Private Sector Participation and Cost-Efficiency in Water Utilities

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1 Introduction

Water is a resource of such fundamental importance to life that it deservedly receives a great deal of attention. Water is used in agriculture, manufacturing, energy production, entertainment, drinking, cooking, cleaning, fire-protection and sanitation. It is either directly found, or its use is implicated, in almost everything. In many cases there are no suitable substitutes. For some, water takes an almost sacred status, and many people have an instinctual reluctance to treat it as any other given commodity. In particular, the issue of privatization (private sector participation) in the provision of water services has been very controversial.

The main arguments against privatization suggest that private utilities will take unfair advantage over their populations, and be a source of inequity. Because water utilities are essentially local monopolies, such profit-motivated firms would be able to extract monopoly rents. This would negatively impact the lives of all people receiving such a company's services. In particular, the lives of the poorest could be severely impacted. Privatization may lead to rate increases that local populations strongly object to, and responses that may even verge on rebellion (Lobina, 2000). However, the reality is that even where private water companies are allowed to operate on a for-profit basis, there may be regulations restricting the prices water companies are allowed to charge, or the rate of return they may realize (van den Berg, 1997).

On the other side, the main arguments in favour of privatization suggest that privatization may lead to financial savings, increased investment in water infrastructure, and/or otherwise improved quality of water service. There are several potential modes of private sector participation, with varying degrees of potential cost savings. Private sector participation may be limited to providing specific services, such as meter reading or billing, or may extend to full privatization. However, without clear evidence of cost-efficiencies related to privatization, there is substantially less reason to support the privatization of water services.

The purpose of this paper is to introduce the controversy surrounding private sector participation in the water utilities industry, and to test for evidence of cost-efficiencies associated with private sector participation. This paper begins with an overview of the variety of modes of privatization, which could be expected to have varying impacts on costs. The next section will be a discussion of the arguments supporting and opposing privatization in water services. This will be followed by a summary of results from a selection of empirical cost-efficiency studies comparing public with private water utilities. The subsequent section provides an empirical analysis of private sector participation on cost-efficiency, based on a dataset of Southeast Asian water utilities (SEAWUN/ADB, 2007), which is followed by a concluding section. Results of this analysis fail to support the hypothesis that water utilities with private sector participation are more cost-efficient than fully public water utilities.

2 Public Utilities and Private Sector Participation

Much discussion of water utilities assumes that without the incentives of the private sector to minimize costs and maximize output, the operational and investment choices made for public utilities may not achieve maximum efficiency. However, it is an oversimplification to generally talk about privatization as a cure-all for assumed public sector inefficiency. There are several forms of both public utilities and private sector participation, and it is important to appreciate their differences in order to appreciate the potential of each to impact efficiency. Unfortunately, not all discussions of water privatization address these differences. This section summarizes an overview of public-private partnerships in the water industry from Vives et al.

(2006). Along the public/private continuum, there are four large categories of service types. With increasing degrees of private influence, these are: 1) fully public, 2) private management contracts, 3) private concession, and 4) fully private.

Public water utilities are not all created equally. At the extreme of fully public category of water are utilities that are directly owned and operated by a government of the day. This may be a local, regional, or national government. Funding for these institutions may come from water users through usage and connection fees, as well as having other revenues from government budgets. These institutions' management decisions may be completely controlled by politicians, and thus the motivations driving the investment, operational, and maintenance decisions may not be driven towards maximizing the long-term efficiency of the utility.

Public corporations are companies that are either directly or indirectly controlled by the government through either ownership or voting rights. This category of companies may include the private sector in management, as long as the government retains ultimate control. Corporatization is a means of attempting to infuse some aspects of market incentives in utility management. There are four principles that may be at work in corporatization: clarity of objectives, management autonomy and authority, strict accountability, and a level playing field with the private sector. By providing legislation specifying the powers and roles of the parties, corporatization changes the relationship between government and utility. These utilities can be thought of as being run by an autonomous board of management with the government as majority shareholder. In these cases, governments directly retain control over water allocation, environmental quality standards, and restriction of monopolistic behaviour.

With private management contracts, the government maintains ownership of the facility and responsibility for infrastructure investments, but contracts out some or all of the operations and maintenance responsibilities to the private sector. Services such as meter reading, billing, facilities maintenance, pipe laying and repair are commonly outsourced on short terms (1 year) for fixed fees. With competitive bidding, this can result in efficiency improvements, as there may be gains from service providers' specialization. However, this may also lead to increased costs, as bidders insert profit margins in their bids. Corruption and collusion amongst bidders may also be a source of inefficiency. Performance-based management contracts are often longer-term (3-5 years) and involve the private sector in decision-making roles, which can provide day-to-day incentives for efficiency. However, the managerial efficiency gains must offset the increased costs of monitoring the private managers.

Concession-type agreements are longer term have less government involvement, and transfer responsibility for investment decisions to private sector participants. These come in several forms, and are subject to defined service quality standards. Lease arrangements (10-15 years) are where private companies bid for complete control over an existing government-owned water system, with the reward being the revenue stream generated over the duration of the lease. Compared to management contracts, leases expose the private sector to greater commercial risks. Winning bids may come in the form of highest price paid to the government, or lowest charges to customers. Until the lease is over, the private water firm is responsible for all operation and maintenance decisions, as well as responsibility for financing infrastructure expansions that may be required under the lease. The main difference between a lease arrangement and a full concession arrangement is that under lease agreements, governments maintain the right to be involved in the planning of infrastructure expansions. Also, full concessions are typically even longer (25-30 years). Ownership of the assets fully reverts to the government at the end of the concession period. Also classified as concessions, bulk water supplies to a government utility are sometimes expanded by private-sector construction of treatment facilities under build-operate agreements. Build-operate agreements have private sector partners design, build and operate new facilities over long periods, with the government water utility typically paying for the water supply under a take-or-pay arrangement. This means that even if the utility does not take the full water supply, it must pay for it. Included in this category are joint-venture utilities where private sector investors own the majority of the shares, as another organizational form where utilities with public investments can be dominated by private sector incentives to increase efficiency.

In starkest contrast with fully public service providers are fully private water providers. These utilities may be the result of sales of government-owned utilities, or may be developed from scratch (a 'greenfield' project) by a private entity. With private sector incentives from the beginning, these utilities might be expected to have the highest efficiency. Regardless of the degree of private sector responsibility for a utility's investment, operations, and maintenance, governments remain responsible for regulating environmental standards, water quality, and other aspects of the water industry. Also, even amongst private utilities, governments may provide subsidies that can impact the drive to seek operational cost savings.

3 The Privatization Debate

The debate over the role of the private sector in water provision is not new. Any time water system privatization is discussed, there are invariably many factors promoting change from a fully public utility. Depending on the inclinations of a particular debater, certain factors may be emphasized or overlooked. In order to develop an informed opinion about what the role of the private sector should be, it is important to consider both the advantages and disadvantages of privatization. At its core, the debate focuses on claims of increased efficiency driven by private incentives and claims of social inequity resulting from privatization.

3.1 Advantages

There are many claims made by promoters of privatization. True or false, these claims are sometimes thought of as loosely falling into five (interrelated) categories (Gleick et al., 2002). Societal, that privatization may improve the provision of basic water needs. Financial, that the private sector can access capital more efficiently. Commercial, that private business is inherently better. Pragmatic, that private sector participation will result in a more efficient and competent service. Ideological, that less government involvement is better.

Three economic theories provide frameworks for these pro-privatization arguments (Renzetti and Dupont, 2004). Principal-agent theory, which says that it is difficult to monitor whether managers (agents) are acting in the best interests of the public owner (principal), suggests that private companies can offer optimal incentives to managers. Property rights theory, which says that private owners have clearly defined incentives (profit) to seek efficient management, and since politicians and bureaucrats may not personally benefit from improved efficiency, suggests publicly owned companies will be less efficient. Public choice theory, which says that public managers act in their self-interest, seeking to increase their budget and reduce their accountability, rather than to maximize their firms' efficiency, suggests publicly owned companies will be less efficient.

Often when a jurisdiction is considering privatization of its water services, it is because there are problems with the current public system. Such problems may be that current infrastructure is unable to provide a sufficient quantity or that the quality of the water is inadequate, possibly even being a source of health concerns.

Coming from a situation where a public water utility has a track record of inadequate service provision, it would be easy to believe that private provision could offer a suitable solution. One study of water privatization in the US found that compliance with regulatory standards was the primary factor in 34% of cases, and a secondary factor in 43% (Hudson Institute, 1999). In some cases there may not even be any public sector provision of water, and without public sector capacity to provide the service, privatization would be the only feasible avenue. A World Health Organization / UNICEF (2010) report estimated that in 2008, over 141 million urban dwellers did not have access to any sort of improved water service, regardless of quality, and found that water services were struggling to keep up with increased urbanization. Absence of access to urban water systems is most prominent in Sub-Saharan Africa. If the public sector cannot provide access, the private sector should be encouraged to provide access.

Water systems can be very expensive, and the public sector often has difficulty financing them. The third UN World Water Development Report (2009) reported that amongst industrialized countries, total needed investments in water infrastructure (including wastewater systems) may be as high as $200 billion US annually. According to the report, water use charges for most urban water systems barely cover operations and maintenance, let alone infrastructure modernization or expansion. Given such large financial demands, many governments' difficulties producing balanced budgets and reluctance to raise taxes, it is not surprising that privatization of public water utilities attracts attention (Brubaker, 2001). Governments that own water utilities may view privatization as a source of income, from one-time lump sums and as income streams through concession fees and taxes. As well as accessing capital that publicly ran water systems may not be able to, private utilities' incentives may result in more efficient use of any capital that is raised. The aforementioned Hudson Institute (1999) study of US water system privatizations found that 31% were primarily driven by unmet needs to finance expanded infrastructure. Financial institutions, such as the World Bank, have been known to require privatization of water systems in exchange for the provision of development financing (Barlow and Clarke, 2002). A World Health Organization report (2008) suggested that development of water systems can be very good investments, finding that depending on location, each dollar invested returns between 4-12 in health benefits alone. However, these returns do not go directly to the water system's investors, so their incentives are not as strong.

Brubaker (2001) discusses how incentives in a public system are different than those encountered in private enterprise and result in inefficient management. Political influence on water system operation is associated with expensive over-employment of workers. Employees of public water utilities may be insufficiently trained and may be constrained by rules the private sector may not be, both of which can impact operational and investment decisions. Rarely are public employees either rewarded for good choices, or punished for bad choices. In contrast, the competitive, profit-seeking motive leads private water firms to shed unnecessary or incompetent workers, and to reward creativity in finding cost savings. Furthermore, competition for privatization contracts should lead to the public receiving the best deal possible. Even after winning a privatization contract, a competitive, profit-seeking firm is required to maintain its drive for efficiency. Otherwise it risks being taken over. Through privatization, water utilities may benefit from access to cost saving expertise and technological developments produced by research only larger parent water companies can support.

One of the most prominent examples of water privatization comes from Britain, discussed by Beecher (1997), is considered to have been generally successful. Throughout the 1980s, under the leadership of Prime Minister Thatcher, nationally owned companies in all areas of technology, energy and resources were privatized. In 1989, 10 regional water authorities comprising the English and Welsh water industry were fully privatized. The motivations for privatization under the Thatcher government were considered largely ideological; that less government is better. However, there were also problems with the public water utilities including a history of operational inefficiency, excessive employment and lack of accountability. It was also true that the public water utilities had failed to meet environmental and quality standards set by the European Economic Community. These problems were attributed to failures to make necessary capital investments. Along with privatization, three regulatory agencies were created to monitor the water industry: the Office of Water Services (OFWAT), to monitor financial aspects and set price caps; the Drinking Water Inspectorate (DWI), to monitor water quality; and the Environmental Agency (EA), to monitor rivers and environmental pollution (Dore et al., 2004). In the six years following privatization, investments almost doubled from the six years prior to privatization (£17 vs. £9.3 billion), but have been accused of being excessive. OFWAT's method for setting water price caps is based on firms' expected rate of return on investment, incentivizing a gold-plated' investment strategy (van den Berg, 1997). These investments have resulted in substantial increases in environmental and water quality; compliance with European standards increased to 92% by 2000, up from 76% in 1989 (Dore et al., 2004). Lobina and Hall (2001) report that by 1998 overall employment of these ten firms dropped 21.5% to 31,363, and collective profits amounted to £2.2 billion, 142% greater than in the first year following privatization. However, to afford these profits, the average water bill increased by 46% to £242 over the same period. OFWAT, which reexamines water prices every 5 years, decided in 1999 that water bills were disproportionate and should be reduced by 12.3% (Dore et al., 2004). The purchasers of these ten water firms also benefitted from substantial additional subsidies, including: a £5 billion debt write-off; £1.6 billion as a green dowry'; sale of the firms' stock for only 22% of their market-value after only one week of trading; and exemptions on paying taxes (Lobina and Hall, 2001).

3.2 Disadvantages

There are also many factors that suggest privatization may not be in the best interest of all parties, both for water system users and the private companies involved. For private water firms, there may be significant barriers to involvement in some water systems. For water service users, equity issues and experiences that resulted in feelings of having been taken advantage of by private water firms are often given the most attention.

In some jurisdictions, there may be considerable discriminatory regulatory treatment against private water firms in comparison to public water firms. In Utah, private water firms are systematically discriminated against in at least four ways (Gardner, 2000). The Public Service Commission of Utah only regulates the rates of for-profit water firms. The State Engineer, which regulates water allocation, places a significantly higher burden on private water firms than public firms, in justifying changes in water diversion. Also, private firms have a more difficult time justifying the accumulation of water rights in expectation of future demand increases. These differential treatments by state regulatory bodies mean that private firms have to bear significantly higher administrative and legal costs of interacting with regulatory authorities. In Utah, private water firms must also pay both income and property taxes, whereas public water firms are not taxed at all. Furthermore, the Utah Division of Water Resources, which provides low-interest loans to water companies for capital projects, only makes loans to public companies. Private water firms must pay full capital-market interest rates. All of these factors make private sector participation in Utah less competitive with public firms, acting as barriers to private sector participation.

The private investor's interest in water system participation comes down to one motivating factor: the potential for a profit. Budds and McGranahan (2003) discuss this. Where this potential is not sufficiently high for a given project, private sector interest will be lower. One key factor in the potential profitability of a project is the scale of the project. Multinational water firms are mostly interested in contracts worth at least US$100 million, located in high- or middle-income municipalities with 1 million or more inhabitants, which are thought to be most profitable. Without inhabitants' ability and willingness to pay sufficiently for water service, private companies will not be as interested. In comparison, most water projects are in the US$10-50 million range, and thus may not attract as substantial private-sector attention and competition. Also, the type of privatization contract affects profitability. Concession-type contracts, especially with infrastructure investments, tend to be the most profitable. This should not imply that privatization is restricted to municipalities with ideal characteristics. Rather, that where these characteristics are not met, there may be less private sector interest. The pace of privatization of water systems grew substantially beginning in 1990, but has dropped since 1997. It was mostly between those years that the best projects, concentrated in Latin America and East Asia, were cherry picked.' Another concern of water firms bidding for projects, particularly in less politically stable states, is the potential for expropriation of their assets (Vives et al., 2006).

As discussed by Budds and McGranahan (2003), the potential benefits from privatization for service recipients stem from competition. Where there is less competitive interest in a given project, any successful bid is less likely to benefit the water service recipients as strongly. Indeed, the competitive forces in water privatization may not be as strong as one would like. As of 1998, only four multinational corporations ultimately controlled 80% of the world's private water market. With such a highly concentrated market structure, the level of competition for many water projects may cause doubt as to the degree of benefit the general public will receive from a given water system privatization. These firms are Suez, Veolia, and Saur of

France, and Thames of England. In 2002 the respective worldwide number of customers served by these firms were 115, 110, 36, and 37 million. Lobina and Hall (2001) report their respective 1998 profit margins at 4.2, 6.3, 3.5, and a remarkable 43.6%. Prior to 1995 most of the water system privatizations in Eastern Europe resulted from unsolicited bids from single firms (Hall and Lobina, 2004). With only one bidder, the level of competition is zero, and winning firms may be able to secure very lucrative agreements. Many other water privatization contracts have had only one bidder, including for Buenos Aires, Argentina, Cochabamba, Bolivia, and Cartagena, Columbia (Lobina, 2005). Even when there is oligopolistic competition for a water project, once the contract is signed, the winning firm will have established monopolistic control over the local market for an extended period (Beecher, 2000). Thus the benefits derived from competitive firm behavior may not be persistently extended to the water service recipients. Furthermore, there is an extensive history of contracts for water services being renewed without any competitive bidding. In France and Spain, countries with long histories of private sector provision of water services, this practice is commonplace (Lobina, 2005).

There are business practices, illegal and legal, which are cited in literature opposing the privatization of water services. Hall and Lobina (2004) discuss some of these practices. The payment of bribes has been the focus of criminal cases in both underdeveloped and developed countries. In 1999, twelve multinational companies were caught having bribed the Chief Executive of the Lesotho Highlands Water Project with over US$5 million. In Grenoble, France, two executives from the water firm Suez were convicted in 1995, along with the mayor, over a scheme funding the mayor's election campaign in exchange for a generous 25-year concession contract. It was determined that the contract would have cost the taxpayers an additional US$150 million over the 25 years. Practices such as private firms' funding election campaigns may not necessarily be explicitly illegal, but may result in state capture.' That is, firms may gain influence over public policy for their own benefit, at the expense of the general public. At the very least, this could give the appearance of corruption.

The quality of the original contract is of particular importance for securing the benefits of privatization for the water recipient. Often negotiators for municipalities are inexperienced negotiating water service contracts, and thus may leave the ratepayers vulnerable to unforeseen risks (Beecher, 2000). These risks may include expensive investment liabilities, and low-quality service-provision for which there maybe little recourse unless adequate regulatory oversight measures are negotiated and enforced. In other cases, contracts may not be as binding as one might imagine, and may be vulnerable to renegotiation that hurts the interests of the water user. In order to secure contracts, firms may engage in underbidding (dive-bidding') (Budds and McGranahan, 2003). After securing a contract to provide water at unrealistically low rates, winning the bid and overtaking the management, a firm may be able to successfully renegotiate for higher rates. The costs of these games must ultimately be born by the water user. It has been alleged by some that intentional underbidding occurred in the 1997 tendering of 25-year concessions of the Manila, Philippines water supply (Esguerra, 2003). Lobina (2005) discusses several cases of water tariff renegotiations. Renegotiations of the Manila water tariffs were sought beginning in 1998, began in 2000, and resulted in tariffs that would not have achieved success in the original bidding process. Within a year of the 1993 30-year concession agreement for the Buenos Aires, Argentina water system, renegotiation began due to unexpected operational losses. By 1998, recurring renegotiation resulted in average water bills 80.9% higher than they would have otherwise been. Furthermore, the firm failed to make US$746 million in required investments over that period. Within weeks of the 2001 privatization of the Belize Water and Sewerage Authority, the newly private owner declared that it would not make the US$140 million in investments it was obliged to, claiming to having been tricked in the agreement.

There are major health implications of populations not having adequate access to clean water and sanitation services, and it is commonly thought to be fundamentally inequitable to deny access to these basic services based on income. However, for a profit-seeking water firm, it does not make sense to provide water services to people who won't be able to provide the firm a profit. As discussed by Budds and McGranahan (2003), privatized water service providers have been known to fail to expand service availability to low-income people. The general experience of large private water firms attempting to expand services to low-income populations has not been one of commercial success. Even when marginal water tariffs may be affordable, connection fees may put service access out of reach. Private water firms may attempt to exclude low-income areas both within and on the periphery of the firm's area-of-responsibility, as occurred in La Paz, Bolivia and Cartagena, Columbia. This practice may be written into original contracts, or may result from firms ignoring universal coverage stipulations of their contracts, as occurred in Cordoba and Buenos Aires, Argentina. Additionally, privatized water utilities may be more likely to cut off water supplies to households following failure to pay. This became an issue following the UK water privatization, until the practice was made illegal under the Water Act of 1998 (Lobina and Hall, 2001).

In order to quickly pay for infrastructure investments and return maximal profits, wherever possible private firms may resort to substantial rate increases. Substantial rate increases may result in substantial burdens, especially for low-income service recipients. One of the most well known cases of water privatization failure resulted from popular revolt over unacceptably high rate increases (Lobina, 2000). In 1999, the water system was privatized in Bolivia's third largest city, Cochabamba. When the minimum wage was less than US$100 per month, and water bills were already often more than 20% of a person's income, water rates that increased by up to 200% following privatization were intolerable for many people. Protests grew to be so heated, in Cochabamba and other parts of the country, that in April 2000 Marital Law was declared over the entire country. Hundreds were injured in the protests and some died. Soon thereafter, the contract was cancelled.

Concerns that private water firms will not value external impacts of water use the same way a public water provider should are another factor resisting privatization (Gleick et al., 2002). Water conservation programs are often ignored or cancelled following privatization. This is because improved water use efficiency results in reduced revenues. There are concerns that private firms have incentives to make efforts to reduce environmental regulatory oversight, and will understate any environmental or health issues that arise. Private water firms also may not have incentives to internalize downstream costs of water appropriation. This can have ecological, recreational, and electricity-generating impacts.

4 Empirical Literature

There have been several studies investigating the impact of private sector involvement on water utility cost-efficiency. The basic question that these studies consider is whether privatized water utilities have cost-efficiencies over public water utilities. This testable question is important because without clear evidence supporting private sector participation resulting in operational cost savings, there is much less reason to support the privatization of water services. Some studies find support for the superior cost-efficiency of private water utilities. Some find support for the superior cost-efficiency of public firms. Others find no conclusive evidence of cost-efficiency superiority for either. One of the limitations of many of these studies is that the description of private sector participation is often limited to a simplified binary public or private ownership variable. This may be due to limitations of the datasets on which some studies are based.

Raffiee et al. (1993) examined a 1989 dataset of American water utilities serving at least 25,000 people, compiled by the American Water Works Association. After removing observations due to missing data, 271 of 430 utilities remained from the original survey. Of these, 33 were private and 238 were public. The dataset included detailed financial information about the labour, energy, materials, debt level, and their related costs. The authors used a Cobb-Douglas type production function with output determined by inputs of labour, energy, materials, and capital. Imposing constant returns to scale, a log-linear cost function was derived. Only the (ln) costs of labour, energy, materials and debt repayment, as well as a dummy variable indicating private or public ownership were included in the regression. The ownership dummy was significantly positive for public ownership at the p=0.05 level, indicating higher costs for public water utilities. An efficiency index was also derived, and it was found that public firms' efficiency index measure was both lower than for private firms, and had a standard deviation about three times that of private firms'.

Bhattacharyya et al. (1995) examined a 1992 dataset of American water utilities, compiled by the American Water Works Association. The sample included 190 public firms and 31 private firms. The dataset included detailed financial information, as well as indicators of service quality and other characteristics such as the water source, length of pipes, population served, population density and ownership. A translog function, with dummy variables for firm ownership type and water source, was used to estimate a cost frontier. The analysis found that both public and private firms were inefficient, but public firms were less inefficient than private firms. As the level of output increased, there was a tendency for utilities to become less efficient. Broken down into categories of firms by production levels, the analysis found that private firms producing between 5-10 billion gallons of water annually were somewhat more efficient than public firms, but for firms producing at least 10 billion gallons annually, public firms were much more cost-efficient.

Estache and Rossi (2005) assessed an international dataset of Asian water utilities published by the Asian Development Bank in 1997. The dataset covered 50 utilities in 29 Asian and Pacific region countries. The dataset included detailed financial information, as well as indicators of service quality and other characteristics such as the water source, length of pipes, population served, water treatment method, and population density. The dataset also allowed identification of how the private sector participated in a particular utility's operation. In particular, the dataset described whether the private sector was limited to an administrative role such billing, collecting, leak repair or meter reading, whether the firm was concessioned, or whether there was some other role for the private sector. In order to estimate a cost frontier, a Cobb-Douglas cost function was assumed, which was transformed by a log linearization, and dummy variables for water treatment method and type of private sector participation were added for the regression. The analysis found significant increasing effects of average salary, number of connections and fraction metered, population served, hours of service availability. The total cost was significantly decreasing with increasing population density. Results found no significance of any mode of private sector participation. An analysis of the error term, broken down into firm-specific inefficiency and a random component, suggested no difference between the efficiency of public and private firms.

5 Empirical Analysis

5.1 Cost Function

Water firms do not control the amount of water that is demanded by their customers. Their cost-efficient, profit-maximizing behaviour is to minimize their total cost function by choosing an optimal input mix, subject to their output and prices of their inputs. The theoretical cost functions faced by these firms is:

$$\mathrm{C} \ = \ f\,(Y,\ P,\ Z) \tag{1}$$

where C is the total cost, Y is a vector of the outputs, P is a vector of input prices, and Z is a vector of exogenous variables affecting cost that facilitate inter-firm comparisons. As is commonly used in similar analyses, the functional form is used in this analysis is Cobb-Douglas. Alternatively, a translog specification could have been used. However, this was not attempted because the inclusion of all the squared and cross terms would have left very few degrees of freedom for the model.

$$\mathrm{C} \ = \ A \prod_{j=1} Y_j^{\alpha_j} \prod_{k=1} P_k^{\beta_k} \prod_{l=1} Z_l^{\gamma_l} e^{\epsilon} \tag{2}$$

Transformed by the natural log, this expression becomes:

$$c = a + \sum_{j=1} \alpha_j y_j + \sum_{k=1} \beta_k p_k + \sum_{l=1} \gamma_l z_l + \epsilon \tag{3}$$

where lower case letters are the natural logs of their upper case equivalents. The parameter estimates α, β, and γ represent elasticities. Following the methodology of Estache and Rossi (2005), dummy variables accounting for the water source, treatment technology, and private sector characteristics can be added to this expression in the regression.

$$c = a + \sum_{j=1} \alpha_j y_j + \sum_{k=1} \beta_k p_k + \sum_{l=1} \gamma_l z_l + \sum_{m=1} \delta_m d_m + \epsilon \tag{4}$$

The cost frontier is the set of minimum costs that can be achieved for different output levels, given input prices, and is represented by the systematic part of this model. Estimation of a proper cost function should include data on the prices of all inputs, including capital and energy. Following similar studies where all relevant price information was unavailable, an ad hoc cost function was estimated using only the price of labor. Competitive capital and energy markets are assumed, and thus all firms should be facing the same prices of capital and energy; so the effects of capital and energy prices become accounted for in the constant parameter. With this assumption, the remaining parameter estimates should be unaffected. Although this assumption may be debatable, previous studies of this topic have used this approach and general functional form in estimating cost effects of private sector participation (Estache and Rossi, 2005).

5.2 Data and Estimation

This analysis uses a dataset of Southeast Asian water utilities published by the Southeast Asian Water Utilities Network and the Asian Development Bank (SEA-WUN/ADB, 2007). The sample contains data from forty different firms surveyed about their performance over 2005. Four countries are represented: Vietnam (17), Laos (1), Malaysia (5), and the Philippines (17). The dataset included a wide range of information about the firms' operational and infrastructure characteristics, including water service quality measures, as well as exogenous environmental characteristics about the area being served. This dataset also includes quantitative information on firms' total annual operations and maintenance costs (Cost), average daily water production level (DailyProd) and production capacity (ProdCapac) in cubic meters per day, the length of pipes managed (Pipes) in kilometers, people served (Clients) and number of connections (Conns), average salary (AvgSalary), staff size (Staff), staff per thousand connections (StaffPerThouConn), fraction of total cost towards salaries (StaffCostFrac) population density (PopDens), the fraction of residents of the service area receiving water from the utility (ServiceCoverage), fraction of total billed water billed to residential customers (MktStruc), fraction of water not accounted for (LostWater), number of residual chlorine tests (WaterTests) and pass rate (WaterTestsPass), number of hours water service was available each day (Hrs). Qualitative variables describing the water sources used (OnlySurface, OnlyGround, BothSurface-Ground), treatment type (Conventional, Disinfection, Filtration) were also reported. This dataset also included a description of the nature of private involvement in the utility's operation, whether there was any form of private involvement (PrivInv), and whether it was limited below or at the concession level (LimitedPriv, Concess). Many of these variables were investigated, however, many did not find remain in the final models.

These data are summarized in Tables 1 and 2. Twenty of these firms have some form of private sector participation. Ten are classified at the concession level, and the other ten have more limited private sector participation, such as in administration, billing, or repair work. Most commonly, utilities used both surface and ground water as source water. Also, water was usually described as being treated using conventional processes. All monetary figures were reported in the dataset in terms of $US. The average salary was computed from the reported fraction of total expenses put towards salary and the reported number of employees. On average, about 18% of the cost of operating the utilities in this sample was staffing. Utilities in this sample vary widely in their size of operations, as can be seen by the ranges of cost, daily production levels, and other variables. No formal test for sample outliers was performed, but three utilities were at least twice as large as the fourth largest utility by volume of water produced. All three of these utilities had private sector participation, two at the concession level. These three utilities can be considered outliers that may not be fair to keep in an analysis of this dataset because they operate on substantially larger scales than the main group of utilities. In order to investigate whether these firm size differences made any impact on this analysis, regressions were run including all the utilities and dropping the three outliers. However, because there are no fully public water utilities of comparable size in this sample, inclusion of the outliers may bias parameter estimates. Figure 1 plots utilities' total annual costs against their daily production levels.

Variable	Total
PrivInv	20
LimitedPriv	10
Concess	10
OnlySurface	9
OnlyGround	13
BothSurfGrnd	18
Conventional	23
Disinfection	11
Filtration	6

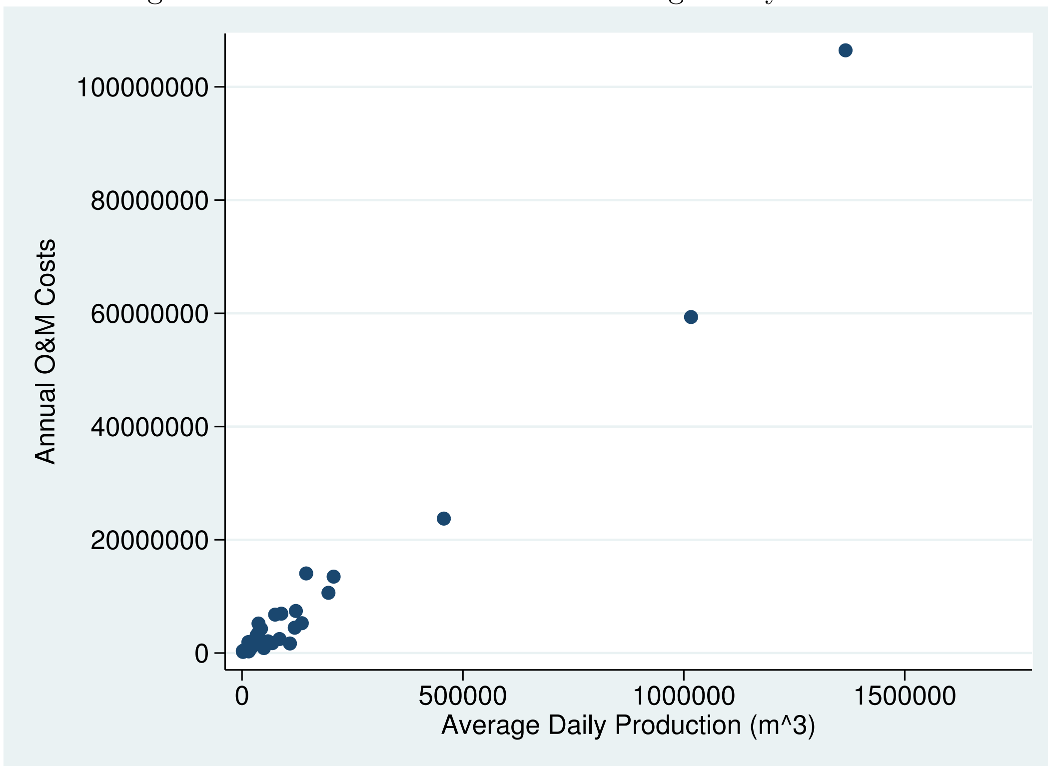
Table 1: Summary of Qualitative Data

Variable	Obs	Mean	Std. Dev.	Min	Max
Cost	40	7744297.00	19100000.00	204020	106000000
DailyProd	40	118885.40	265445.30	1832	1366027
ProdCapac	40	147063.70	306249.50	1858	1502100
Pipes	40	1028.65	2557.89	24	15409
Conns	40	77545.05	148898.50	2440	811874
Clients	40	553937.70	845931.40	19307	4148808
AvgSalary	36	2215.70	1934.98	128.13	9516.03
Staff	38	402.18	533.20	20	2836
StaffPerThouConn	38	7.12	2.83	2.08	12.62
StaffCostFrac	38	0.18	0.10	0.04	0.45
PopDens	38	2893.42	3174.17	20	14371
ServiceCoverage	40	0.75	0.20	0.36	1.00
MktStruc	39	0.68	0.19	0.25	0.98
LostWater	40	0.28	0.09	0.10	0.49
WaterTests	37	12878.54	27372.43	12	130000
WaterTestsPass	36	0.98	0.05	0.74	1.00
Hrs	40	22.91	2.78	10	24

Table 2: Summary of Quantitative Data

Costs are determined by many factors arising throughout stages of extracting, treating, and distributing the water. Total annual operations and maintenance costs would be expected to be highly correlated with the volume of water produced. Keeping all observations, the correlation between total cost and volume of water produced daily is r=0.9868. Ignoring the three largest utilities, this correlation remains very strong at r=0.8644. The source of the water may affect the cost of treatment. In particular, ground water is often less costly to treat than surface water because it has been naturally filtered (Estashe and Rossi, 1999). Additionally, different treatment methods could be expected to have different costs associated with them. The total cost would also expect to increase with the size of the infrastructure network, as it costs more to move water over longer distances, and more to maintain larger networks. As the number of connections increases, so would be the expected costs of administrating those accounts and maintaining each connection. However, there may be savings from operating in a dense population, as maintenance efforts could

Figure 1: Annual O&M Costs vs. Average Daily Production



be lower for the same level of water demand. Service quality increases may be expensive, so lower total costs could be expected to be associated with fewer hours of service availability, fewer water quality tests and lower pass rates, lower levels of service coverage, and higher levels of lost water, which would be kept down by more maintenance expenditures.

The results from four OLS regressions are presented in Table 3. Two regressions were run with all observations, and two dropped three utilities considered to be outliers. Regressions were run with either two private sector participation dummy variables, limited private involvement (LimitedPriv) and concession level private involvement (Concess), or with one private sector participation dummy for whether there was any private involvement (PrivInv). Breusch-Pagan tests were run for all of these regressions, but heteroskedasticity was not identified for any of these cases. Due to the small sample size, p=0.10 was taken as the maximum value for determining significance of a parameter estimate. All parameter estimates' p-values are for two-tailed t-tests.

Cost functions may have more than one variable considered to be an output. From the dataset, the best possible demand-determining output variables included the volume of water produced, the number of connections, and the number of clients. These three variables are each highly correlated with each other. However, due to the small sample size, only one output variable was kept. The volume of water produced made the most sense to be used as the output variable. In all four regressions, the estimated values for Daily Production elasticity of Cost was positive, as would be expected, and highly significant.

Cost functions require the prices of inputs. However, the only input price variable available was the price of labour, AvgSalary. The parameter estimates for Average Salary elasticity of Cost were all positive, as would be expected, although not significant in all cases. In particular, when the outliers were dropped, the impact of salary on total cost was not significant.

In order to compare between different firms, which must operate under different environmental conditions, a variables for the amount of lost water was included in these regressions. LostWater is a variable that can be interpreted as a proxy variable reflecting a collection of exogenous factors that affect the cost of the utility's maintenance. In particular, it would be expected that higher levels of lost water would reflect higher maintenance costs. Such exogenous factors may include geographical differences between utilities, such as the ruggedness of the terrain and degree of difficulty of maintenance, the age of the infrastructure, and possibly local socioeconomic history that affect the amount of damage to the infrastructure or water that is stolen. Although this variable may be influenced by past maintenance decisions, it is viewed as largely an exogenous variable that cannot be easily changed by the water utility.

	All Observations						Outliers Dropped					
Variable		p-value			p-value			p-value			p-value	
lnDailyProd	0.887	0.001	***	0.885	0.001	***	0.833	0.001	***	0.843	0.001	***
lnAvgSal	0.199	0.039	**	0.189	0.042	**	0.140	0.234		0.156	0.147	
lnLostWater	-0.273	0.264		-0.268	0.267		-0.283	0.261		-0.284	0.252	
Conventional	-0.444	0.019	**	-0.424	0.020	**	-0.371	0.061	*	-0.393	0.034	**
LimitedPriv	0.321	0.115					0.397	0.069	*			
Concess	0.437	0.055	*				0.301	0.230				
PrivInv				0.367	0.045	**				0.360	0.055	*
constant	3.641	0.001	***	3.746	0.001	***	4.563	0.002	***	4.356	0.001	***
Number of obs		36			36			33			33	
F	(6,29)	66.75		(5,30)	81.96		(6,26)	33.12		(5,27)	41.04	
Prob > F		0			0			0			0	
R^2		0.9325			0.9318			0.8843			0.8837	

*significant at p=0.10 level, ** significant at p=0.05 level, *** significant at p=0.01 level

Table 3: Results

The parameter estimates for Lost Water elasticity of Cost were all negative, reflecting an increase in total costs that would arise from increasing maintenance in order to decrease the amount of lost water. However, these parameter estimates were never significant.

Another variable that affects the cost of operating a water utility is the treatment method used, which is used as a proxy for utilities' treatment costs. This variable could be expected to be related to the quality of source water, since lower quality water could require higher quality treatment. The dummy variable for treatment type indicated that costs were lower for utilities using treatment systems described as conventional, as opposed to filtration or disinfection systems. This result was significant for all regressions.

Promoters of private sector participation frequently argue that involving the private sector will result in lower overall costs. However, in all regressions, the signs of the parameter estimates for private sector participation dummy variables were always positive, indicating higher costs for utilities with private sector involvement. In both regressions with only a single dummy variable for any private involvement, the parameter estimates were significant. However, the dummy for limited private participation was significant only in the regression excluding the outlier utilities, and the dummy for concession level participation was only significant in the regression including the outliers. This presents a somewhat mixed picture of the impacts from different degrees of private sector participation, but at the very least finds no evidence to support the notion that private sector participation will result in lower overall costs.

In all four models the coefficient of determination (R^2) was quite high, ranging from .88 up to .93 in models including the outlier utilities. This indicates that these models perform considerably explaining the total cost of operating a water utility, with the vast majority of the total cost attributable to the volume of water produced.

In all models, both with and without the outliers, the parameter estimates remained quite similar in magnitude and identical in sign. It is important to keep in mind the relatively small sample size, which limited both the number of variables that were kept in the regression, as well as the significance level that could be attributed to each of the variables in the regressions.

Regressions run with other output variables resulted in very similar patterns of parameter estimates. When only one of the three main output-type variables (DailyProd, Conns and Clients) was used, that output variable's estimated elasticity was always highly significant. The parameter estimates for private sector dummy variables were uniformly larger with Conns and Clients as output variables, and the signs and pattern of parameter estimates' significance were identical in almost all cases. The only differences occurred with Clients as the output variable, where variables for both limited private participation and concession level were significant in regressions with and without the outlier utilities. This suggested that any of these variables could be justifiably used as an output variable in this cost-frontier analysis. However, when all three were run together, the DailyProd output variable was significant while the others were not at all close to significant, suggesting that if only one was to be kept, DailyProd would be the best output variable to use. The parameter estimates for private sector dummy variables were similar to the reported results, taking an identical pattern of significance in the four cases. Due to the small sample size, it was decided to keep only the DailyProd output variable.

The dataset reported utilities using three water treatment technologies. Regressions were also run with two dummy variables describing the treatment technology, indicating utilities using Conventional and Disinfection technology and Filtration technology where both of these variables was null. In all cases, the magnitudes of the Disinfection dummies estimates were positive, close to zero, and far from significant. The Conventional parameter estimates were similar to those reported in the results, but only significant when the outlier utilities were included in the analyses. In regressions run with two treatment-type variables, the magnitudes and patterns of significance for the private sector participation variables were similar to with the reported results. The only difference was with outliers removed and variables for limited and concession level private sector participation, the private sector variables were non-significant. Keeping only a dummy variable indicating Conventional technology use, the Conventional treatment variable became significant, as reported in the results.

Other variables that might affect total operational costs were considered in addition to the proportion of water lost. PopDens and Pipes were considered as proxies for maintenance costs, which would be expected to decrease with increasing population density, and increase with pipe length. The density of the service population is an exogenous variable, and the length of pipes required to provide service would be somewhat exogenous, reflecting geographic differences affecting service provision. Service quality variables WaterTestsPass and Hrs were also considered as output-type variables. With all of these variables included in the regressions, over all four conditions, the only consistently significant variable was the volume of water produced, and none of the private sector variables were ever significant. After eliminating the consistently least significant of these variables, PopDens and WaterTestPass, compared to the reported results, the same pattern of significance for DailyProd, AvgSalary, Conventional, and private sector dummies emerged, though not the same levels of significance. In order to keep the number of variables in the final regression low, only the most significant of these variables, LostWater, was kept as a proxy for maintenance costs.

Regressions were also run with dummy variables indicating the source of water as only surface, or both surface and ground water. Null values for both of these variables indicated only ground water as a source. The pattern of significance of private sector variables was unchanged by inclusion of these variables. In no case did these variables approach significance, and thus were not included in further regressions.

The dummy variables reflecting private sector participation were always positive, and were significant in a wide range of model specifications. This suggests that, at least for this sample of water utilities, private sector participation may result in higher overall costs of operations.

6 Conclusion

In this paper, we have investigated the different modes of private sector participation in operating water utilities, and the advantages and disadvantages of privatization. There are examples to support arguments both for and against privatization. The arguments for privatization boil down to expectations of increased cost-efficiency and increased investment. The arguments against privatization boil down to expectations of privatized water utilities' inequitable treatment of water users. Without evidence of increased cost-efficiency, there is less reason to support the privatization of water services. This paper has taken particular interest in whether private sector participation is associated with operational cost savings.

A dataset of forty Southeast Asian water utilities' 2005 performance was analyzed. To investigate cost-efficiency, a log-linearized Cobb-Douglas cost function with dummy variables indicating private sector participation was estimated. Models were estimated with dummy variables indicating either whether the water utilities had any form of privatization, or whether the firms had concession-level, or a more limited form of private sector participation. All private sector participation parameter estimates were consistently positive, and significantly different than zero under many model specifications. This indicates that private sector participation was not associated with cost savings. Much of the reasoning in support of private sector participation in water utilities operation assumes that cost savings will follow. In contrast, this supports the findings of Bhattacharyya et al. (1995), that public water utilities are more cost-efficient than private water utilities.

There are many reasons why private sector participation may lead to increased operational costs. These may include limited competition for contracts, profit margins that private sector participants insert into their contract bids, corruption, and potentially more demanding regulatory regimes for private firms. However, nothing in the dataset hints at why these utilities with private sector participation had higher operational costs, all else being equal.

Although this analysis does not support the notion that there will be significant cost savings from private sector participation, in some cases there may be other reasons to support privatization. It would have been beneficial to have data on investment rates and service quality indicators around periods of privatization, with particular interest on concession-type privatization agreements. Underinvestment may remain a compelling reason to support privatization; despite the potential for private firms to strategically overinvest where it increases profits, as has been suggested has occurred following the UK water utility privatization (van den Berg, 1997). The question of whether private sector participation should be sought in a particular case should depend on local circumstances, but assumptions of privatization leading to cost-efficiencies should not be taken for granted.

Regardless of whether water services are provided by fully public or to some degree privatized utilities, the regulatory framework and enforcement systems that water utilities operate under will play a vital role in the provision of a satisfactory water service. Adequate regulation may be sufficient to realize efficiency gains in particular cases, while addressing equity concerns related to privatization. However, regulatory adequacy will depend significantly on the quality of institutions in a given jurisdiction.

Limitations of the dataset should be recognized. These include the fact that the sample was quite small, and the countries represented were not as highly economically developed as in the West. Important variables such as the input prices for capital and energy were not available. Additionally, the authors of the original dataset acknowledge that, despite their best efforts, there are imperfections in their dataset (SEAWUN/ADB, 2007).

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