type:[14]

(12) $$w = w(0) + \beta(q - q(0)) = 1 + \beta(q-1),$$

where w(0) = 1 is the base (minimum) wage, and where β indicates the "power" of the incentive mechanism (or the degree to which reward depends on measurable outcome). Define now the following objective function for utility staff:

(13) $$F(w,q) = w - g(q-1) - \frac{1}{2}h(q-1)^2 = 1 + \beta(q-1) - g(q-1) - \frac{1}{2}h(q-1)^2,$$

where we assume that producing at level q = 1 implies no (incentivizable) effort (= the level of effort put up by showing up for work). The disutility of putting up effort q toward improving utility services is, I assume in (13), a quadratic function of measurable-outcome effort. Maximizing (13) with respect to q yields

(14) $$q = 1 + \frac{\beta - g}{h}.$$

The three equations (14), (11) and (12) can be viewed as having four unknowns, w, p, q and β. We can then, from this set of equations, define w, q and β as functions of p. One interpretation of this solution is that p is "chosen" by the public, recognizing this relationship. We are, in particular, concerned with the relationship between q and p, which is decisive for the public's possible choice of output price of the utility. We find the following equation relating these two variables (when eliminating 1 and β):

(15) $$(hq - 1 + g)(q-1) = \alpha(p-1).$$

A meaningful solution to (14) (requiring a solution values q, p ≥ 1) requires that the constraint

(16) $$g + h > 1$$

holds. Solving the quadratic equation (15) for q in terms of p we find:

[14] There could here still be an incentive problem versus each individual employee if what is observed is only the aggregate output and efficiency level of the utility and not the individual-employee contribution to this level. We here ignore such problems by simply assuming that individual-specific mechanisms can be established.

(17) $$q = \frac{1 + h - g + \sqrt{(h + g - 1)^2 + 4h\alpha(p-1)}}{2h}$$

We also have the following schedule between q and p, from (15):

(18) $$\frac{dq}{dp} = \frac{\alpha}{2hq + g - h - 1}.$$

It is easily seen that (for q, p $\geq$ 1) dq/dp > 0, so that this schedule is increasing, but less rapidly when q increases beyond 1.

Consider now possible (locally) optimal, internal solutions for p on the domain [1, p*]. These must be characterized by the optimal choice of p considering the relationship between p and q given from (18). The utility function of the representative consumer, U, can now be found by assuming that the level of water W from (4) applies, giving the following solution for V(W), found from (3), as

(19) $$V(W) = \frac{(a-1)(a+1)}{2b}$$

This yields the following expression for net utility:

(20) $$U(W) = \frac{a-1}{b}\left(\frac{a+1}{2}q(p) - p\right).$$

In (20), we consider q a function of p given from (15) (or alternatively from (18)). The relationship between U and p can then be written as:

(21) $$\frac{dU}{dp} = \frac{a-1}{b}\left(\frac{a+1}{2}\frac{\alpha}{2hq + g - h - 1} - 1\right).$$

There are here three possible classes of optimal solutions: a) dU/dp < 0 (the “optimal” q is less than unity); b) dU/dp = 0 (we have an internal, optimal, solution); and c) dU/dp > 0 for permissible q and p (the optimal solution lies in the range p > p*).

Consider first case b), the internal solution, where (21) is set equal to zero. This yields the following solution for q (= q_M; indicating a “medium-level” value of q):

$$q_M - 1 = \frac{1}{2h}\left(\frac{a+1}{2}\alpha + 1 - (h+g)\right). \tag{22}$$

Most importantly here, we see that the solution value for q_M from (22) is greater than unity if and only if

$$h + g < \frac{a+1}{2}\alpha + 1. \tag{23}$$

The schedule by which staff pay increases when receipts from utility fees rise, must here have a certain minimum positive slope. Thus, *a (local) internal solution for q on [1, q*] exists in this case, if and only if (23) holds.*

β indicates the power of the incentive scheme used to induce effort among utility employees, and is endogenously determined as follows:

$$\beta = \frac{1}{2}\left(\frac{a+1}{2}\alpha + 1 + g - h\right). \tag{24}$$

(24) indicates that the incentive scheme is more "powerful" when α (the fraction of excess payments that can be used for incentivizing utility employees) is higher. One must however be careful in interpreting this parameter, as it is the resulting q level that is key: If either of the parameters g and/or h is too high (so that (23) does not hold), no equilibrium with p > 1 exists, regardless of the solution value for β.

3.2 Locally optimal q for high-efficiency (H) solutions, p > p*

Consider next cases where a locally optimal solution can entail p > p* (given from (9)). In this case w is given by

$$w = 1 + \alpha(p^* - 1) + p - p^* = p - c. \tag{25}$$

Note that we are focusing on local optimality: we do not rule out the possibility that an M solution is globally optimal. The only difference from the discussion in section 3.1 is that, instead of (10a), (25) determines the wage-price relationship. The relationship between q and p is now characterized by

(26) $$(hq-1+g)(q-1)=p-1-c$$

The values of q relevant here are in excess of q* (which correspond to p in excess of p* given from (9)), where q* is given by

(27) $$q^*=\frac{1+h-g+\sqrt{(h+g-1)^2+4h\left(\frac{\alpha}{1-\alpha}c\right)}}{2h}$$

I now derive a relation between q and p, holding for (q, p) > (q*, p*), in similar fashion as under the M case, obtaining the relationship

(28) $$(hq-1+g)(q-q^*)=p-p^*.$$

The solution for q is now

(29) $$q=\frac{1+hq^*-g+\sqrt{(hq^*+g-1)^2+4h(p-p^*)}}{2h}$$

The slope of the q-p schedule is in this case, for q > q*:

(30) $$\frac{dq}{dp}=\frac{1}{2hq+g-hq^*-1}.$$

This slope is steeper than that implied by (17), for an M solution. Thus, *the overall schedule between q and p has a "kink" at the point (p*, q*).* This is the point beyond which all capital cost is serviced, and the entire excess marginal revenue can be expended toward staff pay service quality improvements.

(20) still holds as the expression for U(W). Maximizing (20) with respect to p invoking q(p) from (30) now yields

(31) $$\frac{dU}{dp}=\frac{a-1}{b}\left(\frac{a+1}{2}\frac{1}{2hq+g-hq^*-1}-1\right)=0$$

with the following solution for q (= q_H; a "high" value):

(32) $$q_H - q^* = \frac{1}{2h}\left(\frac{a+1}{2} + 1 - (h+g)\right)$$

I here find that, *for a candidate H equilibrium to be found, a key condition is* $q_H > q^*$*, where* q_H *is given from (32), and* q^* *given from (27).*

4. Equilibrium under Complete Information and High-Quality Government

I will now study possible overall equilibria for this market, and focus on the case where the utility administration is non-corrupt, and this is common knowledge among residents. The model is also assumed to be common knowledge, so that the public knows the true relationship between p and q. Assume that the utility price is determined through public voting over alternatives, leading to the preferred level. It remains to check which solution, among the candidates found, is the actual equilibrium: p = 1 (low-level of L equilibrium); p on (1, p*] (medium-level or M equilibrium); or p > p* (high-level or H equilibrium).

For this problem to be interesting we must, as a minimum, assume the following condition (noting also that (16) must hold):

(33) $$1 < h + g < \frac{a+1}{2} + 1.$$

From (6), (a+1)/2 > 1. The sum of the two parameters h+g must then be required to fall in a particular range, [1, (a+3)/2]. The upper limit of the range is the relevant constraint to focus on here. When this constraint fails, no equilibrium value for q exceeding 1 can ever be found, and neither an M nor an H equilibrium can exist. Intuitively, when h+g is large, utility employees have a high degree of effort aversion.[15] No permissible incentive mechanism can then be constructed which is sufficiently powerful to induce effort q exceeding 1.

Assume in the following that (33) holds. I will now first focus on the more restrictive condition, (23), for an M equilibrium to exist, and assume that this holds, making the problem

[15] On the other hand, when h+g is low, effort aversion is "too low" and an internal maximization solution cannot be found; in this case the problem is not well defined with the given functional forms.

less trivial. We then have (at least) a candidate M equilibrium, as studied in section 3.1.[16] In such cases we may have two candidate equilibria.[17] The issue is then whether an M equilibrium, or the H equilibrium alternative, will be chosen. Note then first that an H equilibrium candidate can be found only if $q_H > q^*$ (with q_H given from (32) and q^* from (27)), following from the discussion in section 3.2.

Let us now define the constants A_1 and A_2 by:

$$A_1 = \frac{(a-1)(a+1)}{2b}, A_2 = \frac{a-1}{b}. \tag{34}$$

Under the M equilibrium, utility can then be expressed as

$$U_M = A_1 q_M - A_2 \left[1 + \frac{1}{\alpha}(hq_M - 1 + g)(q_M - 1) \right], \tag{35}$$

where q_M is given from (22).

Under the H equilibrium, utility is

$$U_H = A_1 q_H - A_2 \left[1 + c + (hq_H - 1 + g)(q_H - 1) \right], \tag{36}$$

where q_H is given from (32), and where we must have, as noted, $q_H > q^*$.

Under these conditions, *an M (H) equilibrium will be the outcome given that U_M > (<) U_H.*

It is here crucial to compare the two levels of utility U_M and U_H. In making this comparison, the magnitude of c is seen to play a major role, and thus for the choice of equilibrium. Briefly expressed, when c is "very large", $U_M > U_H$ always. Intuitively, there is a lot of debt to be serviced in the short run.[18] The price p for utility services to be charged to the public, that leads to full debt service out of variable user charges to the public, is exceedingly high; and an equilibrium incorporating such a price less attractive than one with a far lesser amount of debt service.

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[16] Note again that (33) is not sufficient for an M equilibrium candidate to exist; the stronger condition (23) must hold.

[17] This should be clear also from the simulations below.

[18] We see however, of course, also that when c is very large, we cannot have

By contrast, when $c = 0$, there is no debt to be serviced, and all excess revenue can go toward staff compensation "from the first dollar". In this case, the intermediate M solution disappears. An H equilibrium then always exists, by virtue of assumption (33).

In intermediate cases for c, both solutions can be relevant. A more detailed comparison of utility levels is needed. Note however that, by continuity, there exists a level of c, call it c*, that makes $U_M = U_H$. Thus *for c < (>) c*, an M (H) equilibrium will result under complete information.*

The simulations in figures 1-2 below illustrate the shape of the (p, q) schedule for two alternative values of α, namely 0.2, and 0.5.[19] In the former case (figure 1) "most" of the excess payment to the utility (above 1) goes for servicing debt, and only a fraction 0.2 is allocated to staff incentive payments. The (quality, price) schedule is then relatively flat up to the point where debt is fully serviced, while it rises at a much steeper rate for higher p levels. It is then easy to see that the shape of indifference curves (which will be rising and strictly convex in (p, q) space) will determine which of the two segments corresponds to the optimal solution for the public. Note also that a special case may entail where the highest indifference curve is tangent to both segments. In such a special case, there are two distinct equilibria in this model, for given fundamentals.

In figure 2, a larger fraction of excess revenue goes to staff. This implies a more rapidly rising (p, q) schedule, but a higher p is required before debt is serviced (and all excess pay may go to staff). This also implies that the kink is less noticeable.

[19] In the case simulated, I have set $h = g = 1$, $c = 2$.

Figure 1: Illustration of the (p, q) schedule for α = 0.2

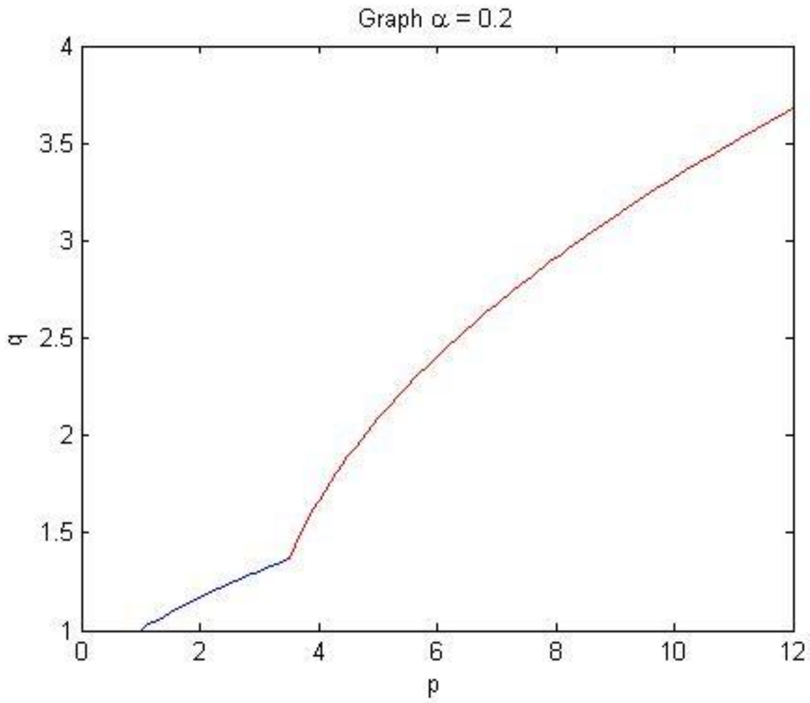
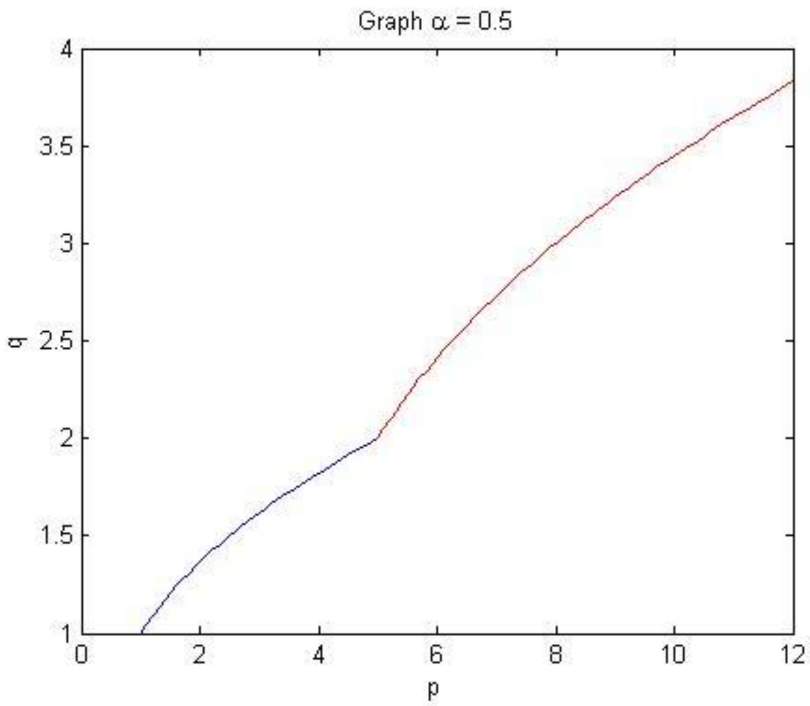


Figure 2: Illustration of the (p, q) schedule for α = 0.5



5. Bayesian Equilibria With Incomplete Information About the Utility's Type

5.1 q_M is the complete information equilibrium

I have above assumed that the utility administration can be either low-quality ("corrupt") or high-quality ("non-corrupt"). The analytical derivations in sections 2-4 were however all based on the assumption that the utility administration is non-corrupt, and that this is common knowledge among the public. In that case, I found that equilibrium is typically unique (apart from in special cases), and can be either an L, M or H equilibrium. Which equilibrium will result, depends on certain parameters of our model; on "economic fundamentals".

I now consider possible outcomes when the nature of this administration is not necessarily known to the public, but must be predicted or anticipated, under uncertainty. In the context of my model, there are (at least) two natural contexts in which the utility administration's type may not be fully known among the public. First, if history up to the particular point in time studied has been one involving only L outcomes, such outcomes cannot distinguish between types; thus the utility administration's type would be non-observable.[20] Secondly, following a change in the utility's management, there may be uncertainty among the public about the quality of this management.

Following this line of argument, assume that the utility administration is non-corrupt, but that this fact is not (fully) known by the public. This implies incomplete information about utility administration type. We will represent this by introducing a parameter θ, which is the public's (Bayesian) prior probability that the utility is non-corrupt, with a complementary probability $1-\theta$ that the utility is corrupt, and such that $0 < \theta < 1$. For the public, the situation is that service delivery, in response to a particular price paid for the service, is considered to be uncertain.

[20] In principle one could, for some time, have had a non-corrupt administration, which however had not been able to prove its quality due to minimum-level finance in past periods.

We now focus on the possibility of an "M-type" equilibrium, where the welfare function of the public related to utility services is given by (20) in the complete information case. Assume $q_M > 1$ so that (23) holds. Ignoring in the following a possible H equilibrium, an M equilibrium exists in the complete information case.

In the current (incomplete information) case, public welfare would be uncertain. (19) would need to be replaced by the following expected welfare expression, where we can now write expected welfare to the public directly as a function of the price charged for utility services:

(37) $$EU(p) = \frac{a-1}{b}\left(\frac{a+1}{2}(\theta q(p)+1-\theta)-p\right).$$

The problem for the public of selecting the optimal p would now amount to finding an equilibrium to the associated Bayesian game, where the public takes the utility administration's (state-contingent) optimal behaviour into consideration.[21] Maximizing EU(p) in (37) with respect to p now yields the following (short-run) optimal solution for q (denoted $q_{\theta M}$ to indicate its dependence on the given prior belief):

(38) $$q_{\theta M} - 1 = \frac{1}{2h}\left(\frac{a+1}{2}\theta\alpha + 1 - (h+g)\right).$$

A crucial issue is here whether $q_{\theta M}$ is smaller or greater than one. If $q_{\theta M} \leq 1$, the "low-level" equilibrium will persist as the chosen price will not be able to sustain a service quality level above the minimum. The utility administration's true type will then not be revealed by the resulting market outcome. This holds whenever

(39) $$\theta \leq \frac{2(h+g-1)}{(a+1)\alpha} = \theta_M .$$

By contrast, when $\theta > \theta_M$, $q_{\theta M} > 1$.

[21] See Gibbons, chapter 3, for an introduction to Bayesian games. Note that the "game" here and in the following section is much simplified as the (type-dependent) strategy space of the utility administration is highly restricted: to produce at minimum level if corrupt; and at the response level from section 3 if non-corrupt.

(39) thus gives the cut-off level for θ: *when θ > (≤) θ_M, an M (L) equilibrium will result under incomplete information, where θ is the public's (Bayesian) prior probability that the utility administration is non-corrupt.*

Once an M equilibrium has materialized for one period, the utility administration's type will have been revealed. Upon observing the higher quality level $q_{\theta M}$ in this case, it will be immediately confirmed to the public that the quality of the utility administration is high (it is "non-corrupt"). The prior probability of non-corruption will then be immediately revised, so that $\theta = 1$ from then on. In subsequent periods, the optimal solution will then be $q = q_M$.

This argument leads us to *multiple equilibria for given fundamentals, such that the equilibrium which actually materializes, emerges as a function of the public's subjective prior probability of a non-corrupt utility administration, θ: For all prior beliefs $\theta \in [0, \theta^*]$, the low-level equilibrium persists, with minimum levels of utility prices, and effort. For all priors $\theta \in (\theta^*, 1]$, by contrast, $q_{\theta M}$ is the equilibrium value of q in the first period, and q_M in subsequent periods.*

5.2 q_H is the complete information equilibrium

Consider next a case where the high-level (H) equilibrium prevails under complete information. Let us then first simply assume that an H equilibrium (albeit with a different (p, q) combination) would prevail also in the incomplete information case.

(37) would still describe the general welfare function for the public in this case. The welfare maximizing solution for the M case, (38), would now be replaced by (denoting the solution for q by $q_{\theta H}$ in this case)

(40) $$q_{\theta H} - 1 = \frac{1}{2h}\left(\frac{a+1}{2}\theta + 1 - (h+g)\right).$$

In general, the solution for $q_{\theta H}$ is less than q_H (possibly much less), due to $\theta < 1$. This raises a number of issues.

A key issue is whether $q_{\theta H} \geq q^*$, from (27), which is still a condition for the H solution to materialize. This holds whenever

$$(41) \qquad h+g<\frac{a+1}{2}\theta+1.$$

Define a value of θ, call it θ_H, which yields equality in (41), and below which only an M equilibrium can exist.

Secondly, assume now $q_{\theta H} > q^*$, as found from (40). While this solution is locally optimal, it need not be globally optimal. This may be the case even when the H solution is globally optimal under complete information.

To understand this, consider the profit expressions for the M and H cases, when information is incomplete ($\theta < 1$). These expressions are respectively:

$$(42) \qquad U_{\theta M}=A_1\theta q_{\theta M}-A_2\left[1+\frac{1}{\alpha}(hq_{\theta M}-1+g)(q_{\theta M}-1)\right]$$

for the M case, with $q_{\theta M}$ is given from (38); and

$$(43) \qquad U_{\theta H}=A_1\theta q_{\theta H}-A_2\left[1+c+(hq_{\theta H}-1+g)(q_{\theta H}-1)\right]$$

for the H case with $q_{\theta H}$ given from (40). The difference in utility is given by

$$(44) \quad U_{\theta H}-U_{\theta M}=A_1\theta(q_{\theta H}-q_{\theta M})-A_2\left[c+(hq_{\theta H}-1+g)(q_{\theta H}-1)-\frac{1}{\alpha}(hq_{\theta M}-1+g)(q_{\theta M}-1)\right]$$

We here see that as θ is reduced (and $q_{\theta H}$ and $q_{\theta M}$ at the same time fall), c does not fall and tends to dominate the expression more. As a result there is a tendency for (44) to be negative in more cases. An M solution will then be selected in "more cases" given that an H and an M solution are both feasible.

The conclusion of the discussion in this subsection is that, "often", the selected equilibrium will take the following form: Whenever (39) holds, select $q_{\theta M}$ in the first period; select q_H in subsequent periods given that $q_H > q^*$ from (27).

6. Conclusions and Extensions

A main objective of this paper has been to characterize potential "low-level" (L) and "high-level" (H) equilibria in markets for public utility services, with particular application to developing and emerging economies. In sections 2-4 of the paper I study the behaviour of a high-quality ("non-corrupt") utility service administration, and where there is common knowledge among the relevant public being served by this utility (information is symmetric). An important feature of my model is how the payment for services, in excess of a stipulated minimum price, affects incentives within the utility service administration. I assume that the basic (minimum) price covers the short-run costs of basic service provision (at a minimum quality level), but with no room for servicing any part of the utility's capital costs. When the price paid by the public is increased, additional revenue is allocated to two different ends: a fraction α is spent on excess payments to utility staff; while the rest (a fraction $1-\alpha$) is spent to service the utility's fixed capital costs (with a maximum such service of C). When the price p is above some higher level p*, capital costs are fully serviced by the fraction $1-\alpha$ of such excess user charges. Additional revenue is then expended in its entirety toward management and staff salary and bonuses. I show that, under such a financing schedule for the utility and its service, and when the utility administration is non-corrupt (and this is common knowledge), three classes of equilibria may obtain: a) a "low-level" (L) equilibrium with low (only basic) service level and prices; b) an intermediate (M) equilibrium where price and service quality are both in an intermediate range; and c) a high-level (H) service equilibrium where the service price and quality are both higher and where, at the margin, all revenue from increased service payments goes toward staff remuneration. Typically, for any given parameter constellation, only one equilibrium exists. Overall, when C is "very small", only an L or an H equilibrium can exist; and when C is "very large", only an L or an M equilibria can exist. In some special (non-generic) cases there may however exist two equilbria, both an M and an H equilibrium, for given parameter values.

When by contrast the quality of the utility administration is low (it is “corrupt”;and this is common knowledge; so there is still no information asymmetry), the L equilibrium is the unique equilibrium. This is because, in my model, the quality of service for a corrupt utility administration is not responsive to increased staff payments within the utility administration. There is then, obviously, no willingness to pay for utility service beyond the minimum, since such extra payment will in no case lead to improved service quality, and this is known to all.

Section 5 studies solutions with incomplete (asymmetric) information, where the quality (or “type”) of the utility administration is not fully known to the public. The true type, I assume, is high-quality (“non-corrupt”). The public attaches a (Bayesian) subjective prior probability, θ, between zero and unity, to the utility being “non-corrupt”' and a complementary probability, $1-\theta$, to it being “corrupt”. I argue that there are at least two plausible reasons for such an information asymmetry to exist. First, when society has been “stuck” in a low-level equilibrium for some time, the true utility type cannot be directly observed by the public in my model. An L solution will then be perpetuated even when the true type is “non-corrupt”. Secondly, occasional changes in the utility administration do occur. Sometimes these changes are drastic as when this administration undergoes a radical transformation (from public to private, or from state- to locally-run, operation). In this transition, there will be some natural uncertainty among the public, about how the utility is likely to perform. When the public is “myopic” (concerned with only one future “period”), a Bayesian Nash equilibrium of the resulting (incomplete information) game is then simple to characterize. First, when θ is below a particular threshold (θ^*), the L equilibrium is the only equilibrium. When $\theta > \theta^*$, solutions in the incomplete information case depend on their complete information counterpart. Common to all such solutions is that the price p per unit of utility services charged to utility customers in the "first period" will be higher than the minimum level p(0), but less than the equivalent level under complete information. This yields a service level, q, which is above the minimum level of q(0), but below the level that would result under complete information. The utility administration's type is then revealed as being non-corrupt in the "first period" (since, if the administration had been corrupt, it would not have been able to provide any increase of q above q(0)).

The analytical derivations in my model are based on the assumption that the public is concerned with only one future period when making its current policy choice, and that this choice only involves the willingness to pay per unit of utility services, p. In particular, information revelation as such (whereby the utility administration type could be revealed, but only if the public would set p above unity) was then of no particular concern for the public's choice of p, in the period in question. In short, the reason for this is that information revelation as such would be of value for future periods only, not for the current period.

Some changes in assumptions, in realistic directions, would also change the nature of some of the results. Assume instead that the public is concerned with two (or more) periods instead of just the one single period ahead. This changes the game, and model, more fundamentally. Think, in particular, of a case where, in the complete information case, an M equilibrium would be selected, and where (23) thus holds. This problem has a simple solution when (33) holds, and is then identical to that discussed in section 5. The reason is that the solution from section 5 is optimal from the point of view of the public, both for period 2 (given the information asymmetry in that period), and for subsequent periods (when there is no longer an information asymmetry).

When (33) does not hold, the system would be stuck in an L equilibrium in the single-period case regardless of utility administration's type. Adding more than one period over which the public maximizes its initial utility will however change this. The public may then take action to raise p above unity in the first period in order to reveal information about the utility administration. This would add to the value of the service in the period. The threshold beyond which an M solution will be selected in the first period is then lowered. This effect is stronger when the future is longer relative to the current period.

A number of extensions of the current model could and should be pursued in future work. One is to extend my set-up so as to accommodate concerns raised when extending it to a repeated game, in a more satisfactory way by including public preferences for more than one period. This would require some basic changes of the model as presented so far. Two changes seem particularly relevant. I have above made the unrealistic assumption that information revelation requires only a marginal increase in p beyond p(0). It is then always optimal to induce such revelation. A first change would here be to assume that a certain minimum increase in p is necessary for truthful revelation. A second (alternative or complementary) change would be to assume that q is a random function of p, so that truthful revelation may not be guaranteed even when the utility administration acts optimally and is non-corrupt. The latter may follow when service quality itself is stochastic. Then observable service quality might not improve even when utility employees put up high effort.[22] Alternatively, service quality may be observed to be "high" in some periods when effort is low.[23]

Some other possibilities then also open up. One is where the utility administration, while inherently "corrupt", tries to signal being "non-corrupt".[24] An incentive compatibility constraint on the administration must then be fulfilled for truthful revelation to take place.[25]

[22] This could be the case if both aggregate demand and aggregate supply for the service in question are stochastic, and when high effort coincides with periods of exceptionally high demand, or exceptionally low supply.

[23] As when low effort coincides with exceptionally low general demand, or exceptionally high supply.

[24] Note that the utility administration will, quite generally, gain from such signaling in the context of our model, since it will be able to charge higher utility prices when it is perceived as non-corrupt, thus giving room for higher rent. From the theory of signaling (Spence (1974); see also Gibbons (1992), chapter 4), signaling costs must be sufficiently high to deter it, for a corrupt administration.

[25] Such an analysis would have its counterpart in the earlier literature on reputational equilibria for finite-period repeated games, as studied by Kreps and Wilson (1982), Milgrom and Roberts (1982), and Baccus and Driffill (1985).

As I noted in the introduction, my model of user-fee financing can be viewed as a “short-hand” representation a more elaborate model. In such an extended model, it would ideally be desirable to specify additional detail such as the level of centralization; the more specific mechanism for funding (with the relative importance of user fees, local taxes, and different types of more central financing, and differentiated by income groups); the issue of public versus private ownership and operation; and further issues such as the possibility of capture by elites. Extending the model to accommodate such features will make it more realistic and rich, but also more complex. It would also be valauble to investigate whether any of these extensions also extend the scope for multiple-equilibrium outcomes. Such extensions would also open up more avenues to empirical research by making the model more adept to empirical investigation; a crucial issue not pursued here, but which be left for future research.

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