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Economics of local public services for drinking water supply

In France, there is a recurrent debate on the choice of organization, management modes and regulation of the water services. They are local monopolies which may be directly managed by the municipality or delegated to a private operator. An econometric analysis of cost for the drinking-water supply services gives crucial information on the potential gains in terms of network performance and resource management. A counterfactual comparison of the costs of the management modes (public/private) shows the differences in efficiency and the existence of an informational rent for private operators.

Purpose of the research

Water services management (drinking water supply and sanitation) may be delegated to a (private) specialized company. The problems of inefficiency linked to the monopoly structure of the services are exaggerated by the deficit of information for the public authority delegating the management performed by the private company. However, direct (public) management is not without problems: production inefficiency, lack of monitoring and so on. The pricing scheme and incentives given to services remain privileged tools in a context of scarcity and fragility of the resource. Therefore, when we want to study the environmental aspects (quality and quantity of services) and the social welfare aspects (invoicing to users), it is important to understand the behaviour of the service operators. In this context, an econometric analysis of the cost of the services proves to be inevitable. It helps to measure the economies of scale that can be exploited, to study the effects on the production of information asymmetries between the operator and administrator of the service, and to compare the management modes in terms of efficiency, price and quality of the service. We present here a review of the research results on drinking-water supply services (DWS) in France.

Organization of the water sector in France and description of DWS technology

Organization and regulations

In France, the organization of the local public services (water, waste, transport…) is the responsibility of the municipality or of a group of municipalities, and the management may be either direct in "régie" or be the object of a delegation agreement (long-term lease contract or concession) with a private company. Public service delegation agreements specify the nature of the expected services, the tariff paid by users and, in the case of long-term lease contracts, the share of replacement work that is the operator's responsibility. Out of the 4.5 billion m^3 of drinking water invoiced in 2006, 72% came from private operators (in particular Veolia Eau, Lyonnaise des Eaux, SAUR).[1]

In France, the lease contract is the most common form because it is the most flexible, suited to a large number of situations. It is usually signed for 7 to 12 years. The operator is in charge of network management and maintenance, it invoices for the service and re-distributes the share going to the local authority. In the case of direct management, the water price results from a deliberation of the council or an agency of the local authorities, the main objective being to balance the budget. When the service is delegated, an invitation to tender determines the choice of operator, then a negotiation phase (*intuitu personae*) allows the municipality and the operator to agree on the service price and quality.

Whatever the management mode, the water services face the same regulations. The 1992 law on water updates the 1964 legislative framework governing water management in France. The objective of the Sapin law (1993) is to put an end to illicit practices between private companies and the people in charge of the local authorities by introducing public information and competition procedures into the delegation contracts. The delegating authorities are in charge of the regulation and control of services, helped when necessary by the DDAF (Departmental Directorate of Agriculture and Forestry) or the audit agencies. The water services must respect public service principles, including the principle of equal treatment of the users as regards access to service, the service provided and tariffs. Furthermore, the 1992 law and the ensuing regulations rules reflect the public authorities' will to take into account the economic realities of the services. This means financially autonomous water services, with a budget balanced and financed by the user. Furthermore, water services for communities of more than 3,000 inhabitants are under the obligation to keep a specific budget (accounts) for the service, proper or annexed to the general budget of the community, and since the 1995 Barnier law, the separation

[1] In 2006, in sanitation, 3 billion m^3 of wastewater was collected, including 55% by delegated services.

between DWS and sanitation has had to be made clear on the water bill. The other statutory constraints concern water quality.[2]

DWS technology

DWS may be separated into two activities: production of drinking-water and the distribution of this water to users. Drinking water distribution generates high fixed costs. The specific nature of the assets makes these fixed costs irreversible. Moreover, the building of parallel networks is quite unrealistic and is a true barrier to entry for any potential competitor, thereby conferring an incontestable monopolistic structure to distribution activity. Furthermore, water is a heavy product which is costly to transport and difficult to store, and quality requirements include a certain proximity between the places of production and consumption. DWS is a service which is naturally the local authorities' responsibility.

The water supply service must produce good-quality water from raw water that may require treatment, and must put it at the disposal of users, adapting continually to their demand and preserving the water quality during its stay in the network. The operation costs of the service are then generated by all the operations covering the transport of drinking water, from abstraction in the natural environment to the user's tap (catchment/treatment, storage, pressurizing in the network distribution, distribution to the user). The drinking water distributed to the user is produced from raw groundwater or surface water. This factor of production (or input) has no acquisition cost, which explains why it is not considered like the other factors such as labour, energy or materials. The only cost of the water "input" is the marginal cost linked to its provision. Groundwater generates higher drilling and pumping costs while treatment costs are usually more substantial for surface water. Last, operation costs may also be different in the distribution phase, because they depend crucially on the size of the areas served, on their population density and on their topography. Therefore, the environment in which the service operates largely explains the differences in costs (and prices) observed between municipalities.

A part of the volume of water distributed in the network does not reach its final destination, mainly due to pipes breaking or to faulty (defective) joints. This specificity is of great extent because the production and distribution costs depend on the network condition. The network returns calculated as the ratio of the volume invoiced to users to the volume put into distribution is a major indicator for engineers and a crucial decision-making variable for service administrators.

Modelling and estimation of costs

This description of the technology helps identify several major determinants in the operation costs - in addition to the standard variables such as volume of production and prices of factors - which depend on the service local context: number of users, network length, network returns, origin of the raw water, topography, type of treatment…We may then define a variable cost function from the operator's service programme, the objective of which is to minimize the costs in production factors under technological constraints (frame 1).

For the econometric analysis, which consists in estimating the structural parameters of technology, it is necessary to define a functional form for the variable cost function (see frame 2). Moreover, the system of equations made up of the cost function and the demand functions for production factors is usually estimated to improve the precision of the estimates. With a large enough set of observations on the key variables explaining the costs, it is possible to find the parameters associated with these variables, and therefore to identify the most important determinants and their interactions. It is also possible to calculate the measures providing information about technology flexibility (substitution of factors of production, economies of scale…). However, it is often difficult to collect information about management of services, perhaps because these variables are not easy to define or because it is not in the operator's interest to disclose them. This is the case of the quality of service provided by the operator or of the economic efficiency (in terms of cost) of service management. Panel data (services are observed over several periods of time) allow the integration into each service of the specific effects which represent the non-observable heterogeneity of the model. Unvarying in time, these individual effects may be correlated to some explanatory variables observed, such as volumes of production. This problem is treated by specific econometric methods.

Results

In the DWS network, the scale of production may be apprehended through several vectors: volume of production, number of users, network size and number of municipalities joining the same service. The returns calculated from cost elasticities (and therefore the first-order coefficients for the average service) may thus be differentiated. The returns to production density measure the behaviour of the average variable costs when the volume increases for the same number of users and a constant network size, thus for increasing consumption per user. The notion of users' density returns is determined for a production increase due to new user connections, but with an unchanged network size and consumption per user. For returns to scale, production, the number of users and the network size increase. This happens when different municipalities group together.

The assessments were made on the basis of 188 observations from 47 DWS services in the Gironde department (France) from 1995 to 1998. These services have lease contracts with private operators (Lyonnaise des Eaux, Veolia Eau, CISE, SAUR, Electricité Service Gironde, SOGEDO). Data come from reports drawn up by the DDAF of Gironde from technical and financial reports made yearly by delegates.

The estimation results show the existence of economies of scale for an average service, thus confirming the advantage of the group of municipalities (Garcia and Thomas, 2001; Garcia, 2002). However, we show that the efficient size of the group is quickly reached, underlining the difficulties of managing excessively complex structures. The estimation of the DWS variable cost function also gives useful information about the efficient use of the "water" input. The occurrence of drinking-water losses in the network may be considered as part of the general inefficiency of the water system. It is clearly a problem

[2] Two European directives concern the quality of surface water for the production of drinking-water and quality of surface-water intended for human consumption. In France, the water agencies adopted a policy of protection of the resource based on water abstraction and pollution fees. These tax revenues are re-distributed to local communities, industrial companies and farmers in the form of financial aid (loans, subsidies) for investments to combat pollution, for the development and management of water resources.

for the administrator of the service in terms of opportunity costs of drinking water lost for potential consumers. From the point of view of an environmental regulator, these losses are not desirable to preserve the resource. We studied how they interfere with the volume of water distributed to users. We show that both volumes of water (losses and consumption) are complementary, that is to say that the marginal cost of access to drinking water for users increases when we try to reduce losses. This may be explained by network repair and maintenance costs which are significantly higher than the costs generated by the increase in production to meet the users' demand.

A study of the contractual relationships between the local authority and a private operator to which the DWS public service was delegated, shows the consequences of the existence of informational asymmetry on water production and in particular the level of water losses (Garcia and Thomas, 2003). The main result of the regulation theory within a principal-agent relationship where the agent has private information on its costs is the existence of the principal's trade-off between production efficiency and reduction of the agent's informational rent. It has been shown that the local authority (the principal) is compelled to authorize sub-optimal water losses to prevent the private operator (the agent) from getting too much informational rent.

In this context of informational asymmetry in delegated management, it is interesting to analyse the costs for direct management and suggest a comparative study of the two management modes - public vs. private (Boyer and Garcia, 2008). Interaction modelling between management modes and operation costs helps compare their performances and pricing scheme. If there are various management modes, each one offering specific advantages for the municipalities, the choice of one mode over another will be determined by a certain number of elements, among which the cost differential between management modes. Ignoring the endogeneity of this choice would lead to a selection bias at the time of estimation of the equations of costs or prices for the services in "régie" and those in private management. In other words, the differences between management modes calculated from the observed costs and prices for services with various operating conditions, give biased results. Conversely, a counterfactual analysis allows the costs and prices to be estimated when the alternate mode of management would have been chosen.

The panel of private services is completed by observations of the "regies" (52 services observed from 1995 to 1997, or 156 observations) in a northern French department. Information comes from administrative accounts for the financial data and from technical reports about the volumes of water and data regarding the technology and network. We show that the comparison of costs is one of the main choice determinants of the local authorities between direct and private management for the DWS service. This choice is also dictated by the characteristics of the service (loss level, number of users…) and by the sanitation management mode. The panel structure of the data helps estimate the individual effect representing the productive efficiency of the operator. There is a significant difference in average efficiency in favour of private management, but "regies" seem to be higher performing in network returns. The characteristics of services also explain the level of prices and margins. For instance, a network in better physical state (less water losses) brings an increase in margins (rewarding the managers' efforts). In the case of private management, the effect of the variables included in the contract (invoiced volume of water and index of losses) on the rents is modified with the concentration of operators. For instance, network quality has almost no more impact on margins when the contract is signed by a private operator that is well established in the department. Last, when management is private, the calculation of predicted margins helps validate the presence of private information as well as its impact on price. For a price average of 0.36€/m^3, we estimate the average informational rent at about 17%.

Conclusion

The results presented here give a general idea of the information revealed by the econometric analysis of costs. The network returns are estimated in order to measure the potential economies according to the production scale and they give indications on the degree of saturation of the facilities and the investments to be made. When the cost model integrates drinking-water losses, it is possible to obtain answers about resource management. In particular, we show the trade-off between the repair of leaks and the upward increase in production. We also show how this problem is exaggerated by the presence of informational asymmetries in the case of private management. Moreover, the comparison between private and public management modes confirms the differences in efficiency and the existence of informational rent for private operators.

Other concerns such as the quality of the service provided were integrated into the analysis of costs. The results from a sample of American DWS services show how the quality indicators are decisive in the explanation of the performance of services (Bouscasse et al., 2008). Their omission may lead to incorrect ratings in a benchmarking system, in particular when comparing public and private management.

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Pour en savoir plus

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Frame 1 – The cost function

The production process may be modelled by a transformation (or production) function:

$$F(V, x; z) = 0,$$

signifying that the volume of drinking water distributed to users V is produced from various inputs x (capital K, labour L, energy E, material M), given a certain number of local service characteristics included in the vector z. Note that V, service production, could also represent the different volumes produced for various categories of users (households, industrial companies, and farmers) for example, within multi-product modelling.

The duality principle in the theory of production says that technology is synthesised in all its economic aspects by the cost function C dual to the function of production F. Given the technology used and the input prices, the producer is supposed to choose the quantities of inputs in order to minimize its costs of production. The assumption is implicitly that the producer resolves a minimization programme as regards all the inputs. However, in reality, capital K is an almost fixed input in the sense that an adjustment in the short term is not feasible. In this case, we build a short-term cost function from the minimization of the variable factor costs (according to the volume produced) under technological constraint, and conditionally to the installed capital $\bar{K}$:

$$\min_{x_v} wx_v \text{ under constraints } F(V, x_v, K; z) = 0 \text{ and } K = \bar{K},$$

where w represents the variable input prices, themselves noted x_v. The short term cost function from this programme is the sum of the fixed cost (CF) and the variable cost function (CV):

$$CF + CV(V, w; \bar{K}, z).$$

The variable cost function contains the same information as the original production process. A cost function has the following properties: non-negativity and non-decreasing in V and w, homogeneity of degree 1, concavity and continuity in relation to w. Moreover, the variable cost function is not increasing in $\bar{K}$.

Frame 2 – The econometric analysis of costs

The Translog form is a quadratic function which is sufficiently flexible to impose only a few *a priori* restrictions on the technology characteristics. It is a local approximation expressed in logarithmic form:

$$\ln(CV_{ht}) = a_0 + a_1 \ln V_{ht} + a_2 \ln \bar{K}_{ht} + \sum_i a_i \ln w_{iht} + \sum_j a_j \ln z_{jht} + \frac{1}{2} a_{11} (\ln V_{ht})^2 + \frac{1}{2} a_{22} (\ln \bar{K}_{ht})^2$$

$$+ \frac{1}{2} \sum_i \sum_{i'} a_{ii'} \ln w_{iht} \ln w_{i'ht} + \frac{1}{2} \sum_j \sum_{j'} a_{jj'} \ln z_{jht} \ln z_{j'ht} + \sum_i a_{1i} \ln w_{iht} \ln V_{ht} + \sum_i a_{2i} \ln w_{iht} \ln \bar{K}_{ht}$$

$$+ \sum_i \sum_j a_{ij} \ln w_{iht} \ln z_{jht} + \sum_j a_{1j} \ln z_{jht} \ln V_{ht} + \sum_j a_{2j} \ln z_{jht} \ln \bar{K}_{ht} + \alpha_h + u_{ht},$$

Where h indexes the services, t the periods, i the factors of production, and j the characteristics of the services (z), the variables being defined in frame 1. α_h is the individual specific effect capturing the efficiency (in terms of cost) specific to each service, and u_{ht} the classical term of error. The estimations are correct around the reference point (often the average of the variables) and the first-order coefficients may be directly interpreted as cost elasticities. For example, a_1 represents the cost elasticity in relation to V for an average service. It may be interpreted in the following way: a 1% increase in the volume of water brings an increase of $a_1\%$ in the variable costs.

In practical terms, we estimate the equation system composed of the cost function and shares of production factors $s_i = w_i x_{vi} / CV$.
Several methods of estimation adapted to the panel data may be used according to the assumptions on data (variability in time, heteroscedasticity) and on the correlation between the explanatory variables and the individual effects.

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