Summary of the thesis

Public utilities

Utilities' provision does not excite too many people. Nevertheless, the effectiveness of the supply of public transport (trains and busses), electricity, gas, water, waste, sports and recreation, medical and social services and urban development influences the shape of an economy and the well-being of its citizens. Frequently, the utilities are arranged by the municipalities which have organized themselves in intermunicipal utilities. As intermunicipal utilities are initially established by the municipal budget, they still constitute the municipal balance sheet. As such, municipalities could sell their share in the intermunicipal utilities to counterbalance financial setbacks (if, e.g., budget surpluses or unused tax levels are depleted). Knowledge of the value of the utility seems essential. Still, 94% of the Dutch municipalities could not provide full insight in the value of its participations. Among the explanations, they attribute wrong (not up-to-date) information and wrong bookings of assets (Gerritsen, 2002). By using the net assets, De Witte and Moesen (2006) estimated the value of the Flemish intermunicipal utilities at 13 billion euro in 2003 (about 9% of Flemish GDP). It is clear that intermunicipal utilities are not a negligible sector.

Besides the lack of knowledge of the value, (public) utilities often face a poor corporate governance structure (De Witte and Moesen, 2007). For example in Flanders, by law mandatory in (public) utilities are required to be politicians. This raises doubts about the objectivity of the appointment (i.e., are they appointed because of intrinsic qualities or because of a political agenda?). In addition, the board of directors (which according to corporate governance rules is preferably small in order to be effective) is often too large and acts as a consolidation price for unelected politicians. Large boards provide incentives for free riding, complexity and low effectiveness. This in turn harms the efficiency of the utility.

The quiet life

Basically, the two problems are related to a third problem which is intrinsic to the nature of the goods. The public utilities often have a natural monopoly characteristic in that the provision of the good is cheaper at a larger scale. As such, the public utilities are monopolists, or at least regional monopolists. Without facing competition and with captive customers, the monopolists lack incentives to provide the goods as effective and as efficient as possible. Hicks (1935) illustrated this by the quiet life in which the workers of a monopolistic company are unmotivated (e.g., longer coffee breaks, surfing on the internet, etc.). Leibenstein (1966) showed the problem by pointing to the X-inefficiencies in which the firms' managers overinvest, acquire unnecessary resources to expand (and show) their wealth or in which labor unions bargain for above-market wages. Moreover, a (regional) monopolist can easily make excessive profits by increasing the prices for the captive customers.

To increase the performances of the regional monopolies, society (the principal) should create incentives for the utility (the agent). The incentives could firstly originate from the utilities which anticipate changes in society (when, e.g., thanks to increased technological possibilities and to changed ideological preferences a threat of privatization arises). Secondly, regulators could provide incentives by setting maximum prices or maximum revenues (i.e., yardstick competition). Thirdly, a concerned public opinion could stimulate efficiency if performances are published (i.e., sunshine regulation). In a similar sunshine regulatory framework, the performance measure should be comprehensible (e.g., one composite indicator instead of a set of (contradictory) values), correct (e.g., account for diverging exogenous influences among the utilities) and robust to the model assumptions (e.g., they should not rely on a particular functional form which heavily influences the results). Especially the composite indicators could yield clear advantages for both the utilities, the regulator and the public opinion: (1) knowing at a single glance the performance, (2) comparing the overall performance of entities, (3) easiness to explain to outsiders and stakeholders, and (4) setting targets and guiding long term objectives easily.

Methodological choice and issues

In this thesis, we focus on composite indicators as a tool to provide incentives to regional monopolists. To develop composite indicators for the performance of the utilities, we start from the non-parametric efficiency measurement literature. Relying on only a few assumptions, the non-parametric models `let the data speak for themselves' as they do not require an *a priori* specified functional form on the data. As such, efficiency is defined as a relative concept in which the input usage and the output production of an evaluated observation is compared to best practice observations. The excessive input use, or output shortfall, relative to the best practice observation is considered as inefficiency. As efficiency is defined in terms of production possibilities, efficiency is technical (Fried *et al.*, 2008).

The focus on non-parametric models is not unchallenged. The parametric literature is well developed (e.g. Greene, 2007). It is for example relatively easy to explore statistical inference, capture endogeneity and allow for noisy data. In addition, parametric models have in comparison to non-parametric models a high rate of convergence and a low curse of dimensionality. Efficiency evaluations are possible by parametric (e.g. Corrected Ordinarily Least Squares) and semi-parametric (e.g. Stochastic Frontier Analysis) models. Nevertheless, the parametric literature has one major drawback on the non-parametric models. In particular, the models require the *a priori* specification of the production function. This is extremely problematic in many real life studies as the researcher often has no idea on this specification. A well specified parametric model (thus the same estimated model specification as the true underlying model) delivers superior results (in terms of rate of convergence) than a non-parametric model. However, a wrongly specified parametric model delivers inconsistent results. As particularly this true underlying model specification is typically unknown, the main focus of the thesis lies on non-parametric models.

There are three intricate issues in the non-parametric models. Firstly, by construction the relative performance evaluation is sensitive to outlying and atypical observations (as these best practice observations could heavily distort the efficiency scores). We deal with these observations by the robust order-*m* efficiency scores (Cazals *et al.*, 2002). Secondly, the utilities should only be compared to `comparable' utilities, in particular utilities with similar exogenous variables. For this purpose, we use the conditional efficiency estimates (Daraio and Simar, 2005; De Witte and Kortelainen, 2008). Finally, non-parametric efficiency estimates depend on the observed data so that a bias between a true (unobserved) production process and the observed production process could arise. Bootstrapping algorithms provide a solution to estimate the size and direction of the bias (Simar and Wilson, 2007).

The second part of the thesis applies the non-parametric approaches of the first part to the regional monopolistic drinking water sector. The drinking water sector is an extremely interesting and promising sector to study as (1) the debate is complicated by ideological opinions (e.g., private versus public water provision), (2) these ideological opinions created various regulatory models with a diverging effectiveness, (3) as supra-national bodies (e.g. European Union) do not seem to succeed in creating homogenous regulation (in contrast to other network sectors as railways or electricity), (4) as the responsibility of the water provision (mostly) belongs to the municipalities which often lack the resources to create a strong principal-agent setting, and finally (5) as in the future the importance of a (clean, cheap and efficient) water provision is expected to increase in importance. Studying technical efficiency in the water sector is attractive as we focus on the ability to avoid wasting resources (e.g., too large capital base, too much investments, leakage of water).

In Chapter 4, by comparing several regulatory models as implemented in 5 countries, we evaluate the effectiveness of incentive mechanisms. Indeed, the merits of competition are abundantly demonstrated in economic theory. However, a monopolistic configuration may be desirable in certain activities. Particularly operations with large sunk costs or increasing returns to scale could lead to a natural monopoly. Irrespective of ownership, whether private or public owned utilities, every natural monopoly involves welfare cost to society by creating the quiet life of Hicks (1935), the X-inefficiency of Leibenstein (1966) or making excess profits. The problem is similar to a principal-agent problem under asymmetric information. The monopolistic utilities (the agents) have private information about their ability to transform inputs into outputs. As society (the principal) wants a guaranteed service at the lowest price possible, the utilities can extract information rents. The objective of society is to minimize the extraction of information rents while assuring a satisfactory service. Policy makers can apply a broad range of incentive schemes in order to reach this goal. The different institutional frameworks (e.g., divestiture, concession or yardstick competition) reflect the different regulatory and ideological views among societies. Especially within local public utilities ideological views could prevail, mainly if the water services are deemed services of general interest and not services of general economic interest and, therefore, should not be subject to competition law.

Chapter 4 examines the role of incentive schemes in the drinking water sector. We investigate whether regulatory and benchmark incentive schemes ameliorate the efficiency of utilities which are encouraged by incentives. Indeed, whatever the ideological background, no one can accept inefficiencies which are, basically, resources left over on the table. This chapter compares the incentive schemes of five different countries: benchmarking the drinking water sector as in the Netherlands, privatization as in England and Wales, a strong regulatory framework as in Australia, municipal provision with private sector participation as in Portugal or different levels of public management as in Belgium. To the best of our knowledge, this is the first thesis applying international benchmarking in the water sector to the developed countries and trying to determine the most effective incentive scheme towards efficiency maximization.

Our results show large differences in inefficiencies. On average, the benchmarked and public Dutch drinking water companies are performing better (average efficiency score of 1.40) than the privatized English and Welsh utilities (1.55). However, the strict regulatory model of Australia (1.66), the municipal provision in Belgium (1.80) and especially the Portuguese municipal provision with private sector participation (1.90) are lagging behind.

We have interpreted the average `national' efficiency score of a country as a measure for the homogeneity in efficiency of a country's drinking water sector. It turns out that the efficiency of the Belgian and Dutch drinking water sectors are the most homogeneous. In those two countries, policy makers should relatively easily find agreement among the utilities to adopt new laws.

By second stage procedures, we sexamine to which extent the inefficiencies could be attributed to (un)favorable physical, social and institutional environmental factors. Therefore, we have employed censored and truncated Tobit models and compared these to the superior double-bootstrap procedure. The results detect the negative effect on efficiency of the proportion of industrial customers and groundwater extraction, the consumption per capita and the effect of a corporate structure. The portion of leakage, the gross regional product, only supplying drinking water, the delivery in only one municipality and the regulatory and benchmark incentive schemes yield a positive effect on efficiency.

Finally, we have incorporated the physical, social and institutional environmental factors in the efficiency scores by suitably adapting the conditional efficiency measures of Daraio and Simar (2005) to the bias correction model of Simar and Wilson (2007). With equalized exogenous influences, the variation left between the observations can mainly be attributed to managerial influences. We noticed that the Dutch, English and Welsh, Australian and private Portuguese utilities are working in a favorable environment. In addition, our results provide significant evidence for the positive effects of incentive schemes on efficiency. The analysis demonstrates that in absence of clear and structural incentives the average efficiency of the utilities even falls in comparison to utilities which are encouraged by incentives. The presence of benchmarking (in the sense of sunshine regulation or yardstick competition) is a key element which replaces competition in the market or competition for the market by competition by comparison.

In Chapter 5, we examine the influence of potential scale economies for both large and small utilities. Indeed, both academics and practitioners are interested in the optimal scale of operations. From the viewpoint of scholars, the scale of operations touches the debate on returns to scale of the production frontier. Returns to scale denote the relation between a proportional change in inputs and the corresponding (proportional) change in outputs. On the other hand, practitioners are interested in insights on the optimal scale of operations as (1) they guide the individual utilities in their strategic decisions, (2) give direction to the government's incentives, or (3) inspire merger commissions and regulators.

The issue of returns to scale is particularly relevant to public utilities as water utilities. Although water utilities frequently point to the natural monopoly characteristics (since the unit costs of production decrease as the volume of output increases), many studies show that above an optimal size the utilities experience diseconomies of scale. The optimal size depends on several factors and is particular to each operational environment (depending on technology, area, customers, etc.). Some authors refer to a minimum efficient size from which on there are substantial size economies (e.g. Fraquelli and Moiso, 2005; Braadbaart, 2007). In this chapter, we study the optimal scale of operations for both large and small water utilities.

The main proxies for economies of scale in the water sector are the volume of water supplied, the number of customers and the supply area. Scale economies are particularly relevant when the supplied volume increases for a constant number of customers and supply area (i.e., density economies). Scale economies arise from the large fixed costs, technical requirements (e.g., the diameters of pipes, engineering works and the skilled staff), the market power in inputs (e.g., procurement) and investment in innovation. In contrast, some factors corroborate the existence of a threshold for scale economies, such as the complexity of the network, either in operational terms (e.g., leakage) or in the management of a large system. In addition, the network encloses the area of the municipality and, as a rule, the growth and expansion of the system occur at extreme points, normally corresponding to small consumptions with a large cost (e.g., due to transportation of water and to replacement of the existent pipes by others with larger diameters).

The economies of scale are interrelated with the economies of scope. As discussed by Baumol et al. (1988), a larger scope of operations involves also a larger size of the entity. Therefore, we disentangle the effects of scale and scope. The literature on economies of scope in the water sector is relatively scarce. The research questions encompass the existence of scope economies between (1) water and wastewater services; (2) wholesale activities (production of water including treatment and transmission and wastewater treatment) and retail activities (distribution and sewer); (3) water delivered and water lost; (4) quality of water and wastewater treatment and (5) environmental services and water supply. Although studies point to diseconomies of scope, some studies find the opposite.

To analyze the large utilities, we focus on the Dutch drinking water sector. Particularly for the Dutch drinking water sector, we have to distinguish efficiency gains arising from incentive regulation from efficiency gains arising from merger economies. Studying the effects of benchmarking and mergers in the Dutch drinking water sector, this section does not find an impact of mergers on efficiency. In particular, it ascertains the absence of the two underlying mechanisms to merger economies, i.e. scale economies and increased incentives to fight inefficiencies. Although scale economies are present for very small companies, larger utilities are not producing at lower cost. This observation is especially important as in many countries the drinking water sector is involved in a debate on the optimal scale of its utilities. In addition, we show the effectiveness of the incentive regulation, i.e. a voluntary benchmarking project since 1997. This incentive regulation significantly increased the efficiency of the Dutch drinking water companies. Therefore, regulators should be cautious with respect to factors which undermine the effectiveness of incentive regulation. Particularly mergers undermine the effectiveness of incentive regulation as the remaining utilities could easily invoke atypical circumstances. If the quality of incentive regulation is based on the quality of information about utilities, which is generally the case, mergers probably decrease the effectiveness of regulation. It is suggested that regulators should not give the benefit of doubt to merger projects of utilities in an incentive regulation environment if the number of firms is already relatively low, which is the case in the Netherlands. On the contrary, these regulators should consider to break down larger companies into smaller utilities in order to obtain more comparable units and, hence, further increase the effectiveness of the incentive regulation.

To analyze the small water utilities, we focus on the Portuguese water sector. Our results indicate for the small utilities the existence of scale economies and the absence of scope economies. Further analyzing the returns to scale, we observe that, if all inputs are considered simultaneously, most utilities are performing at their 'most productive scale size'. Examining the optimal scale, we find, for the sector as a whole, that the minimal costs are situated around 10 million m³. This denotes that Portugal optimally counts about 60 utilities (in contrast to the 300 utilities now).

Chapter 6 analyzes for the Dutch drinking water sector the influence of the public debate. In other words, could a public debate provide an effective alternative to (strict) regulation? If public opinion makers denounce the performance, profits or prices of the utilities, do the utilities change their behavior? By comparing profits, quantity and price effects before and after the introduction of sunshine regulation in the Dutch water sector and by pointing to different trends in the data, we shed light on the impact of the sunshine model on firm performance. Although we do not intend to provide an exhaustive description of the Dutch drinking water sector (see Van Dijk *et al.,* 2007), we review the various debates on reform of the Dutch drinking water sector since 1992. Indeed, besides the introduction of sunshine regulation the sector faced discussion about privatization, yardstick competition, profit regulation, etc. Regulatory shifts and the preceding discussions are also found in other sectors (e.g., postal services, telecommunications, railway sector). However, the interesting characteristic of the Dutch drinking water sector is the extended time period (1992-2008) over which these debates have continued, and the ultimate retention of public ownership. Moreover, the wide ranging debate touched the very nature of drinking water provision by considering, private versus public water supply provision and how to design incentives for those private or public utilities. This analysis suggests that the regional drinking water monopolies anticipate potential regulatory changes and their resulting change in conduct subsequently delays or postpones the planned legislation.

Our contribution naturally follows, as we analyze the Dutch drinking water sector to investigate the behavior of the regional monopolists in this frequently changing regulatory environment. Monopolists can, in comparison to competitive firms, more easily seize the opportunity to increase prices and make excess profits. Thus, it is interesting to investigate how discussions on, e.g., a privatization, the incentive model or profits affect the behavior (in terms of profits, productivity, prices and activity) of regional monopolists.

Our results suggest that after the implementation of sunshine regulation in 1997 the productivity performance of the publicly owned Dutch drinking water utilities improved markedly (this in the absence of privatization and without the establishment of a more robust incentive regulation system). Thus, while during the period 1992-1997, productivity declines caused an 83.4 million euro (in 1995 prices) reduction in economic profits, after 1997 productivity gains contributed 145.464 million euro of increased profitability in the industry. Moreover, while large increases in output prices in the 1992-1997 period contributed significantly to increased economic profits, output prices fell considerably after 2000. As economic profits, nonetheless increased between 2000 and 2006, our results strongly suggest that this consumer benefit did not accrue from inappropriate political interference, but was instead the result of passing past productivity improvements from producers to consumers. These results therefore suggest that `naming and shaming' in a sunshine regulation system can induce publicly owned utilities to improve their productivity, and can also insure that such productivity gains are eventually passed to consumers in lower prices. In sum, this chapter suggests that in an appropriate political and institutional context, sunshine regulation can be an effective and appropriates means of insuring that publicly provided services are efficiently and profitably provided.

Policy conclusions

Although the previous summary already presented some insights for policy makers, we briefly bundle the main policy conclusions which arise from this thesis. In doing so, we focus on the policy conclusions which might be interesting for regulators, administrations and CIRIEC.

Firstly, when assessing efficiency, regulators should account for the operational environment where the regulated entities operate. A simulated exercise shows that neglecting the operational environment delivers significantly different results, which favours entities operating in a favorable environment (see Chapter 1). If the regulator fails to include the operational environment, (at least in the longer run), utilities operating in an unfavorable environment will challenge the independence and aims of the regulator.

Secondly, a regulator who decided to include the operational environment faces major difficulties to define the appropriate variables. For the same research question, the literature defines various input, output and exogenous variables (see Chapter 4). A different variable selection results in different outcomes. Obviously, the regulated entities will lobby for variables which suit them best. Including a broad selection of variables is impossible in the non-parametric framework because of the curse of dimensionality (see Chapter 1). The parametric alternative is often not feasible as the production function is unknown. Nevertheless, similar results between a non-parametric framework and a flexible parametric model could add confidence to the results (see Chapter 5).

Thirdly, utilities facing incentive regulation perform more efficient in comparison to utilities which do not face incentives (Chapter 4). Utilities which are not influenced by incentives suffer from a quite life and X-inefficiencies. Therefore, administrations should develop adequate incentive schemes, particularly for utilities operating in (regional) monopolistic markets.

Fourthly, the managers of utilities often favor a larger scale of operations. At least for the drinking water utilities, we show that the performance of the utilities increases until a particular scale level: a larger scale is advisable, however, water companies can be too large. After a particular (and country specific) scale size, a larger scale of operations harms efficiency. Therefore, governments and regulators should analyze potential mergers very carefully. Indeed, a merger could result in increased market power (e.g., because there are less comparable units in a benchmarking incentive regulatory framework) and even diseconomies of scale. It may be worth considering the split of very large utilities into subutilities. This will increase the competition and comparability in (a benchmark inspired) regulatory framework.

Fifthly, in particular situations, sunshine regulation, which a very soft regulatory model consisting only of `naming and shaming', can be an effective tool to regulate utilities (see Chapter 6). Indeed, with a good mix of internal carrots and external sticks, sunshine regulation triggers a race to the top which is similar to a competitive market. However, the effectiveness of sunshine regulation (as every incentive which draws on benchmarking) is influenced by the number of comparable units. Therefore, it would be advisable to define the relevant market as large as possible in order to include more entities in the analysis. To do so, supra-national organizations should define the variables very precisely such that utilities of different countries and regions can compare themselves and learn from the best-in-class.

Finally, administrations and regulators should create a stable environment for the regulated utilities. The regulated entities are trying `to game' the regulator in periods of instability and discussions on the regulatory regime (see Chapter 6). Utilities should know exactly in advance how they are assessed during a particular period of time.

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On Analyzing Drinking Water Monopolies by Robust Non-Parametric Efficiency Estimations

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