Reforming Urban Water Systems
In Developing Countries

by

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ABSTRACT

In most of the world, urban water supply systems are public enterprises, usually part of a local government, and the recent increased interest in privatizing public enterprises has not led to reforms of water systems. Nevertheless, in about 50 cities in the developing world, the water system either has been privatized or franchised to a non-governmental entity for its operation and maintenance. This essay applies economic and political theory to identify the potential problems and advantages of private operation, and evaluates the reform experiences in six large cities – Abidjan, Buenos Aires, Conakry, Lima, Mexico City, and Santiago. The first part of the paper argues that efficient operation of water systems is politically more difficult in cities in which the marginal supply price of water is steeply increasing and in which waste water creates large externalities. The empirical section finds that reform improved performance in all cases, but the improvements were fare greater in cities in which neither of these problems were large. Moreover, it finds that the reform process was able to progress furthest in cities in which both water and safe waste disposal were relatively inexpensive. The paper concludes with suggestions for further research that would extend the analysis both to more cases and take into account more institutional variables.
Political, technological and institutional changes have spurred many developing countries to adopt reforms to improve the performance of their infrastructural industries by setting prices that are more in line with costs, creating independent regulatory agencies, involving the private sector in formerly nationalized industries, and allowing more competition. The earliest reforms were in telecommunications (see the preceding chapter) and transportation, and quite a bit of economics research has focused on these sectors. More recently, electricity and urban water systems have been included in the reform process. While some research has examined electricity reform, very little has dealt with water.

This chapter analyses reforms of urban water systems. The chapter first summarizes and extends the basic economic conceptual model of water systems, and then applies this model to organize and to compare the results of World Bank case studies of reforms in the capital cities of six developing countries.¹ The main theme is that water supply, though conceptually rather simple and seemingly straight-forward to reform, is sufficiently different from other infrastructural industries that appropriate reform is more variable across countries and frequently very difficult.

Water supply has four key features that strongly affect the choice of the best performing organization of the market. First, the costs, availability, and quality of water resources vary substantially according to locality, leading to major differences in appropriate market structure, regulatory institutions, and price rules. Second, direct competition is possible in some aspects of water supply, but in others it frequently is neither feasible nor socially desirable, and the appropriate scope of competition also depends on local conditions. Third, average asset lives are very long in water supply, so that governments face considerable obstacles in trying to convince private companies that economically reasonable depreciation rules will stay in place long enough to allow capital costs eventually to be
recovered. Fourth, water use causes important health and environmental externalities that frequently are very difficult to internalize or to regulate efficiently.

Despite these problems, many countries have begun to experiment with reforms that involve some degree of private participation. The World Bank utility database lists 53 cases in which private operators manage urban water and/or sewerage systems in 27 developing countries. Of these, only three are sales of equity to private operators. Differences between water and other utilities and local differences in water resources and institutions are reflected in the variety of governance institutions and forms of private participation. A majority (29) are concessions in which the operator is responsible for investment in expansion as well as operations; the rest are management contracts (11), and leases (10).²

The difficulty in approximating optimal management of a water system in practice is illustrated by recent water reforms in Abidjan, Cote d’Ivoire; Buenos Aires, Argentina; Conakry, Guinea; Lima, Peru; Mexico City, Mexico; and Santiago, Chile.³ The two systems in this group with the highest costs are Lima and Mexico City. Because of their locations and water endowments, water consumption in these two cities produces costly externalities: water-borne diseases from pollution in Lima, and damage to buildings from ground subsidence as the aquifer is depleted in Mexico City. In both cities, the reform process was terminated before an efficient policy and institutional structure was in place because the political costs of change were too great. In contrast, Abidjan, Buenos Aires, Conakry, and Santiago have sustainable water systems with lower opportunity and externality costs. In three of these cities, reform has worked reasonably well, but in the fourth, Conakry, weak governance institutions have caused the benefits of reforms to be less than was realistically feasible, despite enormous possibilities for delivering greater net social benefits.

The experience with reforms in these cases illustrates the effects of water’s unique characteristics. Because competition has not been part of any reform plan and, in any event, is likely to have more limited efficient scope than in other infrastructure, reformers have faced greater regulatory challenges. The presence of important externalities in some locales further complicates regulation and creates political problems. Nevertheless, water’s distinguishing characteristics do not imply that private participation is undesirable. Even in very weak institutional environments, such as Guinea, private participation plausibly is more efficient than a system of public management.
The next section summarizes the economic theory of water policy. Following that we consider supply, demand and policy in our case studies, and then assess their recent reform efforts. We conclude with some pressing issues for further research.

THE ECONOMIC THEORY OF WATER SYSTEM POLICY

The economic theory of water supply yields several important implications for policy and the political feasibility of reform. The economics of urban water systems has four main components: (1) the private supply cost of water delivery; (2) the demand for water by major customer groups; (3) the externalities associated with water delivery and use; and (4) the market and political institutions that allocate water among competing uses. We first consider supply costs and their implications for policy and political feasibility, distinguishing between renewable and nonrenewable water resources. Next we consider demand, externalities, and regulatory instruments.

Water Costs

The cost of exploiting a water resource depends on whether current extraction rates are sustainable. Water usage is sustainable if the net usage of water (including the maintenance of the quality of the water that remains and is returned to the environment) is now, and in the future will be, less than the inflow. If usage is sustainable, the opportunity cost of incremental water use today is zero. In this case, the only relevant costs of the resource are the private cost of water treatment and distribution plus the external costs of exploitation and use. If water use at prices reflecting these costs exceeds inflow, either temporarily or permanently, then usage in one period has an opportunity cost equal to the net value of foregone use in the future. We first consider the costs of sustainable resource systems, then extend the analysis to unsustainable systems.

Private Costs of Sustainable Resource Systems

Water delivery systems have four components: (1) capturing the basic natural resource (diversions, reservoirs and wells); (2) transporting the water to areas where it will have an economic use (aqueducts, penstocks and mains); (3) treating the water to raise its quality; and (4) delivering water to users (ditches, pipes and taps). All components require very long-term investments in fixed capital assets. Although operating costs can be substantial for treatment facilities and for wells and transport options that involve extensive pumping, the fixed costs of a water system usually are very high.
compared to the variable costs. For example, fixed costs account for over 80 percent of the costs of supplying water in the U.K (Armstrong, Cowan and Vickers, 1994).\textsuperscript{4}

The private cost of water systems depends on the short-term variability in the flow of water into the resource. If water usage always is less than inflow throughout the year, water system design is greatly simplified. Water need not be stored, so that capture simply means diverting water into the transportation system. Pumps and diversion canals provide a steady flow of water to satisfy all demand at all times.\textsuperscript{5}

In most water systems, some components exhibit engineering economies of scale, and so appear to be a natural monopoly. Of course, engineering scale economies do not necessarily translate into organizational scale economies that cause the most efficient market structure to be a monopoly. Three factors can offset engineering scale economies: diseconomies of scale in organizational management; quality differentiated demand that cannot be satisfied efficiently in a single network; and productive inefficiencies arising from a lack of competition. The consensus view is that the simplicity and generally low cost of water systems causes water to be the most likely infrastructure industry to be a natural monopoly; however, this conclusion has not been subject of extensive empirical testing, and some analysts believe that considerable competition could be introduced into at least some aspects of water supply (London Economics, 1998). For reasons explored below, this conclusion probably is not accurate for all aspects of urban water systems in all locations, but is probably true for some components of many systems.

Water transportation and distribution systems typically exhibit engineering scale economies for two reasons. First, the capacity of a canal or pipe is governed by its cross-sectional area, which increases in proportion to the square of the external dimensions of the conduit. While larger conduits must withstand more weight, within the relevant scale range strength requirements do not offset the volumetric gain from expanded circumference. Second, larger canals and pipes have less turbulence, so that effective capacity expands more rapidly than in proportion to the expansion of the cross-sectional area of the conduit.

Likewise, water capture from a particular resource also is likely to have natural monopoly characteristics. A reservoir typically exhibits substantial economies of scale up to an upper bound that is determined by the geology of the site and the intertemporal variation in water flow. For example, a dam to impound a river with a highly
variable seasonal flow at the bottom of a deep canyon typically will have huge economies of scale up to a storage capacity that is many times annual flow. A large minimum efficient scale of a single reservoir, however, does not imply a natural monopoly in either the entire system or even in the part of the system that requires these facilities. In multi-reservoir water systems, a single reservoir is like a single electric generation facility in a large electrical grid. Analogously to electric utilities, in a multi-reservoir system one can imagine a decentralized, competitive wholesale water market in which competing reservoirs bid to deliver water to either long-distance transportation systems or user communities.

Pumping from an underground aquifer is not a natural monopoly; however, efficient pumping may require some form of centralized management. Pumping from many wells, whether from a fully renewable underground aquifer or an aquifer that serves as a reservoir through injections in periods of excess flow, can be organized into multiple, independent sources. However, because pumping from one well can cause a drop in the water table such that pumping at other wells is more expensive, efficient exploitation of a single aquifer from many wells may require some form of centralized regulation of pumping. Whether managing the externality is more efficiently accomplished through owning all the wells or coordinating their outputs (perhaps by production taxes) is an empirical question. In the petroleum industry, where the pumping externality also is important, decentralized ownership of wells combined with centralized, cooperative field management is widespread, indicating that a similar structure might be most efficient in water systems.

Finally, water treatment is mildly a natural monopoly. Whereas treatment plants in themselves may not exhibit scale economies, treating water that is delivered from a single transportation system is likely to be most efficiently accomplished at a single site at or near the end of the transportation conduit, as opposed to diverting the water through separate conduits to several different treatment plants.

Two significant conclusions follow from this discussion of the direct costs of water systems. First, even though capture, transportation, and treatment from each water resource may be a natural monopoly, for urban systems that rely on multiple water sources, decentralization and competition among vertically integrated entities that operate a single capture-transportation system still may be feasible. Second, distribution is most likely to be a natural monopoly bottleneck to an urban water system.
Whereas competition in any component of the piped water system has not been considered in any of the water systems in our sample, it is not entirely unknown (Roth, 1987). In many urban areas in poor countries where the piped distribution system is sparsely developed or delivers water of poor quality, private water vendors, using trucks or carrying large water bottles, sell potable water on the streets. In addition, some residents dig private wells or construct catchment facilities for rainwater as an alternative to obtaining piped water. Finally, parallel piped water systems can be found in some arid areas, where one system delivers pure water for direct human consumption and the other delivers lower quality or reclaimed water for such uses as flushing toilets or watering gardens. Thus, some competition even in delivery, based on quality differentiation and price, can be found, indicating that reformers ought to consider whether their water system really is a ubiquitous natural monopoly.

**Policy Implications of the Cost Structure**

A water system’s high ratio of fixed to variable costs has important implications for pricing. As long as average water flow exceeds average use in the long run, the optimal pricing structure is a two-part tariff. The first part is a capacity charge that determines a user’s maximum usage during periods of excess demand plus any other costs that are not recovered from the second part. The second part is a usage price equal to marginal cost.

Two alternatives to the optimal two-part tariff are theoretically less efficient but may be practically attractive because they are easier to implement. One is a two-part tariff in which the first part is a fixed hook-up charge that does not imply a limit on usage. The second is a variant of peak-load pricing, in which usage prices include capital costs and, during the low-flow period, are higher to reflect the marginal cost of storage capacity. These price structures are less efficient than the capacity-charge approach because they do not permit consumers to determine their maximal claim on capacity in low-flow periods, but they are easier to implement because they do not require that utilities have the technical capability to cap individual usage during low-flow periods.

Because the marginal cost of water usage frequently is very low except in periods of temporary shortage, the implied usage charge in a two-part tariff also is very low. Indeed, in many systems, especially ones that tap nearby abundant resources, the costs of metering and usage-based billing are high compared to the cost of water, in which case the question arises whether metering is actually worth the cost. The principles guiding the decision to meter, however, extend beyond whether charging for usage vastly increases the system's marginal cost of delivering
water to customers. For metering to be justified, the efficiency gains from giving customers an incentive to curtail usage that has a high variable cost or a high opportunity cost due to variability of flow must offset the transactions costs of metering. A third consideration is whether usage-based prices are an efficient means to internalize the costs of externalities from water use. This issue is discussed at length below. The important point here is that if externalities are a substantial part of the cost of urban water systems, the benefits from charging for usage can tip the scales in favor of metering even in cases in which the direct private cost of supply (delivery and storage) is very low.

**Costs, Rents, and the Political Economy of Water**

Regardless of the details of the price structure, a high ratio of fixed to variable costs in a self-financing water utility implies that a large proportion of revenue is quasi-rents. By definition these quasi-rents do not need to be collected in the short run to induce continued supply. Because capital investments in water systems are extremely durable, a water utility may be able to operate for many years, even decades, without recovering its fixed costs. But if quasi-rents are not paid, investors will not recover their investments, and private funds for new investments are not likely to be forthcoming. If the urban area is experiencing economic development and/or population growth, under-investment soon leads to shortages even if the system is operating well, but even in a static community, eventually elements of the system will need to be replaced. Hence, if a society decides to rely on private water distribution, optimal future investment requires that government must be able to make a credible promise that it will not expropriate these quasi-rents from investors by imposing low prices. We will return to the problem of commitments after discussing other issues that can give rise to regulatory supervision of water utilities.

Quasi-rents are not the only rents arising in water systems. Two others are monopoly rents and Ricardian rents. Monopoly rents arise when a water utility can set price above average cost because effective competition is absent. Ricardian rents do not arise from market power, but from the superior productivity of better resources. Ricardian rents can occur under optimal pricing in a water system with multiple sources or storage sites. For example, a water system in a region with a large river and an underground aquifer may be optimally served by one large reservoir and some wells. In this case, the first-best usage price will include the pumping cost of the wells, causing the usage price of water from the reservoir to be above its marginal cost.
Whereas payments of quasi-rents have important implications for efficiency, these other forms of rents do not contribute to efficiency, and in most societies they carry little, no or even negative normative weight as distributional entitlements. On the contrary, policy intervention to limit monopoly profits can improve efficiency as well as distribution. Whereas monopolists theoretically can extract excess profits through an efficient system of price discrimination, the more common circumstance is for some prices to exceed corresponding marginal costs, and hence inefficiently to exclude some users whose valuation of output exceeds the cost of supplying it.

**The Regulatory Design Problem: Commitment without Capture**

Monopoly rents, high fixed costs, and different costs from different resources create a potential problem for government to commit to allow efficient prices and full cost recovery in water systems, a problem that is certainly important in other infrastructure industries but may be most important in water. The presence of substantial rents can give rise to two types of political demands to extract these rents.

First, consumer groups may organize to force down prices to average total cost (to extract Ricardian rents) or even average variable cost (to extract quasi-rents). The effect of this policy is to encourage consumption while discouraging investment, thereby creating excess demand. Second, water utilities may be able to siphon substantial cash from the system. If this cash flow is siphoned by operators (whether private or public) rather than used to pay off investors or to make necessary repairs and replacement investments, the water system eventually will deteriorate, again causing excess demand but in this case at high, rather than low, prices.

The possibility of monopoly rents is especially important, not just because of allocative and productive inefficiencies, but also because they give rise to pressure for regulation or other government intervention to reduce prices and improve service. Thus, the presence of a natural monopoly in some aspects of water delivery increases the credibility problem. Given that political pressures to control monopoly are widely regarded as normatively valid, and so are probably impossible and certainly difficult to resist, how can government commit to limit monopoly rents, while not expropriating quasi-rents and inefficiently extracting Ricardian rents as well?

Governments have no perfect way to make these commitments, but they can increase the likelihood that a commitment will be honored by increasing the difficulty of abrogating it. The likely durability of a commitment can be increased in four ways:
1. Insulate governance institutions from short-term political forces that influence elected officials and civil servants who serve at their pleasure. Examples are regulatory authorities and judicial overseers with long-term appointments and decision-making autonomy.

2. Create "high law" (like the U.S. Constitution) that is difficult to amend to protect the rights of investors. One example is a rule stipulating that government cannot unilaterally abrogate contracts with private entities, and another is constitutional protection against expropriation of property without reasonable compensation (in this case, the value of utility assets in a hypothetical competitive regime).

3. Adopt a system of representation that reduces the likelihood that advocates of expropriation will gain power. Examples are proportional representation and separation of powers, i.e. governments in which policy change requires unanimous consent among several political bodies, each having a different base in the electorate.

4. Commit financial resources to large projects, such as by making loans, guaranteeing debt, or issuing contingent liabilities that mature only if assets are expropriated. Government also can maintain a large but not controlling equity stake so that it bears part of the financial cost of low prices.

Commitment mechanisms can give rise to regulatory capture. If regulation is too distant from broadly based political pressures or too vigilantly protects government's financial stake, it can become a mechanism for serving the interests of the regulated entity. Excessively protective regulation has been every much as big a problem as expropriation, as reflected by the fact that most of the research literature on the politics of regulation focuses on capture, not expropriation.

The risk of capture is increased when the design of regulatory agencies makes them responsive to the regulated utility or some other organized interest among its customers and suppliers. Regulation is inherently anticompetitive because it causes price and entry decisions to be the result of a non-market interaction among interested groups that participate in the regulatory process. Because participation is expensive, the information and political pressures that an agency receives are likely to be biased in favor of groups with a large stake in its decisions. Design instruments for ameliorating excessive influence by well-organized interests are open
information, procedural transparency, standing for anyone affected by a regulatory decision and competition policy advocates, and a broad scope for judicial review.

Vertical separation of a water system that has multiple sources can provide additional protection against regulatory capture, and also can reduce expropriation and commitment problems. If a local retail utility buys water at market prices from multiple sources, the distribution system is likely to be the only significant source of monopoly rents, and so can be directly regulated for this purpose. The remainder of the system can be freed by statute from the authority of the regulator, and instead governed solely by competition policy. Whereas a distribution utility will have high sunk costs, and so will need to collect quasi-rents to maintain efficient investment, most of the quasi-rents and most likely all of the Ricardian rents will be spread over many independent actors rather than in a single, vertically integrated entity.

*Extensions to Unsustainable Resources with Externalities*

The preceding analysis deals with a water system in which exploitation does not cause the quality of the resource to decline for either urban customers or others who are not part of the water system. Some water resources, for example, a large lake or underground aquifer, can be regarded as essentially nonrenewable. Using part of that resource today has the opportunity cost of using the same quantity of water in the future. In addition, extracting more water now can raise the cost of extracting a given quantity tomorrow as a lake becomes smaller or an underground water table sinks. Likewise, greater exploitation today can lower water quality for other uses either now or in the future. First-best usage prices must take into account all of these effects so that each user faces the marginal direct cost plus the opportunity cost of water usage.

In principle, regardless of whether water use is sustainable in the long run, users who suffer temporarily from deteriorating quality, higher costs, or lower availability can outbid other immediate users to retain the size and quality of the resource. The same principle applies to allocating water usage through time if usage is not sustainable. Variation in the market value of usage typically can be dealt with efficiently if permanent, transferable property rights in the resource are well defined. Under such circumstances the holder of the resource can balance the financial benefits of short-term exploitation against the return from postponing exploitation to a period when the market price is higher. As long as water prices fully reflect all of the social costs of water exploitation and usage,
including the opportunity cost of future use, there is no reason to believe that markets for a finite and diminishing stock of water will work any less well than markets for other nonrenewable resources.

In practice, Coasian transactions costs may be sufficiently different among categories of users that the market on its own does not adequately deal with these problems. In addition, collective action problems may mean that some users are not organized to participate effectively in a market for water supplies, so that their valuations of water will not affect water allocation. Whereas these problems can prevent some efficient uses of a renewable resource, the problem is worse as well as more complicated if effective demand is not sustainable because in this case excessive use by one group imposes harm on another group. For example, people who live on a river or lake may have their welfare adversely affected by a drop in the water's edge, but if they are not part of the market for the affected water source, they can not bid to retain an adequate water level. Or, as is the case in Mexico City, property owners are adversely affected if the depletion of an aquifer causes ground subsidence, cracking buildings and making some structures unsafe. If for some reason components of a full-blown water market fail to emerge because of externalities, incompletely defined property rights, and transactions costs, market allocations will be inefficient.

In principle, government can compensate for this form of market failure by either taxing usage or directly allocating quantities independently of the price system. In practice, efficiently intervening in either way is itself subject to distorting influences because the political influence of the various groups (such as urban dwellers, farmers, and fishermen) will not necessarily accurately reflect the opportunity costs of water to each. Indeed, organizational and institutional factors that distort the market are likely to distort political influence as well. For these reasons, the best policy response to water market distortions may be no policy at all, or it may be to facilitate the creation of an organization to aggregate the demands of the excluded users.
Water Demand

The significance of water, as distinct from other infrastructure industries, derives from the fact that human survival depends on access to water that is free of unhealthy pollutants. Hence, at some level, the demand for healthful water must be perfectly inelastic. As a practical matter, water demand for many uses is likely to exhibit some elasticity, with estimates for developing countries in the range of -.25 and -.7. Even in the poorest urban areas many uses of water are not purely for subsistence. Moreover, humans pick areas for urban settlement on the basis of the economic value of the location, including whether water supply is sufficient to make human life sustainable. Consequently, even where water is relatively expensive, the price is still low enough that marginal uses among low-income households are far more prosaic than sustaining human life, such as washing, cleaning, and gardening.

Sources of Price Elasticity

For essentially all uses, water consumption can be varied substantially by small changes in usage methods. Water is usually one input into a household production process, with opportunities for changes in input proportions in response to movements in relative prices. Moreover, part of demand is euphemistically called waste, i.e., a failure to fix leaking pipes, or to turn off taps after use. The price of water strongly influences these so-called water losses. An aspect of "waste" that is not widely recognized is that if water is very inexpensive, "wasting" water is perfectly rational. If the price of inexpensive water simply reflects the fact that it is plentiful and its delivery costs are very low, then "wasting" water is inefficient only if creates a significant external diseconomy, an issue that is explored in the next section.

This conclusion applies to both consumers and water utilities. A frequently used indicator of the efficiency of a water utility is its proportion of “unaccounted for water” (UFW). One source of a (UFW) is a leaky distribution system. Fixing these leaks is a substitute for expanding diversion, storage, transportation, treatment, and distribution capacity. Repairing leaks is worthwhile only if the value of the water saved justifies the investment in new pipes, which may not be the case if plentiful, high-quality water is available nearby.

The other important implication of demand that exhibits some price elasticity is that a mistake in pricing can have large consequences for water use. Prices that are too low create a demand to expand water delivery beyond the efficient point. If the costs of the water system are not primarily financed by water revenues, but by
general taxes or revenue from another utility (such as electricity), under-pricing water can be very expensive to society by leading to massive, uneconomic expansion of the water delivery system. Alternatively, if water prices must cover all costs and if costs are high due to inefficient or corrupt management, much economically warranted water usage can be cut off, and a small improvement in the efficiency of the operation of the water utility can yield large economic benefits.

Another problem with water prices is that consumers may not value water quality highly enough because of information imperfections. Some users may lack understanding of the relationship between water quality and health. Others may understand these relationships in principle, but they can not costlessly observe aspects of quality such as the presence of microorganisms or trace chemicals that are health hazards. If the effective demand for quality is too low because of information imperfections, consumers may respond to higher prices for piped water by consuming too much low-quality water from contaminated alternative sources. This market failure can be corrected by subsidizing some minimum amount for human consumption. Subsidies may introduce other distortions, however, and their costs must be weighed against the benefits of the health effects from consumption of safe water.

**Usage Externalities**

The preceding discussion deals with one form of externality: the costs of extracting water resources that are imposed on other users. This section deals with two additional externalities associated with usage: pollution and spillage.

**Pollution and Sewage Treatment**

The purpose of urban water systems is to increase the availability of water at relatively low cost, thereby expanding the uses of water. This expanded usage inevitably increases the amount of polluted water that a community produces. Water that is polluted through use often is simply returned into the natural environment by dumping it into a nearby stream, lake, ocean, dry canyon, cesspool, or vacant plot of land. The external costs imposed by water pollution depend on the circumstances surrounding its disposal. Whereas all pollution will have some effect on the natural environment, the cost depends on the value of the environment for other uses (including preserving the original state of nature).
The most important source of variability in the costs of pollution arises from the exposure of human populations to unhealthy pollutants, either by polluting the environment in which they live or by polluting their food and water sources. Research on the effects of improved water systems demonstrates that simply increasing the quality of water at the point of consumption is not very effective in improving the health of the population. For example, a careful study of water and sanitation systems in eight developing countries found that improved wastewater and sanitation policies significantly improved the health and body weight of children, especially in urban areas, and that improvements in the quality of delivered water improved health only if accompanied by improvements in sanitation (Esrey, 1996). One family can not capture the benefits of sanitation by installing sewage disposal if all around it are dumping their wastes in the neighborhood; hence, even with perfect information, private incentives to install sewage are less than its social value.

If either users or water utilities are not held accountable for the costs that they impose on others, they will overproduce pollution and use an inefficiently large amount of water for polluting purposes. The economist's stock solution for this problem is to impose a tax on pollution that fully reflects the marginal cost of pollution on others (see Baumol and Oates, 1988, and Cropper and Oates, 1992). Taxes create a financial penalty for water pollution, and so provide a financial reason to invest in either sewers or water treatment facilities. These investments, in turn, will raise the price of water use, and so curtail consumption and the pollution that it creates. Users and water utilities will then have an incentive to cut back on polluting uses of water, and to treat waste water to remove pollutants, until the marginal cost of abatement equals the marginal cost of pollution. If instead of using taxes the government issues regulations that require these investments, the utility has a financial incentive to delay taking actions (to postpone costs) and to undertake the minimum actions that are consistent with the law.

The decision about the level of tax to impose (or, more generally, how much abatement to require) is subject to distortions in the political process. Of course, distortions in the political process may cause the government to demand too much rather than too little abatement. In addition, political distortions also may misallocate the burdens of pollution and pollution abatement for the same reason that they can distort the price structure.
The pollution issue raises a problem of institutional design: how can government commit to a long-term pollution policy that reduces the harms from pollution while avoiding overzealous pursuit of environmental policy that indirectly expropriates the investments of the water utility? The optimal design of environmental policy institutions and instruments is beyond the scope of this paper; however, an essential part of the assessment of the performance of an urban water system is whether this problem has been addressed in a reasonable way.

**Water Spillage**

Another externality arises when water is priced so low that there is little economic incentive to repair a leaky tap, or even to turn off a tap in the garden before water floods the street. In a society with an extensive and mandatory sewerage system, or with good natural drainage due to topography or soil conditions, uncontrolled release of water is not likely to create much of an externality. But in some communities water spillage neither runs off, percolates into the soil, nor evaporates quickly, but instead remains in standing puddles or slow-moving open waterways. In these circumstances, water spillage creates a serious external cost by serving as a breeding ground for disease-carrying insects and disease-causing microorganisms.

The implication of this externality is that in some conditions water usage should be priced even if delivery costs are low compared to metering costs and consumers have very limited incomes. Failing to price water usage gives consumers insufficient incentive to prevent spills that create community health problems. Fortunately, because water demand has some elasticity while the cost of epidemics of infectious diseases is high, very large benefits sometimes can be obtained with relatively small price increases. But in other cases the effect of pricing water usage is to cause users to switch from relatively high-quality piped water to dangerously polluted natural water sources, in which case the usage price makes matters worse.

**Regulatory Instruments**

Many of the significant implications for regulatory policy have already been raised in the discussions of costs, demand, and externalities. These discussions have focused on optimal pricing theory, in which the price system is based on social costs, and on avoiding both expropriation and capture. This implies cost-based price regulation of water utilities. But cost-based price regulation is at variance with the recent emphasis in the policy literature on price-cap regulation. Price caps decouple prices from costs, so future price adjustments are not based
on any measurable item, such as costs, that the firm can influence. The main reason for implementing price-cap regulation is that otherwise, if firms possess more information about their operations than regulators and if regulators base prices on indicators that a firm controls, firms can increase their profits by distorting the performance indicator. The firm thereby achieves higher profits (and prices) but does not produce at maximum production efficiency.

Price regulation that adjusts price index ceilings without considering costs can solve several problems. First, it assures future price performance at least as good as expected prices under cost-based regulation. Second, it leads to a second-best optimal price structure, given the firm’s overall price index requirement, because a firm facing a price-index constraint maximizes profits by setting second-best optimal prices in relation to its privately known costs. Third, it eliminates the incentive of the firm to distort its production behavior and generates an unconstrained incentive to minimize costs, given its quality decision. Fourth, by eliminating the requirement to measure costs, it avoids an expensive regulatory system that employs large numbers of professional accountants, engineers, and economists, an especially important attribute in small, poor countries where individuals with these skills are few in number.

In reality, a pure price-index regulatory system cannot be implemented. Regulators do not have sufficient information to pick a price adjustment formula that neither expropriates the firm’s capital nor, eventually, allows the firm to earn monopoly profits as if it were not regulated. Moreover, this form of regulation faces problems when technology changes the optimal product mix and quality offerings of a firm. In practice, price-cap regulation usually is implemented as a with periodic cost and quality reviews to adjust the pricing formula.

Other factors particular to water systems and other industries that generate large externalities can affect the efficacy of a price-index system. For example, if price ceilings are updated by cost audits only infrequently, the firm can influence the magnitude of externality costs through decisions about investments in capacity and water treatment, and the usage resulting from its pricing and investment decisions. The firm’s general incentive to minimize cost after the price index is adopted will lead it to reduce costly efforts to diminish external costs. Taxes are often imposed to encourage the firm to internalize externalities but the incentive effects of a tax based on the external costs of the water system are not as sharp if the firm is subject to price caps. If the cap is a binding constraint, the tax will be part of the initial and subsequent cost basis for the price cap, and so will be recovered.
completely by raising the after-tax retail price of water. Hence, the incidence of the tax will fall more on consumers and less on the water utility than would be the case if the utility were an unconstrained profit-maximizing firm. The higher retail price will reduce usage and so give the firm some incentive to make investments to reduce pollution, but the incentive is weaker than if the cap did not exist. The alternative policy of putting the full incidence of the tax on the water utility is also inefficient because it does not discourage use as a means to curtail pollution.

The theoretical solution to this problem is to have part but not all of the tax enter the price constraint, based on the elasticity of demand and the marginal cost of both water supply and externalities. Practically speaking, even if this formula is based on historical costs and takes the form of an automatic adjustment formula, it imposes a substantially greater information burden on the regulators each time the price formula is adjusted. Under cost-based regulation or standard price-cap regulation, regulators typically do not need to know the details of the components of marginal and total costs nor demand elasticity to know how to set an overall revenue requirement or price-cap formula. In general, a greater informational asymmetry between regulators and the regulated firm advantages the firm at the expense of its customers, so an attempt to deal optimally with externality problems through the system of price regulation can be expected to reduce the effectiveness of regulation.

The upshot of this discussion is that the likely outcome of well-intentioned attempts to control externalities of water systems is likely to include performance standards as well as economic incentives through the price structure. Efficient regulation of prices makes efficient use of tax incentives in environmental regulation more difficult, and so increases the attraction of performance standards over pollution taxes. In addition, the difficulty of efficiently dealing with externalities through the regulatory system constitutes an argument in favor of integrating sewers into the water supply system.

WATER REFORMS IN SIX CAPITAL CITIES

The preceding discussion suggests that optimal design of water systems will vary with the nature of water resources, but certain general principles are universal. To summarize, in systems where a large proportion of the cost is opportunity cost of depletion of the resource or externalities, regulation should charge consumers the
marginal social cost. To attract private investors, governments will need to provide credible commitment that quasi-rents can be recovered for future investment. Mechanisms that limit monopoly rents and reduce the risk of capture will enhance credibility as well as efficiency.

This section summarizes and compares studies that were commissioned by the World Bank of reforms in six cities within the preceding theoretical framework. In the late 1980’s/early 1990’s all six cities planned reforms which included eventual private participation through sale of assets (Santiago), concessions (Buenos Aires and Lima), lease (Abidjan and Conakry) and service/management contracts (Mexico City). In Abidjan, a private contractor managed the secondary network and maintained the primary network under a lease contract starting in 1959, before independence. The operator’s responsibilities were increased in 1987, which is the date of the reform examined here.

In Santiago and Lima a number of preparatory steps towards private participation were taken, including negotiations with potential bidders, but the privatization process was never completed. Santiago proceeded to introduce all of the planned regulatory changes in 1990, but kept the utility under public ownership. Lima introduced only a few of the regulatory changes that were planned under the proposed concession before stopping the reform.

In Mexico City, service contracts with four private companies were introduced in 1993-94 to expand metering and regularize billing. The plan also contained provisions to contract out operation and maintenance of the network, but this stage of the contract is already three years behind schedule with no clear sign of when, if ever, it will be fully implemented. In Buenos Aires and Conakry private involvement was implemented as planned: in Buenos Aires with the signing of a concession contract in 1992 and in Conakry with a lease in 1989. Finally, Abidjan introduced changes in tariffs and the leaseholder’s investment responsibilities in 1987.
Pre-Reform Conditions

As argued in the theoretical discussion, location-specific aspects of water resources as well as the surrounding institutional environment strongly influence the performance of a water utility. This section analyzes how private supply costs, externalities, price policy, demand conditions, and the pre-reform political environment shaped performance and the demand for reform.

Private Costs of Supply

By private costs, we mean the long-run direct economic costs of an efficient water supply system, ignoring externalities arising from resource exploitation, usage, and disposal. As discussed above, private costs are strongly influenced by whether the water resource is sustainable at current extraction rates. Short-term variability in supply is also an important determinant of costs.

Water resources can be considered sustainable with low variability in four of the cities in our sample: Abidjan, Conakry, Buenos Aires, and Santiago (Table 1). In all four, relatively clean water from rivers or an aquifer is in ample supply with the rate of extraction well below the rate of replenishment. Transport costs are negligible in Buenos Aires because it is located on the supplying river, and in Abidjan, Conakry and Santiago because their systems are largely gravity fed. Although comparable numbers are not available, Abidjan probably has higher costs than the other three because it relies the most on pumping.

Lima and Mexico City are in very different circumstances (Table 1). Lima is in a desert and two-thirds of its water comes from a badly polluted river where extraction needs exceed available supply during the dry season. The rest is from an aquifer that becomes contaminated by salt water when extraction during the dry season causes the water table near the ocean to drop. Water is rationed during the dry season and interruptions are frequent. Mexico City relies for nearly two-thirds of its raw water on wells from 70 to 200 meters deep in the city’s rapidly depleting aquifer, while the rest is pumped uphill from distant rivers. One source is 127 kilometers distant and 1,200 meters below the city. The extraction rate from the aquifer is currently 37 percent higher than the replenishing rate. Hence, the opportunity cost of water consumption is much higher in Lima and Mexico City than in the rest of our sample.

Another cost consideration is whether present capacity of the shipping and transporting water can meet current demand and provide reliable service, or whether substantial investment is required to serve all potential customers or to
raise service standards. All of these cities are growing, some quite rapidly, mostly through migration of poor rural populations to the outer edges of the metropolitan areas. An influx of foreign migrants accounts for substantial growth in Buenos Aires and Abidjan, while Conakry has gained a large number of refugees. Santiago and Mexico City were able to keep pace with this expansion and connect most of their potential customers (Table 2). By the time of reform, Abidjan, Buenos Aires, and Lima had connected only 60 to 75 percent of potential clients, and Conakry only 38 percent.14 Sewage connection rates lag behind water, especially in the two African cases, while sewage treatment was minimal in all of the cities.

The cost of expansion is high in Buenos Aires, Lima and Conakry because the scale of the new investments that are required is so large. In these cities, expansion of service requires not only laying more connection pipes in the existing network, but substantially increasing the capacity of the backbone water system. According to the concession agreement for Buenos Aires, some US$1.2 billion would need to be invested to bring coverage to about 80 percent in five years. The cost to expand service to 100 percent of the population of Lima in 30 years was estimated in 1994 at US$3 billion. The cost to expand and upgrade the water system in Conakry to meet all potential demand at a reasonable price is about US$105 million, which is large in relation to Guinea’s GDP. In contrast, investment costs to keep pace with growing demand in Abidjan and Santiago were much lower because no large facilities were needed. Future expansion in Abidjan will require major investments since the system is now at 90 percent capacity. Mexico City was providing water to most people in the service area at the time of the reform. Future expansion will be costly because of the need to develop water sources outside and below the basin and pump water up to the city as the aquifer diminishes. Current plans are to develop a source 140 kilometers from the city with an investment cost of US$500 million.

Before reform, service quality – pressure, interruptions, and water quality – ranged from very good in Abidjan, good in Santiago, fair in Buenos Aires to poor in Mexico City and very poor in Lima and Conakry. Under-investment in maintenance and replacement of aging systems led to leakage, low pressure, and occasional interruptions in Buenos Aires and Santiago. In Mexico City neighborhoods in the southeast, which were at the periphery of a poorly maintained system, had serious problems of pressure, outages and leaks. Even today, 172 out of a total of 499 “colonias” (districts) have no service at least six hours a week. In Lima about 48 percent of the connected population received water service for an average of less than 12 hours a day, 28 percent for less than six hours a day. This was partly because of seasonal
variation in supply and inadequate storage facilities, but also because of breaks in the lines and pressure problems. The system in Conakry was on the verge of collapse, delivering poor quality water (in some cases through lead pipes) for only a few hours a day.

**Externalities**

An important external benefit of easy access to safe water for drinking and bathing is the reduction of contagious diseases. Before reform, the social benefits from expanding water connections and improving reliability and quality were highest in Lima and Conakry. Unconnected households in Lima spent as much as seven hours per day collecting water from public stand-pipes (Webb, 1992), which reduces time for child rearing. Moreover, residents of Lima’s slums suffer from an average of eight cases of diarrhea a year, a significant proportion of which is caused by polluted water. Before reform, connected users in Conakry drank very poor quality piped water, while unconnected consumers used either well water that was contaminated by latrines or water from vendors or stand-pipes that was stored in unsanitary conditions. The lack of safe water for drinking and hygiene and improper sewage disposal accounted for high rates of infant deaths from gastro-enteric diseases and periodic epidemics of cholera.

The other two cities with low rates of connection, Buenos Aires and Abidjan, suffered smaller but still important external effects as well. Most of the 30 percent of the population without connections in Buenos Aires relied on well water. They suffered higher rates of water-borne disease than the rest of the city because of contamination of groundwater by untreated industrial waste and raw sewerage seeping from the cesspools of households that were not connected to the sewer system. Some unconnected areas in Abidjan used wells that were contaminated by ocean water, leading to higher rates of water-borne diseases than the rest of the city. Storage of water in unsafe conditions was also a source of disease.

Santiago’s main social costs stem from dumping raw sewage into rivers that surrounding farms use to irrigate food crops. The main external costs of this practice were a higher rate of water-borne diseases than for the rest of Chile, and a risk to food exports. In Mexico City, although rates of connection were high, people at the periphery, where service interruptions are frequent, also suffered higher rates of water-borne diseases. Nevertheless, Mexico City’s incidence of cholera is believed to be lower than the national rate.

Among the social costs of water reform are the external effects of increased water usage on others. These costs were low in Buenos Aires and the two African cities. The main usage externality in Buenos Aires arises from dumping
untreated wastewater into two rivers that flow through the city, which affects people who live along their banks. These rivers discharge into the River Plate, which is sufficiently large that dilution and natural self-purification are sufficient that downstream communities do not suffer significant pollution. The main usage externality in Abidjan is the eventual threat to its aquifer from latrines as the city expands towards the hilly, northern area that is the source of its raw water. In Conakry, as we have seen, wastewater contaminates the aquifer that is the source of water for users not connected to the system.

The externalities of resource exploitation probably were higher in Lima and Mexico City than for the other cases because these systems are unsustainable. Scarcity of water in Lima led to rationing and unsafe storage, along with pollution of ocean fishing grounds and irrigation water by untreated waste, which have been blamed for a cholera epidemic that started in Lima and killed almost 3,000 people in Peru in 1991. The most important usage externality in Mexico City stems from the fact that the city is built on a dry lake. Because of the nature of the soil, pumping from the aquifer has caused the city to sink. The downtown area sunk by an average of 7.5 meters since the beginning of the 20th century, causing cracks in buildings and making some structures unsafe. Some sections have fallen even faster; parts of the city center have sunk by over two meters in the last decade alone. Besides the damage to structures, the sinking has also caused increased water leakage as pipes buckle and break.

**Prices and Demand**

Although the private and social costs of water usage are highest in Lima and Mexico City, this was not reflected in higher prices. Table 3 presents two approximations of price, reflecting the troublesome problem of dealing with bills that are not paid. The first is the average price that is billed, calculated by dividing total billings by estimated total consumption. The second approximation is the average revenue collected per unit of output: the ratio of total revenues collected to total cubic meters distributed. These average prices reflect very different systems of revenue collection: the extent of metering varied greatly, non-metered charges were estimated differently, the number of unregistered connections differed, and the extent and success of trying to collect bills varied enormously. In addition, hook-ups to pipes within a building could be considered a different good than a private standpipe outside the structure. Nevertheless, when compared with average costs, these average prices give some sense of how far Lima and Mexico City’s water tariffs were from reflecting the marginal social costs of water consumption.
when compared to similar tariffs in cities with much lower costs.\textsuperscript{16} They also help explain why Buenos Aires was the only city which was able to bid a concession on the basis of a tariff reduction, which is plausibly part of the reason it was able to proceed with its planned private contract.\textsuperscript{17} (Recall that Abidjan’s system was already privately operated.)

Although the high opportunity and external costs of water in Lima and Mexico City suggest that the return to installing meters would be positive, the rate of metering was lower than in Buenos Aires, Santiago, and Abidjan (Table 4). In Lima only thirty percent of connection were metered, and only nine percent of the meters were read. Although we do not know the extent of metering before reform in Mexico City, about a third of all connections were not registered, and many that were registered either did not receive or did not pay the bill. Fifty three percent of revenues were from large industrial or commercial users, representing only about 2 percent of the customer base and 20 percent of total water usage.

Conakry, the other city in our sample with virtually free water and almost no metering, was in very different circumstances than Lima and Mexico City. Unlike the other two, Conakry’s source of raw water was renewable and reliable. Its main usage externality was contamination of the aquifer under the city, which unconnected households then consume from wells. This externality could be eliminated by connecting existing consumers to sewers or unconnected households to water. But either of these strategies was financially impossible because prices in Conakry were insufficient to cover the private cost of operating the water system, let alone the capital costs of expansion of sewer installation.

Unaccounted for water (UFW), the difference between water delivered to the distribution system and the water sold, was high in Buenos Aires, Lima, Mexico City and Conakry (Table 4). High UFW was partly because of commercial losses (failure to register, meter and bill connections) and partly because of physical losses (pipe breaks and overflows).\textsuperscript{18} As argued above, reducing UFW might not be worth the cost when water is plentiful, as in Abidjan, Conakry, Buenos Aires, and Santiago. Yet even in these cities, with the exception of Abidjan, the rates of UFW before reform in Table 4 seem very high. By way of comparison the average for the USA is 12, Tokyo is 15, and Singapore is 6. Where water extraction exceeds replenishment and losses have high social costs, as in Mexico City and Lima, reductions in the rates of UFW seem unambiguously worthwhile. UFW that arises due to the failure
to collect revenues that are needed to keep the system operating at reasonable quality is unlikely to be justified anywhere.

Another sign of incorrect incentives was the relatively high rates of per capita production and consumption of water in Lima and Mexico City. Mexico City’s production per capita was 368 liters per day while Buenos Aires’ per capita daily production was 628 litres. Both numbers are very high in comparison with Europe, where the average rate is 150 to 200 l.p.d. Consumption in Mexico City is especially excessive, considering that costs are also very high. Lima’s consumption per capita was lower only because of rationing. The low rates of consumption and production per capita in the African cities partly reflect their higher prices and lower purchasing power, but it is also partly a result of carrying water from an outside stand-pipe rather than having it pumped into the home.

The performance of these systems indicates that water policy provided little incentive for the utilities in Lima and Mexico City to consider the high private and social cost of water in making decisions about meters, bill collection, maintenance, or investment, or for consumers to consider costs in making decisions about usage. Pricing policy in Conakry left little incentive or wherewithal for the utility to attempt to capture the high social benefits to be gained from expanding and upgrading the system.

**Pre-Reform Institutions and Operations**

Before reform quasi-rents were being captured for consumers by pricing below fixed costs in all our sample cities except Abidjan and Buenos Aires. After 1959, Abidjan’s water system was run under a lease with a private firm. Prices were high enough to cover operations, capital costs, and investment in expansion of the system. In Buenos Aires, tariffs before reform barely covered the costs of the inefficient utility running the system, but were high enough to permit an efficient operator to improve service, expand the system, and earn a reasonable return on capital. Evidence for this is the fact that the subsequent concession attracted three bidders who offered a lower tariff and promised annual investments of US$240 million over the first five years; average annual investment in water over the previous decade had been only US$10 million.

None of the other water systems earned enough revenues to cover total costs. They varied in the extent to which their costs were high because of inefficient operation. Santiago’s water utility was relatively efficient with prices set below fixed cost by the government for political reasons. It lost money during the 1980’s until
government raised prices to break-even levels shortly before the 1990 reforms. Lima’s state-owned utility was at
the other extreme and highly inefficient. Its tariffs were below its operating costs, but probably would not have
covered the fixed costs of an efficient operator and certainly would have been below the fixed costs of a system
providing reasonable service to the entire client base.

Conakry’s utility was even less efficient than Lima’s, with the highest rate of staffing (42 per 1000
customers) for an almost inoperative system. Tariffs did not cover operating costs, much less capital costs; the
water company owed US$4 million in interest arrears on its external debt alone in 1983. As in Lima, tariffs were
too low to cover the fixed costs of an efficient operator.

Mexico City’s circumstances are not strictly comparable because the system is not operated by a single
corporate entity. Different types of costs and revenues were the responsibility of different organizations. One
municipal entity was responsible for building new infrastructure, another was responsible for administration, and
sixteen political sub-units of the municipal government (delegaciones) were responsible for the operation and
maintenance of the secondary distribution network. The delegaciones and the other distribution and investment
units operated as government departments, and their costs were covered by government transfers. The Federal
Government paid a significant share of the investment costs for the large projects that bring water from outside the
Mexico City basin. Responsibility for billing, collecting, and funding operational and local investment costs rest
with the government of Mexico City (the Distrito Federal or DF). Tariffs were raised only five times between 1970
and 1990, and covered less than half of the system’s operating costs.

The Politics Leading to Reform

The political benefits of water reform usually are often low, which means that political costs must also be
low for net political gains to be positive. The major political hurdle to reform arises from the fact that governments
can take advantage of the durable fixed assets in water systems to divert quasi-rents for politically useful purposes,
such as low prices for political supporters. Governments also derive political benefits from making patronage
appointments, locating new connections in areas chosen to secure political support, or awarding lucrative contracts
to political allies. Reform, especially if it involves private participation, requires governments to raise prices to
cover the private and social cost of water and to give up political command of employment and investment.
In contrast, the political benefits from water reform are often small. Water supply is local in character and so has political saliency only in some urban areas, whereas economic reform in developing countries is usually a national decision. Revenues from private participation are small or nil because water assets have relatively low value compared to many other industries that are candidates for privatization, so that even most governments that are committed to reform still may take a long while to get around to water. Finally, water reform frequently means raising prices. While excluded users or users whose service is frequently interrupted or of low quality may welcome high prices and regular, high quality service, others may resist a reform that has very attractive overall economic benefits. In the six cases, the political desirability and feasibility of reform depended heavily on how much prices would have to increase to permit cost recovery and the extent to which the regime’s supporters would be harmed.

The political economy of water reform is illustrated by contrasting Santiago, Lima, and Buenos Aires. All three governments announced plans to sell or concession their water companies and embarked on sweeping programs of privatization of other state assets. Both Chile and Peru gave low priority to water privatization, delayed the transaction, and after initially contacting bidders, ultimately failed to privatize. In contrast, Argentina treated the Buenos Aires concession as a priority and moved promptly to auction the system. This difference in outcomes was not due to the situation in the sector, for the water system in Lima was in much worse shape than in Buenos Aires.

The Buenos Aires concession went forward because the net political benefits to President Menem were larger than the benefits to President Fujimori in Peru or to General Pinochet in Chile from taking similar actions. Menem received solid support from the poorer suburban areas of Buenos Aires in the 1989 election, but mixed support from the middle and high income central district. Yet a coalition of political factions representing middle income voters formed the core support base for Menem’s reform program in Congress. The water system concession was designed to benefit voters who were already connected to the system. The tender was awarded on the basis of the lowest water tariff, and was designed to bring substantial improvements in service. The poor also were expected to benefit from increased access, but required to pay much of the cost of the expansion of the secondary network through a so-called infrastructure charge.

In contrast, both Santiago and Lima would have had to raise prices substantially to attract private investment. The bidding documents for Lima’s concession, for example, would have permitted an increase in tariffs
of up to 40 percent, and some observers thought even that increase was inadequate to attract enough investment to meet government’s target of 98 percent of potential clients connected in ten years with 24-hour continuous service. Many slum dwellers in Lima, who were President Fujimori’s core constituents, would not be able to afford the cost of a new connection and a higher water bill, so the President’s political benefits from the concession were small. The net political benefits were further reduced by a US$600 million loan in 1994 that made a number of short run improvements in the system, thereby reducing the immediate benefits of proceeding with reform.

Net political benefits were small in Chile, but for different reasons. Full cost recovery required doubling prices in real terms, but this was not why privatization did not proceed. The political costs of raising water prices were low because, judging by the 1988 referendum, Santiago was not a strong base of support for Pinochet and, in any event, an explicit subsidy was planned to reduce the immediate impact of reform on consumers. But the prospective political benefits to Pinochet of completing the reform were also low. Views on the Pinochet administration were highly polarized, and General Pinochet had little expectation of changing his support base in Santiago, for good or ill, because of water privatization. Thus, even though the government was ideologically committed to privatizing the water system and passed all the necessary enabling legislation, it delayed the transaction until after all other major infrastructure was privatized. This delay proved fatal. The 1989 elections, which took the Pinochet administration by surprise (Constable and Valenzuela, 1990), brought in a coalition that was ideologically opposed to selling water assets and so stopped the process. Hence, the utility was not privatized as planned, although privatization is again on the agenda.

As in Lima, the net political gain from water reform in Mexico City was low or negative. At the time of the decision to auction service contracts, the ruling party, Partido Revolucionario Institucional (PRI), had lost support in the capital. In the 1988 presidential elections, PRI won only 27 percent of the city’s vote. The new Salinas administration designed water reform to minimize political costs. The new service contracts did not raise prices anywhere close to costs, did not create incentives to lay off supporters in the myriad water agencies, and did not cede control over water investments to the operators. Furthermore, responsibility for revenues and maintenance was to be extended to the private operators in the third and final phase of the contracts. Since the third contractual
phase coincided with a growing threat that the opposition party would capture the Mexico City government (as indeed it did), the final phase of the contracts was put on indefinite hold.

Conakry’s move from the lowest to the highest water tariffs in our sample resulted from a combination of internal and external political factors. Guinea was another case where prices would have had to rise considerably to make private operation feasible. Conakry’s water system was in a state of collapse by the mid-1980’s, with almost no households connected, only 5 percent of connections with a working meter, less than 12 percent of users actually charged for their connection, and almost two thirds of water lost through leaky pipes and illegal connections. Water was available only a few hours a day and was of poor quality when available, while government price controls made bottled water scarce. The utility had little incentive to reduce losses or increase billing because prices were well below operating costs and, in any case, it could not cut off non-payers. The water utility depended on government transfers and was in a state of continuous financial crisis. Guinea had been ruled by a dictator (Sekou Toure) whose main concern was providing water to the military and government elite. The death of Sekou Toure in 1984 led to a new military dictatorship, which was uninterested in protecting the government elite because it’s support base was military and rural. Still, the government might not have agreed to a private lease had not the World Bank and the French government, which were expected to fund the large new investments needed, insisted upon private participation as the price for support. Finally, although Abidjan’s system was well run, a crisis in public finances in the mid-1980’s made it hard for the government of Côte d’Ivoire to implement the investment required to meet the rapidly expanding demand for water in Abidjan. The World Bank and French government pushed Côte d’Ivoire to shift more responsibility for implementation of investments to the leasor who also agreed to reduce tariffs for a number of users.
Assessment of the Reforms

How well did reform approximate the optimal policy principles described earlier? We first consider pricing policy. We then assess how well regulatory design provided commitment to durable policies and prevented capture or reneging.

Pricing and Operating Efficiency

Among the six cities, Santiago’s pricing formula is best in terms of both efficiency and equity (Table 5). The fixed part of the tariff covers the maintenance and operation of the system and administrative costs such as billing, collections, etc. All connections are metered, and the variable cost per M³ is set according to the long run marginal costs of a hypothetical best-practice, efficient company, adjusted to cover average costs and assure at least a 7 percent return on assets. Instead of cross subsidies, financial assistance is provided through a direct, means-tested discount. Tariffs are indexed annually to inflation, and readjusted every five years to account for changes in real costs.

One weakness of Santiago’s price system is that the externalities from dumping untreated sewerage are not internalized through either a tax or imposed treatment costs. Although the law prohibits unhealthful pollution, the utility’s performance standards are not enforced. The price formula allows a full pass-through of the cost of sewage treatment. This provision eliminates the economic disincentive to invest in sewage treatment, but it does not eliminate the political disincentive if water consumers perceive that the tariff saving exceeds the value to them of reduced risk of epidemics. This circumstance is plausible, for society at large, not just Santiago water customers, bear the cost of polluted discharges. In particular, farmers have been forced to bear part of the cost of water pollution since 1991 when the Chilean government responded to Peru’s cholera epidemic by prohibiting the use of untreated sewage to irrigate food crops that grow close to the ground, and destroyed all such crops in the field.

Buenos Aires’ prices have many more distortions than Santiago’s. Only 14 percent of connections are metered. Unmetered customers pay a fixed charge based on the size, location, characteristics (low income, luxury), and age of buildings, size of the property, and type of service. Metered customers pay a fixed charge equal to half the bill for an equivalent unmetered customer plus a variable charge for use above 30 cubic meters. Cross-subsidies are large. In 1995, for example, the ratio of tariffs for properties of similar size but different characteristics was 7:1.
Tariffs are adjusted every five years, based on investment plans. Tariffs are not indexed to inflation, but instead are adjusted whenever a composite cost index increases by over 7 percent. The social cost of reducing pollution of the aquifer in Buenos Aires by cesspools was initially internalized for those who had wells and cesspools by charging new consumers a connection fee that included part of the capital charges for expanding the system. When this proved uncollectible, the concessionaire negotiated its replacement with a fee for all customers.

Lima raised tariffs despite the decision to delay planned privatization, which paradoxically may have had perverse effects on further reforms. Most of Lima’s customers are still unmetered and pay a flat tariff based on hypothetical consumption estimates for the customer’s type. The estimated consumption used for billing may be higher than the amount actually consumed since the company often makes no allowance for periods when water is cut off. Cross-subsidies abound in the price structure. Non-residential consumers pay two to six times the rates charged residences, giving large volume consumers an incentive to drill private bore holes, further depleting the aquifer. Tariff increases are ad hoc, occurring when the company’s request coincides with government’s desire to reduce the budgetary burden of its subsidy. Currently the social cost of depletion and contamination of the aquifer is borne by people who fall ill and customers who invest in wells, cisterns, and other off-system facilities that are motivated by the desire to avoid shortages or unreasonably high prices for the services that are provided.

Tariff rates in Mexico City continue to be very low. Since 1995, prices can be changed only by vote of the municipal assembly. The increase in average tariffs in Table 5 has come from metering, better collection, and reductions in unregistered connections, not from price increases. Cross-subsidies also are common. In 1998, residential consumers paid between twenty and eighty percent of the non-residential tariff, and residents of larger dwellings paid prices that were two to four times as high as the prices charged for small dwellings. The cost of aquifer depletion is borne by property owners and the federal government, which continues to pay most of the cost of pumping water from outside the Mexico City basin.

Abidjan’s reform did not change its cost plus pricing regime, which passes all costs on to consumers. Metering, billing and collecting from private consumers are almost universal; the main exception has been large accounts receivable run up by the government. Large volume consumers, who are almost all industrial, cross-subsidize all other users, including government, while small consumers (less than 18 M³) pay least, about a third of
the tariff on large volumes (over 300M³). Consumers in the rural areas within the district also are cross-subsidized. Even taking into account the possibility that exchange rate valuation may overstate water tariffs, consumers in Abidjan pay much higher prices than in the Latin American cities. Affordability does not seem to be a problem, perhaps because of cross-subsidization and lower consumption patterns motivated by yard taps, as well as the absence of a fixed charge.

The signing of a lease in Conakry introduced a cost plus pricing regime similar to Abidjan’s. Prices were initially subsidized by government with funds from international and bilateral aid agencies, but they nevertheless increased sharply from about US$0.13 M³ in 1988 to US$0.90 M³ by 1994. Small volume consumers are subsidized, although by far less than in Abidjan. Affordability is a serious problem: an average monthly residential bill in Conakry in 1996 was about US$22 for a connection that serves, on average, 27 people, compared to an average annual per capita income of US$560, or the monthly salary of a top civil servant of US$150. In contrast, an average bill was US$12 in Abidjan, serving 15 people with higher per capita income (US$660 in 1996). The net effect of higher per capita consumption and fewer people per connection is that total water consumption per connection is about six percent higher in Conakry, compared to prices that are over 50 percent higher. Moreover, according to household surveys the owner of the connection customarily does not charge other users in Conakry, while selling water to neighbors is accepted in Abidjan, which explains why households are less likely to acquire a connection in Conakry.

Many people in Conakry get water for free. Even though metering went from virtually nil to almost universal, only about 60 percent of billed charges are collected from private customers because Guinea’s laws make it hard to disconnect nonpayers permanently or penalize persons for illegal connections, while lack of good information on the city’s population makes it hard for the company to keep track of customers. But the worst source of accounts receivables has been the government, which paid only 10 percent of its bill in 1993. The operator has been keeping the revenues it collected for the government water investment fund to cover these arrears.

One reason tariffs are so high in Conakry is that the costs of a system sized for a larger customer base are spread over so few paying connections. Conakry, with a 1.7 million population, had only 17,338 legal connections
in 1996, many of which were delinquent. Another 3,500 illegal connections are believed to exist. In addition, the system has only 130 stand-pipes, serving an estimated 975 persons each. In comparison, Abidjan has close to 180,000 connections for 2.8 million people. In addition, Conakry’s tariff was set to cover the cost of servicing the debt contracted prior to the lease, even though much of this was inefficiently invested. Thus, Conakry has a system with abundant, low cost water that is priced beyond the means of many citizens. Only about 748,000 people, or less than half of Conakry’s population, have access to water from a legal connection or a public standpipe.

Price policies also have had an effect on unaccounted for water in all cities except Abidjan, where it was already in the range of European cities before reform. UFW fell from 44 to 34 percent in Buenos Aires and from 34 to 19 percent in Santiago (comparing 1992 and 1996). UFW in Mexico City and Lima fell by about five percentage points but continued high at 37 and 36 percent, respectively, in 1996, a sign that their reforms were less effective in providing efficient incentives. In Conakry, UFW was not accurately measured before reform and remained very high at 50 percent in 1996 because of the inability to collect bills and prevent illegal connections.

**Contractual and Regulatory Institutions**

How well do the contractual and regulatory institutions in our sample rank against what theory would suggest? The governance institutions vary widely in some respects (Table 6), but are universally weak in dealing with wastewater and sewage treatment or the allocation of use among competing demands. None of the cities tax pollution, and where wastewater is controlled the costs have largely fallen on farmers and food consumers. Usage rights are allocated by government command. Chile has private, tradable water rights, but the market is so thin as to be nonexistent because property rights in water generally are not recorded.

Santiago’s institutions are the best designed to provide commitment against expropriation, resist capture, and provide incentives to overcome market failures and reduce externalities, despite the fact that the utility is state owned. The regulator’s independence and discretion, the price formulas and processes, and commercial autonomy of the utility are spelled out in detailed regulations. Because Chile’s constitutional, electoral, and legislative institutions make it very difficult to change laws, water regulation is protected from politically motivated expropriation of quasi-rents. Another safeguard is a means tested subsidy for water bills, which is calculated in a
way that benefits many middle as well as low income consumers, and hence has reduced the incentive of water
consumers to seek inefficient price reductions. The company can appeal the regulator’s decisions to a neutral
arbitration committee or an independent courts system.

Santiago has fewer safeguards against capture or reneging by the operator. Tariffs are set secretly, with
little scope for consumer input or judicial review. Although performance requirements are spelled out in the laws
and injured parties have the right to sue the company for non-compliance, no suit has occurred. Fines for non-
performance are set by law and were quite low until recently. Thus far the regulator has been reluctant to sanction
companies and has never revoked a concession. Even when the small private operator in Santiago failed to meet its
required investment plan and this contributed to its inability to supply consumers during the 1996 drought, the
regulator never considered revoking the concession.

Institutional protections against both expropriation and capture seem weaker in Buenos Aires than in
Santiago. The regulator answers to a board of political appointees, two each from the federal, provincial, and
municipal governments. Increasing political divisions between these administrations have made the regulator’s
decisions more partisan. Thus, in 1998 the municipal representatives blocked the cost-adjusted price increase
required under the concession, and eventually 1.6 percent was granted instead of the 11.7 percent requested. The
company can appeal regulatory decisions to the ministry or the judiciary, but the courts are not regarded as
independent. The company has protected itself by going directly to the executive branch, where reputation effects
work in its favor. For example, after the dispute over price adjustments in 1998, the ministry added 3 percent to the
1.6 percent price increase approved by the regulatory board. Concern about Argentina’s reputation with investors is
an important incentive for the federal government since it must safeguard the credibility of the country’s fixed
parity with the dollar.

The government also has experienced problems in forcing the company to adhere to the original
agreement. In 1997, the company forced renegotiation of the contract, dealing directly with the government rather
than going through the regulator. The company claimed that the original privatization agreement ought to be voided
because the government did not reveal all the facts about the utility, even though the tender disclaimed the accuracy
of the information it contained. Among other things, the renegotiation overturned several fines levied by the
regulator for failure to meet performance goals and reduced the concession’s coverage requirements for the first five years.

Regulatory and contractual designs in Lima and Mexico City offer less protection against confiscation of quasi-rents than in either Santiago or Buenos Aires. Power in Peru is centralized in the executive branch, and both the legislature and judiciary are very weak. Despite legal and budget autonomy, Lima’s regulator has in practice been subservient to the central government. The regulator answers to the same ministry as the water utility, has no legal standing to protest interference, and unlike other regulatory bodies in Peru does not have a board or council representing non-government interests. While the regulatory institutions might have been strengthened had the concession been tendered as planned, curbing the power of the executive to act arbitrarily is likely to prove to be difficult, although in the short run executive dominance does not necessarily imply a poorly performing utility.

Peru has a relatively open economy, which could induce a presidential concern about reputation that would work in favor of a private, partly foreign-owned water operator. Nevertheless, Peru’s strong executive system does not help build the credibility of all long-term commitments, including the one to an open economy. This problem will need to be addressed if Peru’s new plan to carry out privatization is to succeed.

Political interests dominate Mexico City’s water regulation. Mexico has no independent regulator and no safeguards against expropriation through under-pricing. Mexico reduced the financial exposure of private operators by dividing the city into zones and paying fee-for-service in the first two phases of the contracts. The phasing-in of operating risk under the contract was expected to build credibility and contain political opposition to private operation. Ultimately, direct election of the mayor and assembly made political circumstances even less favorable towards reform, while Mexico City’s handling of the contractors (including persistent late payments of fees to operators) reduced government credibility as a partner.

Mexico City lacks mechanisms to mediate competing interests for the use of its scarce and costly water. The federal government finances a large part of the investment and decides how to share raw water between agriculture and the municipal system. The municipality tries to control extraction from the aquifer by charging high prices (US$1 per M3 in 1997) for well water for non-residential uses. The exceptions to this charge are many, and some are made for political reasons.
The Abidjan contract is a lease, so the operator bears no investment risk. Operating risks also are low, even though courts are not independent and the provisions for international dispute arbitration has not proved practical. The company is protected in part because the French government and the World Bank have been willing to assist in clearing up problems between the operator and the Côte d’Ivoire government. For example, in 1997 the French aid agency, Caisse Francaise de Developement, loaned the Côte d’Ivoire CFA Fr 12 billion conditional on tariff adjustments and payment of its water bills. Furthermore, the operator collects all revenues, including funds for the government to use for investment, and it has withheld the funds when government has failed to pay its bills.

Institutions to ensure that the operator complies with its obligations under the contract are weak. Four different government bodies, all lacking clear lines of responsibility or political insulation, monitor the private operator. The leaseholder manages the system, collects all revenues, and undertakes most investments, despite the fact that larger projects are supposed to be competitively bid.

Finally, the lease in Conakry did not overcome an extraordinarily weak institutional setting. The leaseholder’s main risk has been from confiscation of quasi-rents by government and consumers through non-payment of water bills in a legal system where cut-offs are hard to enforce.35 As in Cote d’Ivoire, the operator has been able to reduce its risk because it collects revenues, and can simply keep the funds due the government to cover arrears. It can also use the backing of international actors like the World Bank and the French government in its negotiations with the government and the regulator.

Enforcement of the contract’s performance requirements also is weak. No credible regulatory body exists. Instead, a state enterprise is responsible for both investment and regulation, and has been in constant conflict with the operator. The staff of the state enterprise is weak and poorly paid, information about operations is almost nonexistent, and the fact that the lease covers urban areas in the entire country has made it almost impossible to sort out activities in Conakry. The operator routinely violates its obligations to submit information under the contract or to maintain the assets.

Public Versus Private Operation
Given these institutional weaknesses and the ubiquitous presence of monopoly, the case for private over public operation is not as clear as it would be if competition were present. To gain some further insight on this issue, four of the six cases had sufficient information to allow a crude cost/benefit calculation of the reform. (Too little information was available to support this calculation for Mexico City and Abidjan.) Using the approach developed by Galal, et al. (1994), we have worked with the authors of these four cases to calculate the net consumer surplus and net changes in the welfare of workers (largely wage and shares in the private operator minus any net costs to laid off workers), government (mostly taxes minus lost quasi-rents, conversion of debt to equity, etc.), and buyers during the post reform period. These components were then projected to create a calculation that was based on ten post-reform years for each case. The net changes in welfare were then compared to a counterfactual for the same period based on pre-reform trends, accounting for any changes that would have occurred regardless of ownership. The results of these calculations are as follows.

The Buenos Aires concession resulted in net domestic gains for the ten-year post-reform period equal to US$150 per capita in 1996 dollars, almost all of which went to consumers. The average annual gain in the ten post-reform years was 51 percent of system revenues in the last pre-reform year. The increase in consumer surplus is due to the 27 percent drop in tariffs, which were only partly offset by subsequent increases, and the rapid expansion of the system. Coverage of water rose from 70 to 81 percent and sewerage from 58 to 62 percent in the first three years of the concession.

Santiago’s domestic welfare gains under state ownership were also large: US$64 per capita in 1996 dollars for the ten-year period. The average annual gain in the post-reform period is 52 percent of system revenues in the last pre-reform year. About 85 percent of these gains accrue to government from increasing prices to bring them more in line with cost, and most of the rest went to workers.

Lima’s ten-year gain from reforms under state ownership was $7 per capita in 1996 dollars, about 40 percent of which went to government and the rest to consumers. The average annual gain amounts to only 7 percent of the revenues in the last year before reform. Had the concession been signed and all of the requirements been fulfilled, the domestic welfare gains would have been 11 times larger at US$85 per capita in 1996 dollars (annual gains equal to 61 percent of revenues), split between consumers and domestic buyers. While new connections
increased under state ownership, the rate just kept pace with the growth of the city. Under the concession, coverage was planned to rise from 75 to 85 percent for water and 70 to 83 percent for sewerage by 1996. While assuming that all of the concessions targets would have been met is unrealistic, the size of the projected gain indicates that there would have been considerable room for reneging under privatization before the city would be worse off.

In Conakry, the ten-year gains from the reform are higher than in Lima at $12 per capita in 1996 dollars, despite the problems of the reformed utility. The average annual gains equal 112% of sales in the last pre-reform year. The percentage gain is enormous because the moribund state enterprise that preceded the reform was incapable of reaching most consumers or supplying reliable, safe water to the few it did reach. Under private operation, capacity more than doubled, water quality and service improved dramatically, the population served almost doubled, and coverage expanded from 38 to 45 percent. Although over half of the city’s population is unable to afford piped water under private operation, one cannot assume that they would have had access to piped water under any realistic counterfactual. Guinea’s weak institutions made it hard for the government to negotiate and commit to an affordable water tariff with the private operator. These same weaknesses paralyzed operation under public ownership. Since the city’s consumers who cannot afford connections have no safe alternative, water-borne diseases continue to be a problem. In 1994, for example, 330 people died of cholera in Conakry.

These cost-benefit calculations suggest that net changes in welfare from private participation are positive and large. Although Santiago had large gains under state ownership, its strong public institutions make it an outlier. We could not quantify the external benefits from the reforms, but these also seem generally positive. If we assume that any increase in water and sewerage connections had positive health effects where people were consuming unsafe alternatives and practicing poor hygiene, then there were health benefits even in Guinea. The gains are reduced by some associated costs. Although the amount of sewage is not necessarily increased because of increased access to water, the amount of wastewater is. Although transporting waste away from human contact has health benefits, these are reduced if untreated wastewater or spillage creates other costs. As we have seen, externalities from pollution or spillage were probably high in Lima and Conakry, and low in Buenos Aires and Santiago.

CONCLUSION
Among the six cases, if water reform more closely approximates optimal policy, the system performs more effectively. Thus, Santiago’s water institutions are closest to what theory would recommend, which explains why it has the most efficient system.

None of the six reforms was designed to cope with water’s distinguishing characteristics.

First, all reforms failed to maximize benefits from health and external effects. Only two of the contracts (plus the failed Lima concession) addressed coverage and UFW, none of them had effective provisions to control pollution or wastewater use, and enforcement of the requirements that were present was weak in all cases. Even two institutionally strong, low cost cities – Buenos Aires and Santiago -- have not been able to charge polluters the marginal cost of pollution. To the contrary, the possibility that the cost of sewage treatment would substantially increase water bills in Santiago may be one reason why the treatment facility has not yet been built.

Second, only Santiago provided formal, institutionalized protection against expropriation of quasi-rents, and none is effective in protecting against capture. To protect against expropriation, the other reforms relied on reputation effects, outside intervention, and hostage revenues. These informal mechanisms have drawbacks. The diversion of revenues to pay government arrears in Abidjan and Conakry, for example, reduced the funds available for new investment. Informal mechanisms also seem to be less durable and to make capture more likely. As to protection against capture, no reform gave opposing interests such as consumers standing in the regulatory process. In most cases decisions are made by a national water regulator for all urban centers, which has reduced the influence of local interests in the process. In the two cases where the regulator must respond to local government representatives, Buenos Aires and Mexico City, decisions have been politicized, making commitments against expropriation of returns through low prices less credible.

Third, the local water conditions have profound effects on the political economy of reform. The two cases with the highest opportunity cost of usage, Lima and Mexico City, also made the least progress in internalizing their externalities. The political system simply was unwilling to raise prices to the extent that was required to reflect the high social marginal cost of water. In contrast, the Buenos Aires concession illustrates the political advantages of a low cost, renewable water system. There it was feasible to reduce water prices and still generate enough return to attract private investment.
Fourth, despite serious failings, the privately operated systems produced gains over a reasonable counterfactual. For example, the lease in Conakry brought safer water and a 40 percent increase in number of connections, something all knowledgeable observers agreed would not have occurred under state ownership.

Nevertheless, Conakry’s experience, and to a lesser extent Abidjan’s, illustrate the cost of private operation where institutions are very weak. These cities have low cost sustainable systems, but their prices appear to be much higher than in Buenos Aires or Santiago. These high prices are partly because of the African governments’ weak ability to overcome information asymmetries with private operators, and partly because they cannot offer commitment against expropriation of rents. Interestingly, rents are not expropriated in Abidjan or Conakry though low consumer prices but by forcing the operator to supply non-payers, especially the government.

Conakry would be far better off with realistic prices, effective enforcement of rules against illegal connections and nonpayment, and a subsidy to assure low income consumers access to safe water. How this would work in practice in such a weak institutional environment is questionable. Government is already free-riding on the rest of the bill paying populace in Conakry, and efforts by outside aid agencies such as the World Bank to settle arrears and raise the capacity of the judiciary to enforce payment have had limited success. Recent efforts by the World Bank to reduce costs in Africa by allowing private self-supply, community participation in service delivery, greater innovation and variation in technology, and the like may be more practical than a subsidy.

Our analysis is based on a small sample, and our survey of the sparse literature leaves many questions about water system reform in developing countries unanswered. Once recent experiments in water reform have more of a history, future research should be able to draw on a larger sample and analyze how well the many different contractual options being used perform in different institutional settings.

An important issue for further research is the cost, practicality, and effectiveness of competition in water supply. None of the cities opted for competition in any aspect of the system, which is still relatively rare in water supply. Although Chile’s legislation allows competitive bidding for new concessions or for old ones that are revoked for noncompliance with regulations, even this limited form of competition seldom is used. Comparative competition, often touted for water systems, is not used by any of the cities in our sample, even Mexico City, which relies on numerous wells supplemented by distant sources and which divided the city into zones in which
distribution was contracted out to a separate operator. How do water and sewers differ from other networks where
competition has been introduced? Would it be possible to increase competition in institutionally weak settings such
as Abidjan and Conakry to reduce the risk of capture? Why is yardstick competition not more widely practiced?

More systematic and theory-driven data collection also is needed to support the development of better
performance measures. Comparing the performance of water systems would be easier and more accurate with better
disaggregated data. Metered and unmetered water are different products, as are water taps in the house, taps in the
yard, and public stand-pipes, yet coverage and pricing statistics often do not distinguish among them. Information
on costs, including direct, opportunity, and social costs, is very poor, as is information on quality, such as potability,
pressure, continuity, and the like. Unaccounted for water is widely used as a measure of efficiency without
considering whether supply is plentiful and sustainable or scare and non-renewable. Judgements are made about the
appropriateness of prices based solely on the principle of cost recovery without always considering whether
operational costs are high because of inefficiency or whether significant opportunity costs and externalities are
present. Researchers can not adequately correct these mistakes in the absence of a better standard for data
collection, such as exists in telecommunications and energy.
Table 1: Nature of the Water Resources

<table>
<thead>
<tr>
<th>Principal Source</th>
<th>Buenos Aires</th>
<th>Lima</th>
<th>Mexico City</th>
<th>Santiago</th>
<th>Abidjan</th>
<th>Conakry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>River (92%)</td>
<td>River (2/3)</td>
<td>Wells (82% in 1987; 64% in 1993)</td>
<td>River (89%)</td>
<td>Wells (100%)</td>
<td>River (90%)</td>
</tr>
<tr>
<td>Variability</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Sustainable*</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*At current rates of extraction.

Table 2: Conditions in the Water Systems before Reforms

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Growth rate (% 1980-95)</td>
<td>1.5%³</td>
<td>3.1%⁴</td>
<td>2.3%⁵</td>
<td>1.8%</td>
<td>5.1%</td>
<td>9.0%</td>
</tr>
<tr>
<td>% Population¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>70%</td>
<td>97%</td>
<td>75%</td>
<td>99%</td>
<td>60%</td>
<td>38%⁶</td>
</tr>
<tr>
<td>Sewerage</td>
<td>58%</td>
<td>86%</td>
<td>70%</td>
<td>88%</td>
<td>35%</td>
<td>10%⁶</td>
</tr>
<tr>
<td>Principal Externalities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Water-borne diseases, pollution of</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>aquifer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water-borne diseases, depletion of</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>aquifer, pollution</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Cholera epidemic in 1989, pollution,</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>contamination of aquifer</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Water-borne diseases, pollution,</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>risk to crop exports</td>
<td></td>
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<tr>
<td>Water-borne diseases and pollution.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No sewerage collection; high</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>incidence of water-borne diseases</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

1. Includes private taps in yards.
2. National. Source: PAHO. These were predominant in Abidjan and Conakry, and important in Mexico (20% of connections) and probably in Lima; they were minimal in Santiago and probably Buenos Aires.
5. 1993-1996.
Table 3: Average Revenues Collected/M³ Distributed¹

<table>
<thead>
<tr>
<th>Average Price M³ ($US)²</th>
<th>Buenos Aires</th>
<th>Lima¹</th>
<th>Mexico City³</th>
<th>Santiago</th>
<th>Abidjan</th>
<th>Conakry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Price M³ water (US $)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*based on bills</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-reform</td>
<td>$0.21</td>
<td>$0.21</td>
<td>n.a.</td>
<td>$0.09</td>
<td>$0.85</td>
<td>$0.13⁴</td>
</tr>
<tr>
<td>Post-reform</td>
<td>$0.18</td>
<td>$0.20</td>
<td>$0.37</td>
<td>$0.14</td>
<td>$0.87</td>
<td>$1.00⁴</td>
</tr>
<tr>
<td>*based on revenues</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-reform</td>
<td>$0.18</td>
<td>$0.14</td>
<td>$0.22</td>
<td>$0.08</td>
<td>$0.81</td>
<td>$0.13⁴</td>
</tr>
<tr>
<td>Post-reform</td>
<td>$0.16</td>
<td>$0.18</td>
<td>$0.18</td>
<td>$0.14</td>
<td>$0.86</td>
<td>$0.62²</td>
</tr>
</tbody>
</table>

2. Revenues net of indirect taxes and adjusted for collection rates /M³ produced adjusted for UFW.
3. Includes sewerage.
5. The World Bank subsidized these prices. The amounts that customers were actually billed was $0.34, and the amount actually paid was $0.19.

Table 4: Metering, Billing, Losses and Consumption

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Connections metered</td>
<td>2%</td>
<td>NA</td>
<td>9%⁴</td>
<td>99%</td>
<td>96%</td>
<td>5%</td>
</tr>
<tr>
<td>Billed amounts collected</td>
<td>90%</td>
<td>NA</td>
<td>43%²</td>
<td>93%</td>
<td>64%</td>
<td>12%</td>
</tr>
<tr>
<td>Unaccounted for water</td>
<td>44%</td>
<td>37-47%</td>
<td>42%</td>
<td>34%</td>
<td>13%</td>
<td>54%</td>
</tr>
<tr>
<td>Water consumption p.c.³</td>
<td>352</td>
<td>232</td>
<td>217</td>
<td>188</td>
<td>63</td>
<td>37</td>
</tr>
<tr>
<td>Water production p.c.³</td>
<td>628</td>
<td>368</td>
<td>372</td>
<td>285</td>
<td>70</td>
<td>59</td>
</tr>
</tbody>
</table>

1. Metered and read; about 30% are metered.
3. Average liters per day.
Table 5: Pricing Formulas After Reforms

<table>
<thead>
<tr>
<th></th>
<th>Buenos Aires</th>
<th>Lima</th>
<th>Mexico City</th>
<th>Santiago</th>
<th>Abidjan</th>
<th>Conakry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjustments in tariffs</td>
<td>Adjusted to cost index when inc. is &gt;7%. Review every 5 years.</td>
<td>Arbitrary cost plus based on company request.</td>
<td>Commission proposes, municipal assembly must approve.</td>
<td>Adjusted to cover MC &amp; AC efficient co. every 5 years.</td>
<td>Cost plus revision every 5 years.</td>
<td>Cost plus revision every 4 years.</td>
</tr>
<tr>
<td>Unmetered tariff</td>
<td>Location, size and type of property, size of built area, age &amp; type of house adjusted by K factor.</td>
<td>Flat charge based on estimated minimum monthly consumption level for type of consumer.</td>
<td>Flat fee based on location and type of property, except in areas 70% metered, then charged average metered charge.</td>
<td>No unmetered connections.</td>
<td>Almost no unmetered connections.</td>
<td>Almost no unmetered connections.</td>
</tr>
<tr>
<td>1996 Tariff¹</td>
<td>US$0.22² (includes sewerage)</td>
<td>US$0.32 (includes sewerage)</td>
<td>US$0.22 (includes sewerage)</td>
<td>US$0.28</td>
<td>US$0.51</td>
<td>US$0.74</td>
</tr>
</tbody>
</table>

1. Average revenue per cubic meter distributed, calculated as in Table 3.
2. 1995.
## Table 6. Contractual and Regulatory Provisions after Reform

<table>
<thead>
<tr>
<th>Protection against expropriation</th>
<th>Buenos Aires</th>
<th>Lima</th>
<th>Mexico City</th>
<th>Santiago</th>
<th>Abidjan</th>
<th>Conakry</th>
</tr>
</thead>
</table>

| Representation of consumer & other interests in regulatory procedures. | Local governmt reps on board. No consumer reps | None | Local governmt control. No consumer reps | None. Tariff setting secret. | None | None |

| Coverage, universal service requirements | 80% water, 64% sewerage in 5 years, yearly targets. Regulator must approve 5-year investment plan | 95% water & sewerage in 10 years. | Not part of service contract | 100% coverage required by law. Regulator must approve 5-year investment plan. | Not part of lease contract | Not part of lease contract |

| UFW, standing water requirements | UFW from 45 to 25 by year 30. 45% water network renovated by year 30. Non-resid. must be metered | 95% metering, 25% UFW in 10 years | 100% metering target. UFW part of Stage 3, on indefinite hold. | 100% metering required by law. | None. | Mainten. targets (not enforced) |

| Wastewater use, sewage treatment requirements | 100% secondary treatment of effluents of those connected to sewers, year 13. | None | Not part of service contract. Farm use of untreated wastewater controlled. | Farm use of untreated wastewater controlled. Sewage treatment required by law, not enforced. | Not part of lease contract | Not part of lease contract |


1. Refers to draft concession contract and actual regulatory arrangements.

2. This requirement was later reduced.
References


1. The six studies are: Abdala and Alcazar (1998) for Buenos Aires, Argentina; Alcazar and Xu (1998) for Lima, Peru; Brook Cowen and Haggarty (1998) for Mexico City, Mexico; Shirley and Xu (1998) for Santiago, Chile; and Clarke and Menard (1998a and b) for Conakry, Guinea and Abidjan, Cote d’Ivoire.

2. Data on private participation in infrastructure assembled by the Private Sector Development Department. We exclude private participation in the construction and operation of single greenfield plants or facilities (most of which are “BOT” schemes in which a private entity builds a facility, operates it for a while, and then transfers ownership of it to a government entity).

3. The lease contracts in Cote d’Ivoire and Guinea cover all major urban areas in the country. Our numbers cover only the capital cities unless otherwise indicated; however, the nature of the leases distorts some of the indicators.

4. Storage systems typically are extremely durable, long-term capital investments with negligible variable costs. The classic example is a large reservoir, but another common storage method is simply to flood the surface above a large underground aquifer to increase the water table for later well extraction.

5. Seasonal and annual variability in the flow of water into the resource introduces another source of costs. Intermittent flows can cause temporary circumstances in which usage exceeds inflow, even though over a longer period usage is less than total inflow. For subsurface aquifers, pumping that exceeds inflow causes the water table to drop, thereby increasing pumping costs. For all types of water sources, storage systems can be used to transfer water from periods of excessive supply to periods of excess demand.

6. Unlike quasi-rents but like monopoly rents, investors do not need to receive Ricardian rents to induce future investments; however, if the productivity of a resource is uncertain until an attempt is made to exploit it, the recovery of at least some Ricardian rents ex post is necessary to induce optimal exploration for new resources ex ante. Exploration incentives are unlikely to be very important in the case of water supply, so that the recovery of Ricardian rents is unlikely to have significant efficiency consequences. The main problem arising from an attempt to extract Ricardian rents is that the method employed frequently is to set prices equal to the average cost of water. These prices are below the marginal cost of supply, forcing utilities to satisfy demand by exploiting expensive resources for which the cost of water is below its value to consumers. For example, British Gas, the distributor of
natural gas in the UK, used to relate its retail price to the average price paid to gas suppliers at the beachhead. In the 1980’s the retail price was below marginal costs because marginal fields were more expensive to develop. Improved extraction technology, however, has meant that price has been above marginal cost in the 1990’s. See Armstrong, Cowan and Vickers, 1994.

7. See Lupia and McCubbins (June 1998) for a formal treatment of these mechanisms.

8. For a summary of the literature on how imperfect information and the economics of organization bias regulatory outcomes, see Noll (1989).

9. See, for example, Gisser (1983) on the economics of nonrenewable water.

10. For comprehensive reviews of the price-cap literature, see Baron (1989) and Laffont and Tirole (1998).


12. A sale is defined as private ownership of a controlling stake. A concession is a contract where the operator manages all aspects of the system, including financing and implementing all investment, but the government retains ownership. A lease is a contract where the operator manages the system, raises working capital, and makes maintenance investment but is not responsible for other investments. A service contract is one where the contractor performs specific tasks for a fee and takes no capital risk.

13. Buenos Aires suffered seasonal shortages before reform, but these were caused by inadequate maintenance of storage facilities rather than by shortages of raw water. Similarly, Conakry had chronic shortages until the construction of a new transmission canal and treatment plant in the early 1990’s.

14. These numbers understate the amount of the population that was not connected because they exclude squatters and poor suburban areas that are outside the utility’s water district. The meaning of a connection varies. In the Latin American cases it generally refers to a hook up to internal pipes within the house, while in the African cities a connection is usually a standpipe in the yard close to the house. As a result a connection in Africa typically serves a much larger number of people than in Latin American; for example, a connection in Abidjan serves an average of 15 people versus 5 in Santiago.
15. Most unconnected households in Conakry rely on shallow, hand dug wells (as little as 15 feet below the surface). People report in interviews that they know the water to be unsafe but sometimes use it. Less than one percent of the population gets water from vendors and less than five percent from public stand-pipes. The amount of theft of water from the piped system is unknown but believed to be high.

16. Good recent estimates of marginal costs are not available for these cities. The estimates available also suggest that pre-reform prices were too low. World Bank (1994) estimated the marginal cost of water and sewerage in Lima at US$0.45. The average incremental cost (AIC) of groundwater and water from the Rimac River in Lima was estimated at US$0.25 per M³, while water from the next available source (the Atlantic watershed) was estimated to cost US$0.53 per M³ (World Bank 1993). Groundwater in Mexico City was estimated to have an AIC of US$0.41 and water from the next available source, the Cutzamala River, at US$0.82 (World Bank 1993). The rate setting agency in Mexico City (CAN) charged private, non-residential users $1.00 per M³ to extract water from private bore holes in 1997 (field interviews). In contrast Nasser (1997) estimated the marginal cost of water in Buenos Aires to be as little as $0.15.

17. One reason Buenos Aires’ tariffs were so high was that they were increased in anticipation of continued inflation in the two years before privatization, but since inflation was falling rapidly, the result was an increase in real terms.

18. A survey of the water system in Lima found that two thirds of the losses were due to leakage (World Bank 1994).

19. The firm, SODECI, Société de Distribution des Eaux de Côte d’Ivoire, is owned by a French water company, SAUR (48%); private Ivoreans (48%) and National Financing Bank (4%).

20. Chile phased in price regulation based on the marginal costs of an efficient benchmark company adjusted to assure at least a 7 percent return on assets by 1995. That price is twice the 1989 average price in 1996 dollars.

21. Constable and Valenzuela 1990 further argue the General regarded the polls suggesting his defeat as biased and ignored them.

22. For example consumers in low-income neighborhoods are assumed to consume 22 M³. In 1996 the tariffs were: US$ 0.36 for up to 18M³; US$0.55 for 18M³ to 90M³; US$ 0.91 for 90M³ to 300 M³; US$1.04 for over 300M³; and US$0.76 for government.
24. The price has since dropped in dollar terms to about US$0.80 M\(^3\) in 1997 because of devaluation; the tariff in local currency has not fallen. As in Cote d’Ivoire, tariffs are uniform across the lease, which cross-subsidizes other urban areas; however, these users are a much smaller part of the customer base in Guinea.

25. In 1996 the tariffs were US$ 0.60 for up to 20M\(^3\), US$0.75 for 20M\(^3\) to 60M\(^3\), and US$ 0.81 for over 60M\(^3\). Thus, the lowest tariff in Conakry is 70 percent of the highest, compared to 35 percent in Abidjan.

26. The bill is estimated based on average daily consumption of 37 liters per capita in Conakry compared to Abidjan’s per capita consumption was 63 l.p.d.

27. The introduction of meters drastically reduced government consumption and the intervention of the French aid agency in 1996 helped the government and the company settle their cross debts and keep down arrears.

28. In Buenos Aires and Lima government absorbed past debts before moving tariffs closer to cost recovery.

29. The volume of water distributed in 1997 was only about one fourth the system’s potential production (9.3 million M\(^3\) compared to 36.5 million M\(^3\) production capacity).

30. The institutions were created when privatization seemed imminent. Note too that the institutions rule all urban water systems in Chile, some of which are private, including a small private operator in Santiago (serving 5 percent of the city’s population).

31. An absolute majority is required to change laws and the constitutional provision for non-elected senators plus an electoral system that tends to split the legislature make the water legislation very hard to change. For details see Baldez and Cary (1997).

32. See Gelbach and Pritchatt (1997) for a discussion of politically sustainable subsidies.

33. Since 1994 the Municipal government has been popularly elected and has been controlled by the opposition party. The province was controlled by President Menem’s main rival within his party.

34. In addition, the Law of Sanitary Services has an article stating that “tariffs can be modified in the event that the population’s interests are affected by the privatization process.” Alcazar and Xu (1998), p. 25.

35. Although the operator can and does cut off non-payers, it cannot prosecute them for their arrears. Nor are there penalties for connecting illegally. Often non-payers reconnect under another name or illegally tap into a pipe outside their house.

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36. Although Santiago only increased coverage from 99 to 100%, it incorporated peripheral communities into the service zone and reduced shared housing.