Louvain School of Management

Impact of the Ownership Structure on the cost-efficiency

Author : Frédéric van Naemen

Supervisor(s) : Per Joakim Agrell

Academic year 2019-2020

Abstract

In our modern world, people around the world are using different services in their day-to-day life. Water supply, transports, health care, etc are now common services in most of the developed countries. Gasoline is used in cars to travel, or in the kitchen to cook. Fuel oil is necessary to keep a decent temperature in our houses. All these multiple energy uses have made us dependent from this supply. Electricity is one of the energies we are using daily.

The electricity is produced in production plants which are spread around the country. Then, the electricity is routed toward a distribution network to the consumers. The High Voltage (HV) grid is handled by Transmission System Operators while the Mid Voltage (MV) & Low Voltage (LV) network is managed by Distribution System Operators (DSOs). To ease the management of the distribution service and to generate economies of scale, each DSO has a monopoly position on the portion of network that belongs to it. This situation could lead to unfair behaviour from the DSO since the distribution activity cannot be influenced by consumers' actions (even the consumer can lower his electricity consumption, it will not affect his need to be connected to the network). To prevent this behaviour, the distribution activity is regulated by the authority (usually a federal institution). The regulator has the mission to keep a control on the distribution prices, and through them protect the consumer from unfair actions from the DSO.

DSOs can have different ownership structures. They can be private organizations, state companies, city services, consumer cooperatives, etc. We can assume that, if the aim of each structure is to ensure the distribution of electricity to all their customers, the economical profit is quite different. Some of the structures are more induced to generate profit than others. For example, private organizations have shareholders that expect some benefits on their investments.

In this thesis, we will analyze the impact of the ownership structure on the cost-efficiency giving a focus on the consumers cooperative organization. Using the operating details database of about 150 Swedish DSOs and Benchmarking tools, we will examine how structures handle their resources and how the efficiency of the resources' allocation fluctuates along the years.

Acknowledgements

First, I would like to thank my promoter, Professor Per Joakim Agrell, for his help, availability and involvement throughout the writing of this work.

I would also like to thank all those who supported me in any way during the preparation of my brief.

Finally, I would express a special thanks to my friends and family for all the encouragements they provided

Table of content

II.

Introduction

During the evolution of mankind, different forms of energy have been discovered: thermal, chemical, gravitational… and electrical. With the progress of scientific knowledge, humans have domesticated some energy types and use them to improve their comfort. The development of electricity power during the 19^{th} century and all the possible applications of it has been a revolution in human history. Electricity has radically changed our living habits. Cooking, heating, communicating, etc. Almost all aspects of our lives have been modified. In addition, the sources of energy for producing electricity have diversified: from nuclear, fossil fuels, coal, oil natural gas to renewable energies.

1. Electricity Sector

1.1 Electricity market players

The expansion of the electricity sector triggered the creation of a series of players acting at different levels to ensure production and distribution of electricity to the consumers.

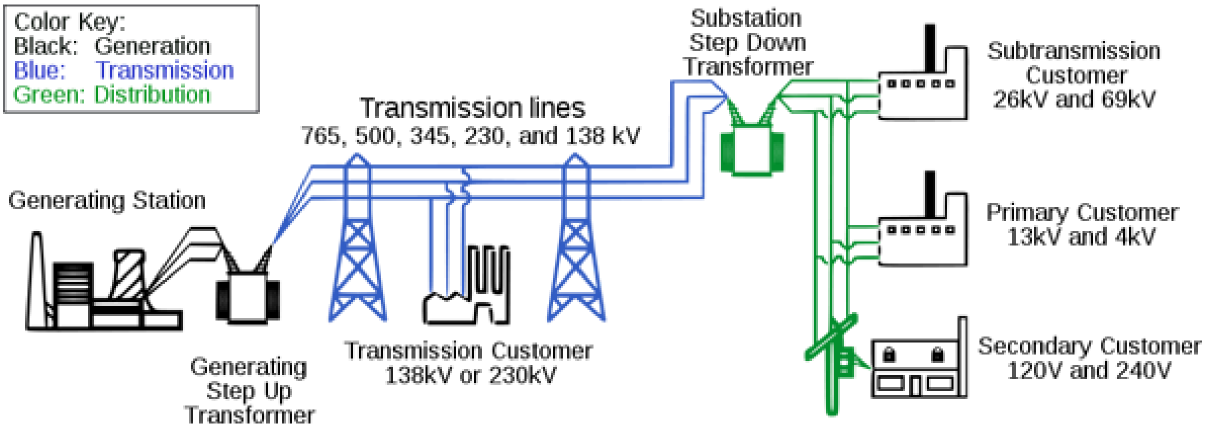


Figure 1-1 : Electricity supply chain

1.1.1 Production to consumption

1.1.1.1 Electricity generators

At the first step, we find the electricity generator: the power plant which produces the electricity. Using a wide range of energy sources: non-renewable energy sources (like fossil fuels, coal and nuclear) and renewable energy sources (like biomass, solar and wind), in various power stations, the electricity energy created is injected into high-voltage transmission network.

Traditionally, all the electricity is produced by large power plants. In 2019, the Swedish Electricity Mix was composed by 39,3% of hydropower, 39,1% of nuclear power, 12,1% was wind power, and the last 9,5% is a mix of biofuels, fossil fuels and peat/coal energy generation (Swedish Energy Agency, 2019). Of course, this energy mix is subject to change according to the seasons.

1.1.1.2 Transmission system operators (TSOs)

The transport of high-voltage electricity is handled by TSOs. In Sweden, there is only one TSO, Svenska Kraftnät.

A TSO is responsible for the day-to-day operation of the HV transmission network. This responsibility also includes its maintenance, its extension if necessary, as well as its interconnectivity with other networks (Glowacki, Transmission System Operators (TSOs), 2019). A TSO also ensures the right energy transmission to meet demand.

The development of a supranational network is required in the strategy to ensure a constant production level, especially with the growing importance of renewable energy production. This way, in case of peak demand, energy can be purchase to other TSO's., For example, if the weather is cloudy and solar production is null, other production regions may sell their overproduction.

1.1.1.3 Distribution system operators (DSOs)

DSOs are the operating managers of mid-voltage and low-voltage electricity network between TSOs and end-users. They are responsible for the correct supply of energy to the network. DSOs can also develop the grid with interconnectivity to other grids (Glowacki, Distribution System Operators (DSO), 2020). They ensure the transmission of electricity to residential consumers and SMEs. Some are also responsible of the public lightning, among other activities. (Electricity market players, 2019).

1.1.2 Regulators

Since the liberalization of the energy production by the European Union, the governments, in recognition of the major investments made, authorize the TSO's and DSO's to be monopolist on their territory. But to limit and prevent the agents to abuse from their monopoly position, a regulator has been set up to guaranty the quality of service and bound price variations.

In 2009, the European commission has decided in Article 35(§1) of the Electricity Directive that "Each Member State [of Europe] shall designate a single national regulatory authority (NRA) at national level". General Objectives of the Directive are developed in Article 36. We can summarize them as the promotion of a competitive secure electricity market, which helps to develop consumer-oriented systems and which ensures system operators to have incentives to increase efficiencies in system performance. In Sweden, this authority is the Energy Markets Inspectorate (EI).

Even if the NRAs are in charge of controlling the DSOs in each European country, on a higher scale, the European commission has instituted the ACER (Agency for the Cooperation of Energy Regulators), whose mission is to coordinate the activities of the different NRAs and to monitor the work of the TSOs. ACER also works towards the establishment of a single European energy market for electricity and natural gas (ACER, 2019).

1.2 Ownership Structure

In this paper, 5 different organizations will be defined. These are the type of firms existing in the Swedish electricity market. These organizations differ from each other in terms of their management structure, what will be named the "ownership structure". In the rest of the document, this name will be used to refer to the type of management.

1.2.1 Cooperative owned company (e)

A cooperative is a firm owned, controlled and ran by and for the members of the firm itself. Depending of the business, the members can be customers, employees, users or residents. Managed in a democratic way ("member, one vote"), the mission of the cooperative is to fulfil the needs and ambitions of the members (EuroCoop, 2012)

The profit is driven to provide best service to the cooperators, as they are decision-maker and beneficiary.

1.2.2 Limited shareholding: State Ownership (s)

A state-owned company is an organisation where the State can exert control in the management of the activities and in the decision of strategies. It goes through a partial or full ownership. Traditionally, people in the board were responsible for defending the profit of the government, which is a public objective.

There can be 3 reasons why a government wants to develop such an ownership.

- Political reasons: the company faces some financial difficulties and a bankruptcy could harm people. The intervention helps to minimize impact. Another political reason is to boost the growth during instable situations, like war periods.
- Natural monopolies: Acting on a national scale, the resources of the government will allow the company to make economies of scale, for example: the management of a national network.
- Infant industries: Considered as “economically desirable”, these activities don’t generate enough profit for private investments, but they are necessary for the society.

1.2.3 Limited shareholding: Municipal Ownership (k)

A limited company owns the distribution network. The majority of the shares belongs to a public owner: the municipalities.

1.2.4 Limited shareholding: Private (p)

In the current paper, a private ownership structure means that the management is of a private type. The members of the directive board are people deciding on their own. They are acting for their own profit and are not necessary submitted to any social objectives. It does not mean that they are free to act as they want because they still have to respect some common rules of behaviours.

In the general literature, a private ownership structure also includes companies with shareholders, but where the shares are not traded on a public exchange. The managers are submitted to the profit research for the shareholders.

The interpretation that will be considered is that in a private ownership type, the decisions made by the managers are based on the look of the biggest “financial” profit, for personal profit or those from the shareholders.

1.2.5 Public Utility (f)

The activity of electricity distribution is an integral part of the municipality's charges, in the same way as waste collection. The workers are communal employees. The firm's finances are integrated into the commune's budget.

2. Literature Review

2.1 Why regulation?

In a competitive market, competition is an essential component that result from scarcity. If someone wishes to buy something from someone else, they will negotiate until both agree on a price to sellor buy. Moreover, when there are multiple buyers and multiple sellers, each will adapt and adjust the prices or quantities they will buy or sell to reach their expectations.

In the 18th century, the economist Adam Smith, in his book An Inquiry into the Nature and Causes of the Wealth of Nations (1776), mentioned the notion of "The Invisible Hand". This expression suggests that in a society in which everyone would seek to maximize his or her profit, this individual search would ultimately benefit everyone. Thus, if everyone wants to produce the best product, it is to the benefit of society.

Later, this notion was taken up by economists to support a deregulation of economic activities. Their interpretation was that leaving agents free to make their own choices would lead to greater overall profit.

However, since the 20th century, it is not the case anymore. Nowadays, a free market will lead to monopolies and personal profit does not lead to general progress anymore.

It means that the electricity distribution cannot be a free market ruled by the invisible hand, as the sales item needs the be accessible for all.

As we live in a profit-based society, companies are seeking to create value. Consequently, firms will look to be as performant as possible to increase their profit. The concept of productivity and efficiency is key here.

The regulator will ensure that productivity and efficiency do not harm the common good.

2.2 Measuring performance

A firm can be modelized as a production of outputs using inputs through a manufacturing process impacted by management decisions and exogenous factors (see figure 2-1). A certain amount *x* of inputs allows the company to manufacture a certain amount *y* of outputs.

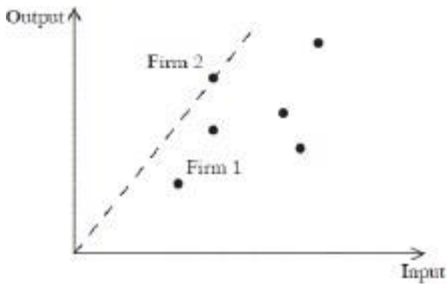


Figure 2-1- Input-output combination
(Source: Bogetoft & Otto, 2010)

As productivity and efficiency are determinant to get best profit, the firm will tend to use the lowest possible level of input to produce as much as possible outputs. The productivity P can be determined, when the (x, y) combination is known.hen we know the (*x*,y) combination of the company, we are able to determine the productivity *P*:

$$P = \frac{y}{x} \qquad \text{(Eq. 1)}$$

When it comes to compare firms, the productivity of 2 firms can be compared. If productivity of firm 1 is $P_1 = \frac{x_1}{y_1}$ and for firm 2, it is $P_2 = \frac{x_2}{y_2}$, the ratio between both is called the efficiency:

$$E = \frac{y_1/x_1}{y_2/x_2} = \frac{y_1/y_2}{x_1/x_2} \qquad \text{(Eq. 2)}$$

If the above ratio *E* is valid, it only illustrates a very simple situation called KPI approach: only 1 input and 1 output, no details about the input-output combination, the sub-process productivity impact… It is time now to relax these assumptions:

1. <u>Technology set</u>

   "The technology set is the set of combinations of input and output such as the input can actually produce the output" (Bogetoft & Otto, 2010). The definition means that the choice of input and output that enters the efficiency determination has to lead to a feasible combination.

   Four implicit assumptions are made through the definition:

a. Free disposability: If *(x,y)* combination exists in technology set, any combination where *x'* is larger than *x* and/or *y'* is smaller than *y*, also exists in the set.
b. Convexity: if two combinations are feasible, any mixture of the two is also a feasible combination.

c. Additivity: if two combinations are possible, the sum of both is also possible.
d. Scaling: The mathematical model developed in previous section provides us a unique optimal ratio. Build according to the assumption of a constant return to scale (*crs*), the model is convenient if all firms are operating in the same range, using similar technologies and in comparable environments.

But it is clear that the reality is not like that. Multiple technologies and several environments, different constraints, etc, may result in firms that are not reaching the optimal scale. The development of a correction of the *crs* leads to the variable return to scale (*vrs*) model. The modification is made by adding the convexity constraint:

$$\begin{aligned} & min_{\theta,\lambda}\theta, \\ st \quad & -y_i + Y\lambda \geq 0 \\ & \theta x_i - X\lambda \geq 0 \\ & L'\lambda = 1 \\ & \lambda \geq 0 \end{aligned} \qquad \text{(Eq. 3)}$$

(Coelli, Rao, O'Donnell, & Battese, 2005)

Where L is a $L \, x \, 1$ vector of ones. That imposes a convex hull to the frontier, enveloping the data points in a tighter way than the CRS. The consequence is that an inefficient firm is compared to “more similar” firms.

In the same way, the non-increasing curve and the non-decreasing curve can be determined by changing the inequality of the enveloping term.

Non-increasing return to scale (NIRS)

$$\begin{aligned} & min_{\theta,\lambda}\theta, \\ st \quad & -y_i + Y\lambda \geq 0 \\ & \theta x_i - X\lambda \geq 0 \\ & L'\lambda \leq 1 \\ & \lambda \geq 0 \end{aligned} \qquad \text{(Eq. 5)}$$

Non-decreasing return to scale (NDRS)

$$\begin{aligned} & min_{\theta,\lambda}\theta, \\ st \quad & -y_i + Y\lambda \geq 0 \\ & \theta x_i - X\lambda \geq 0 \\ & L'\lambda \geq 1 \\ & \lambda \geq 0 \end{aligned} \qquad \text{(Eq. 4)}$$

(Coelli, Rao, O'Donnell, & Battese, 2005)

In the models developed above, the focus was given on the minimization of the use of inputs while still producing the same output level. The same reasoning can be implemented according to the priority: cost minimization, revenue maximization, profit optimality, etc. The difference lies in the maximization (or minimization) calculus of the equation model on the first line.

It shows the variation of output amount in case of a variation in the input amount. If the situation is a constant return to scale (*crs*), the variation is proportional. In case the output increases by less than the proportional change in input, it is a decreasing return to scale (*drs*), the opposite is the increasing return to scale (*irs*). In case, the three variations are present in the same display, it is called variable return to scale (*vrs*).

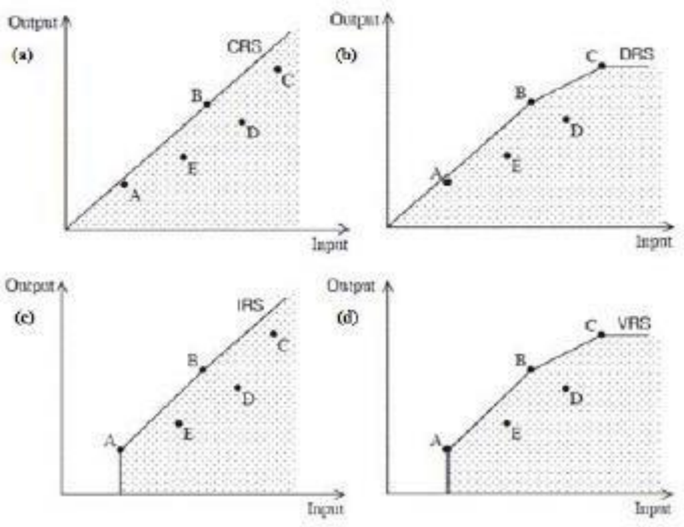


Figure 2-2 - Scaling assumptions:(a) constant return to scale, (b) decreasing return to scale, (c) increasing return to scale, and (d) variable return to scale
(Source: Bogetoft & Otto, 2010)

2. <u>Farrell Efficiency</u>

Previously, the combination was only a single input for a single output. But it is rarely the case in reality. Most of the time, several inputs are used with several outputs, what is called the Farrell efficiency.

Two strategies are suggested:

a) Input efficiency: Maximal proportional reduction of input, while keeping the same level of output.

$$E = \min\{E > 0 | (Ex, y) \in T\} \quad \text{(Eq. 5)}$$

b) Output efficiency: Maximal proportional expansion of output, while keeping the same level of input.

$$F = \min\{F > 0 | (x, Fy) \in T\} \quad \text{(Eq. 6)}$$

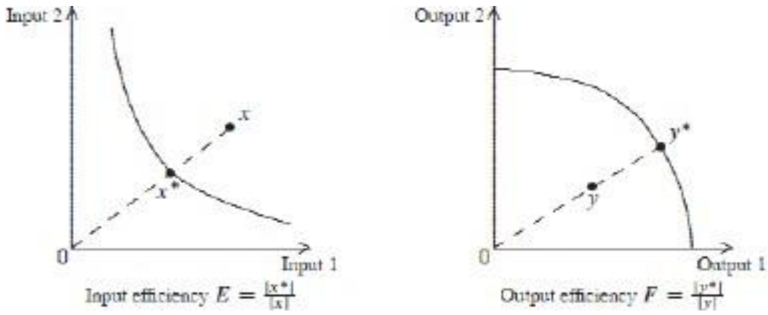


Figure 2-3 : Farrell Efficiency
Source: Bogetoft & Otto 2010

3. <u>Cost efficiency</u>

The assumptions in the previous sub-section was only based on the objective: "less inputs and more outputs". Now it is the impact of the costs and prices that will be considered. The combinations using more or less inputs to produce outputs will be less efficient when the costs associated to the inputs or the prices to the outputs is added in the model.

The Cost-efficiency will be described, but the reasoning is the same when looking to the price-efficiency. Let assume *w* be vector of input prices.

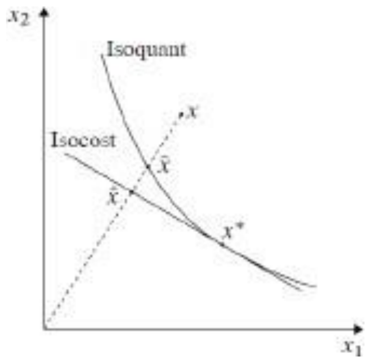


Figure 2-4: Cost Efficiency
Source: Bogetoft & Otto 2010

In figure 2-4, two inputs are analysed, *x* is the combination point of the effective used inputs, and *x** is the optimal level. The cost-efficiency CE is determined as the ratio between optimal cost and actual cost:

$$CE = \frac{wx^*}{wx} \qquad \text{(Eq. 7)}$$

As detailed in Bogetoft & Otto (2010), the cost-efficiency can be decomposed in:

1. Technical efficiency: ratio between actual cost and projection on isoquant

$$TE = \frac{w\tilde{x}}{wx} \qquad \text{(Eq. 8)}$$

2. Allocative efficiency: ratio between optimal cost and projection on isoquant

$$AE = \frac{wx^*}{w\tilde{x}} \qquad \text{(Eq. 9)}$$

3. Scale efficiency: depending on the return to the scale selected, the efficiency may change. For every firm, there is a Most Productive Scale Size, where the average cost is minimal.

$$SE = \frac{TE_{crs}}{TE_{vrs}} \qquad \text{(Eq. 10)}$$

The relationship between the efficiency measures:

$$CE = AE * TE_{vrs} * SE \qquad \text{(Eq. 11)}$$

2.3 Benchmarking

Benchmarking consists of a methodology to compare firms in front of others. Based on inputs and outputs, this tool is flexible. It can be used for comparing firms with each other and for analysing the performance of a company itself. It is particularly used by market regulators, especially when there is not a large amount of data on which regulatory decisions can be based (Lowry & Getachew, 2009). One particular advantage of the benchmarking in regulation is that it is not under influence of the management objectives. It externalizes the terms of service and put external targets.

2.3.1 Data Envelopment Analysis (DEA) method

When it comes to compare firms' performances, benchmarking frontier techniques are commonly used. Designed to illustrate the efficiency and the production, they are easy to understand and, despite some adjustments, sufficiently robust to fit for almost every situation. One of the first technique used is Data Envelopment Analysis (DEA), which is a non- parametric method using deterministic database. There are multiple advantages to use a DEA model: it can measure the performance of several units, point out inefficient operations even if the organization is profitable and handle complex relations between multiple inputs and multiple outputs (Lampe & Hilgers, 2015).

Productivity efficiency is defined by two approaches; the ability to produce the maximum output given a certain amount of input or deliver a defined level of output using as little input as possible (Cvetkosta, 2011).

Introduced by Charnes, Cooper and Rhodes in 1978, DEA requires an increasing and concave production function, which are initial assumptions (Banker, Emrouznejad, Lopes, & Almeida, 2012). Based on these assumptions, linear programming methods are used to calculate the DEA frontier.

In DEA, the measure of efficiency is determined based on several inputs x_i and several outputs y_i. The outcome is a frontier showing the best use that can be done from given level of input. For every Decisions Making Units (DMU), the difference between the DMU's score and the frontier illustrate the relative inefficiency. The score typically ranges from 0 to 1. The frontier is thus used as a target for inefficient utilities and to calculate the the improvement that has to be achieved.

As first introduction to DEA, we will talk about ratio. The ratio will be the relation between the consumption of all inputs over the production of all outputs:$a'y_i/b'x_i$, where *a* is a vector representing the output weight and *b* is the input weight vector.

To find the optimal weight, we have to solve the equation system:

$$\begin{aligned} & max_{u,v}(a'y_i/b'x_i), \\ & st \qquad a'y_i/b'x_i \leq 1,\ i = 1,2,\dots,I, \\ & \qquad\quad u,v\ \geq 0 \end{aligned} \qquad \text{(Eq. 12)}$$

Following the resolution developed by Coelli & al (2005), the derivative corresponding envelopment form is:

$$
\begin{aligned}
& min_{\theta,\lambda}\theta, \\
st \quad & -y_i + Y\lambda \geq 0 \\
& \theta x_i - X\lambda \geq 0 \\
& \lambda \geq 0
\end{aligned}
\qquad \text{(Eq. 13)}
$$

Where θ is a scalar and λ is vector of constants, Y stands for the output matrix $M \; x \; 1$, and X for the input matrix $N \; x \; 1$.

2.4 Regulation

2.4.1 Regulation Models

The complexity of our society has produced a multitude of different economic situations involving a series of different stakeholders. Each situation is unique and is the result of the combination of different places, different players, different consequences, etc. Humans have an inclination to create models to describe and understand the reality around them. But if models simplify the understanding of a situation, it is not possible to have one model for every context. Otherwise, there would be as many models as situations. It is needed to make assumptions and to use variables and parameters which figure the particularities of the different situations.

Concerning the regulation of natural monopolies as defined in the first section, different models have been developed to simulate the evolution of economic activities. Cost-Recovery and Yardstick are two examples.

But the model selection cannot be based only on the theoretical profit, expected consequences and potential advantages. Regulators must have a look to, among others, the cost function of the economic activity and the time horizon of the model application. Several parameters are impacting the decision results and the given firms' behaviour.

2.4.2 Cost Function

A cost function is a mathematical formula that will modelize how the output costs fluctuate ? given input costs in a production process. To determine the costs associated to the production of a certain level of output, The amount and the price of the needed input has to be known The general function is as follows:

$$Q_i = f(p_j, q_j) \tag{Eq. 14}$$

Where Q_i represents the cost of producing the output i (in a determined quantity), and p_j and q_j are the price and the quantity of the necessary input.

The cost function can have multiple variations in the number of variables, parameters, coefficients, etc. For example, in many cases, the cost function will show the production function in an industrial process, where the inputs can be variable or fixed costs.

The first step of the regulation understanding, is to define the operating cost determination. In the present paper, we made the choice to link the costs to the output y, the effort e and the quality q. Some undetermined parameters $k_i \in \mathbb{R}$ are moderating the importance of each element.

$$x_t = f(y_t, e_t, q_t) = k_1 y_t - k_2 \ln(e_t + 1) + k_3 q_t \tag{Eq. 15}$$

1. y_t: The output y_t is the amount of produced output during period t. Based on the delivered service, the evolution follows either a linear function $y = ax$, or a constant function. The hypothesis is that the population increases in a smooth way. In this way, the service amount stays quite stable from one period to another.

2. $ln\ (e_t + 1)$: The following argument is the effort e_t which represents the costs supported by the company to achieve the efficiency. These costs are not currency expenses. They are actions taken to improve the way of working and to get more efficiency in the input use. If they are not directly measurables, they can be approximated through their opposite effect: the inefficiency costs like high salaries or low workload.

Investments are made by the firm to improve the service (extend network, increase maximum peakload, etc) and the relation is expressed following a logarithmic function: one additional unit of effort will not lead to a one-unit cost reduction. The effort level is determined arbitrarily by the regulator. The value of the element is stable during several periods (ex 5 years).

3. q_t: The last inequation term is what we call the quality q_t. The quality represents the service level affordable thanks to all former costs supported by the firm. These former costs are supposed to be the operating expenses, but also all feature procurements and technology developments made by the firm. These elements are providing quality to the delivered service. Since the value of q_t is determined by a function of past $x_.$, the value is a positive amount. The relation is:

$$q_t = g(x_{t-1}, x_{t-2}, \dots, x_0) + \varepsilon_t \text{ with } \varepsilon_t \approx N(\mu, \sigma) \qquad \text{(Eq. 16)}$$

Where g is the relation between costs and quality. It can be interpreted as the cost portion dedicated to the quality. ε_t is the random error term that follows a Normal distribution:

$$\varepsilon_t \approx N(\mu, \sigma) \qquad \text{(Eq. 17)}$$

2.4.2.1 Cost recovery

The regulatory regime type defined as *Cost-Recovery* is a regulation where the operator revenue function is based on the actual costs supported in the previous period. It means that the revenue is linked to the expenses faced by the company in the previous period.

The expenses considered *in these costs can come from of a wide range of type.*

The general revenue function is as follows:

$$R_t^i = (1 + m)X_{t-1}^i \qquad \text{(Eq. 18)}$$

Where $X_.^i$ stands for the operating costs. These costs are declared by the firm. The m-term represents the mark-up factor that a firm can earn to cover part of the capital investments.

2.4.2.2 Cost-of-service

In this case, the mark-up factor equals 0. The firm revenue is directly determined by the operating cost of the previous period.

$$R_t^i = X_{t-1}^i \quad \text{(Eq. 19)}$$

This is the light-handed approach, one extreme of the cost recovery regimes. The firm agreement of $m = 0$ can be due to a public ownership (Growitsch, Jamasb, Müller, & Wissner, 2010).

2.4.2.3 Rate of return

The other extreme is the heavy-handed approach. In this model, utility has the possibility to obtain a revenue that compensates the operating expenses and receive a fair rate on their initial investments. The revenue function can be expressed as:

$$R_t^i = (\,WACC + d)K^i + X_{t-1}^i \quad \text{(Eq. 20)}$$

In the equation, WACC stands for Weighted Average Cost of Capital and d is the mean depreciation rate of the firm asset base K^i.

Under Rate of Return regime, firms are more likely to fall under the Averch-Johnson effect. The outcome is that when a certain rate level is decided, utilities are engaged in capital accumulation with the desire to enlarge the profit volumes (Tahvanainen, Honkapuro, Partenen, & Viljainen, 2012). This over-investment does not allow the company to reach the efficiency point. Also, the rate design exercise has to occur regularly, and more often in periods of high inflation.

2.4.2.4 Yardstick

The main concept behind this regime is the tentative to reflect closely the marketby using real observations to determine the cost function and the revenue that the organisation could charge.

Relying on observations, implies calculating the revenue ex post. Ex post means that the decision is taken after the observed period, and thus, in reaction of the situation. A rule decided as reaction of a detrimental behaviour is ex post, but the law taken in prevision to prevent them is ex ante (Weyman-Jones, 2001). The distinction between those two concepts impacts considerably the regulation model that the authorities wanted to put in place and the message of their action.

As the revenue for h in period t is determined by the cost of the other firms during the same period, the function is simplified:

$$R^i_t = \frac{1}{(H-1)} \sum_{j \neq i} X^j_{t-1} \qquad j \equiv \mathrm{H}, \forall \mathrm{t} \qquad \text{(Eq. 21)}$$

The attractivity of the Yardstick regulation model comes from the fact that the firm is a single residual participant. The firm revenue is directly linked to the competitor's performance and not on its own cost.

The revenue can also be determined, not as an average of all other firms, but only on the smallest one. The revenue has to be equal to the minimum operating cost expense faced by one of the firms. The revenue determination is then:

$$R^i_t = \min_{j \neq i} X^i_{t-1} \qquad \text{(Eq. 22)}$$

2.4.2.5 Ex ante - Ex post

The Ex Post / Ex Ante decision refers to the liberty that the regulator has to put the regulation rules after or before the period. The signification of this strange declaration means that the regulator has the possibility to choose between observing or predicting the costs and revenues. On the one hand, it can use the real amounts which are gathered after the end of the period and then decide the amount of revenue that the firm can earn. On the other hand, the regulator can decide to, predict the revenues that the firm will make during a period, usually based on past tendencies, and fix the maximum amount.

1. Ex post:

These actual costs are known after they have been generated. It thus suggests that a regulatory action is set afterwards. This also depends on whether the company decides to set a higher revenue than what they really spent in costs.

2. Ex ante:

In a more customer-friendly way, the regulator sets a maximum amount revenue. The firm has the responsibility to manage the costs, so it does not overcome the revenues.

2.5 Firm utility

When a regulation system has to be put in place it is important to understand the firm's motivation; what are the companies looking for? Managers will naturally declare that they want to offer the best service level, with best quality possible to the consumers. However, companies are still trying to reach a profit target or, at least, a revenue level that allows the firm to pursue the activities while enabling to generate some extras, which are useful for further investments or in prevision of possible future issues.

For all these reasons, will the firm try to maximise the utility developed in the following formula:

$$U_t(R_t, x_t) = R_t - X_t - \varphi e_t^2 \qquad \text{(Eq. 23)}$$

As we see, the revenue Rt has to be maximised because it is lowered by the operational costs Xt and the effort φe_t^2.

This function can help us to determine which effort level firms are looking for. But now, the regulation model selected has an impact on the effort.

Here are two examples in case of Cost Recovery or Yardstick model.

2.5.1 Cost-recovery:

If the regulation model is a cost-recovery, then the revenue is:

$$R_t^i = x_{t-1}^i \tag{Eq. 24}$$

$$R_t^i = k_1 y_{t-1}^i - k_2 \ln\left(e_{t-1}^i + 1\right) + k_3 q_{t-1}^i \tag{Eq. 25}$$

If we rewrite the firm utility equation

$$U_t = (k_1 y_{t-1}^i - k_2 \ln\left(e_{t-1}^i + 1\right) + k_3 q_{t-1}^i) - \left(k_1 y_t^i - k_2 \ln\left(e_t^i + 1\right) + k_3 q_t^i\right) - \delta {e^i_t}^2$$

(Eq. 26)

Based on the assumptions made earlier, the difference $k_1(y^i_{t-1} - y^i_t)$ can be considered as null. The difference of quality is less or equal to zero: $k_3(q^i_{t-1} - q^i_t) \leq 0$, because the quality function is increasing in time. The last 2 terms are depending of the effort level: $k_2[-\ln(e^i_{t-1} + 1) + \ln(e^i_t + 1)]$ and - $\delta {e^i_t}^2$. The way to maximise the firm utility is to design an effort level close to zero.

2.5.2 Yardstick

If the regulation model is a yardstick form, then the revenue is:

$$R_t^i = \min_{j \neq i} x_{t-1}^j \tag{Eq. 27}$$

$$R_t^i = k_1 y_{t-1}^j - k_2 \ln\left(e_{t-1}^j + 1\right) + k_3 q_{t-1}^j \tag{Eq. 28}$$

Following the same rational, we get the firm utility equation:

$$U_t = (k_1 y_{t-1}^j - k_2 \ln\left(e_{t-1}^j + 1\right) + k_3 q_{t-1}^j) - \left(k_1 y_t^i - k_2 \ln\left(e_t^i + 1\right) + k_3 q_t^i\right) - \delta {e^i_t}^2$$

(Eq. 29)

We do now have to explore different scenarios depending on the position the firm *i* has regarding all other firms.

- $x^i_t < x^j_t$: firm *i* has the lowest operating costs of all firms.
- $x^i_t = x^j_t$: firm *i* has the same costs level as the optimal one.

  . The situation can be compared to the cost-recovery.
- $x^i_t > x^j_t$: firm *i* has the highest operating costs of all firms.

The following formula is developed:

$$U_t = k_1(y_{t-1}^j - y_t^i) - k_2[\ln(e_{t-1}^j + 1) - \ln(e_1^i + 1)] + k_3(q_{t-1}^j - q_t^i) - \delta e_t^{i^2} \quad \text{(Eq. 30)}$$

$$k_1(y_{t-1}^j - y_t^i) \cong 0 \quad \text{(Eq. 31)}$$

Because of the assumption that similar firms are compared

$$k_2(q_{t-1}^j - q_t^i) \leq 0 \quad \text{(Eq. 32)}$$

There are two elements remaining:

$$-k_2[\ln(e_{t-1}^j + 1) - \ln(e_t^i + 1)] \quad \rightarrow \quad increasing\ function \quad \text{(Eq. 33)}$$

$$-\delta e_t^{i^2} \quad \rightarrow \quad decreasing\ function \quad \text{(Eq. 34)}$$

As the two terms are linked to the effort, there is a specific $e_t^{i^*}$ that maximises the utility function. It will be the selected effort level that equals the marginal revenue to the marginal cost.

2.6 Social Welfare

As the firm's utility was studied, it is now time to look at the consequences for the consumers. Since the choices from both the regulator and the firm have an impact on how the service will be delivered to the consumer, the following equation provides a way to determine the social welfare that the consumer gets.

$$\max W = \sum_t By_t - \sum_t R_t + \sum_t Hq_t \quad \text{(Eq. 35)}$$

The welfare is determined first by the output received. As described in the cost formula, y_t represents the service delivered.

The second term, which decreases the welfare, is the firm's revenue. It lowers the welfare because it is the consumer who pays the bill.

The last element is the quality. It increases the welfare since every improvement of the quality gives a profit to the consumer.

2.6.1 Social Welfare: Ownership Structure

$$W = B - X - (1 - \lambda)\Pi \qquad \text{(Eq. 36)}$$

Table 2 -1

Private	$\lambda \approx 1$ $\bar{X} = \zeta(e)$
State, Municipality, Public utility	$\lambda \cong 1 - \tau$ $X^* = \zeta(e^*)$
Cooperative	$\lambda < 1$

We see in Table 2-1 that λ represents the weight of the firm surplus in the social welfare.

3. Ownership Management

3.1 Introduction

With the growing demand of energy in the developed countries and the electrification of transport and heating, the demand to increase the total production will also grow. But all these new consumers and the expansion of the network is going to require a huge development of the distribution network. Let us imagine that all the consumption engines become electric drives, the necessity to transport electricity to isolated places is going to be a priority.

The authority will have to initiate this expansion and define the specifications and the management style. The objective of this thesis is to study the efficiency of the ownership structure selected to manage the Distribution System Operator (DSO). We will try to estimate the social welfare that can be generated and we will seek to observe when one managerial model may be more profitable than another.

To do so, the analysis will be based on a dataset of about 150 DSOs to build a quantitative model, using DEA benchmarking to determinate the cost efficiency.

3.2 Data description

The analysis will be based on the data of 152 firms acting as electricity distributors in Sweden. The period of data covers the years 2000 to 2006. The data provide information on the size of the network in kilometers of lines, the kilowatt-hours transported, the number of connections representing the number of consumers as well as company-specific financial data. Another important characteristic also specified in the data is the property type: State Owned, Municipality Owned, Public Utility, Private and Cooperative. Since all firms are Swedish, the monetary unit is the Swedish Crown (SEK). We will use most of the time the kilo-unit kSEK = 1000 SEK, which will be more convenient in this exercise. The data was provided by Professor Agrell.

The question of this work is to determine whether the managerial structure has an influence on the efficiency of the company in the use of its resources.

Thus, before analyzing the efficiency itself, it is necessary to study the evolution of these firms during these 7 years in terms of size and consumers.

Firstly, the number of enterprises of each type must be specified. The table below shows the distribution of the 152 firms according to their management structure. Information is also provided regarding the amount of connections (consumers) and the kilometers managed (size of geographical network):

Table 3-1

Management structure	Amount of firms		Amount connections		Amount kilometers	
e	31	20%	134 337	5%	11 449	9%
f	6	4%	53 276	2%	3 493	3%
k	88	58%	1 792 059	65%	80 981	66%
p	26	17%	731 653	27%	23 529	19%
s	1	1%	37 095	1%	2 468	2%
total	152	100%	2 748 420	100%	121 921	100%

it appears that 3 managerial structures seem to be used more than the 2 remaining structures. The cooperative, private and public structures bring together 95% of the total number of firms present. The table above also shows the distribution between the structures in terms of consumers and kilometers of cable installed. If the distribution of consumers is similar to the distribution of the number of kilometers installed, the percentages are not in the same line in terms of number of firms. Cooperatives represent 20% of the total number of firms and private ones only 17%. Whereas the percentages are rather reversed when looking at the number of consumers or the number of kilometers.

At this level, it tends to say that private structures are generally larger than cooperative structures. However, in overall terms, we can conclude that there is no managerial structure that occupies a significantly larger place than other structures.

3.3 Internal type heterogeneity

Analysis of the size of firms within a given type of organization reveals that there is a certain amount of heterogeneity between firms. However, it is always possible to group them together into groups of firms of similar size. To that end, the firms will be segmented according to total amount of connections. The mean variation in terms of connections from one year to another is 1%, the maximum variation is 12% (see appendix 2). Since it has been seen that the variation over the six years is negligible, the segmentation will be based on an average amount of connections over the six-year period. Graphs can be found in the appendix 1.

The results of the DEA analysis will be analyzed in line with the size of the firms according to the amount of connections.

3.4 Cost efficiency

The first part of the analysis determines the efficiency of the firms based on an input- oriented DEA model. There are two inputs as x: Opex and Capital, and two outputs as y: number of connections and network length. This model is selected to imitate the actual model applied by the Swedish regulator: Swedish Energy Market Inspection (EI, 2018).

The operating costs are all the expenses needed for day-to-day activities. For a company who sells physical items, operating costs are the cost directly linked to the production or the purchase of the items, plus all the expenses needed for everyday activities (building rental, water, electricity…) (Murphy, 2019).

The assumption was made that all firms active in the same sector are all facing quite the same challenges. Naturally, some differences can appear depending on the environment, the size and the priorities set by the managers. But in the end, in the current case, firms will have globally similar answers to fulfil the activities.

Inputs:

- OPEX: operating expenses, represent the cost for running a business.
- Capital: value of fixed assets and cash.

Outputs:

- Connections: represent the number of entities connected to the grid. No distinction between consumers type (household, companies…) are made.
- Network Length: represents the total length of the network, expressed in km.

Table 3-1: Descriptive Statistics (2000-2006)

Category	Variable	Mean	Median	SD
Inputs	OPEX (kSEK)	58.656	36.265	115.010
	Capital (kSEK)	170.003	73.801	635.217
Outputs	KM	802	552	1.009
	Conn	18.082	10.008	42.805

The DEA approach determines the best-frontier reference. The benchmarking analysis was performed with an input-oriented DEA model, using a variable return to scale (vrs). As previously developed, the country network is divided in portions that belong to the DSOs. The consumers of the portion are defined and the DSO does not have the choice to serve or not. The firm has only a control on the costs. Therefore, the model will determine if the DSO is using the inputs in an efficient way. Moreover, the return to the selected scale is the variable. It allows the firms to be efficient in different ways. It is likely the case in reality.

Mean CE

Ownership	# DSO	2000	2001	2002	2003	2004	2005	2006	*Average*
e	31	57%	65%	75%	74%	73%	73%	75%	*70%*
f	6	53%	58%	71%	69%	67%	64%	66%	*64%*
k	88	64%	66%	71%	68%	68%	68%	68%	*67%*
p	26	60%	60%	73%	71%	67%	69%	67%	*67%*
s	1	66%	63%	100%	84%	85%	83%	88%	*81%*

Efficient DSO

	2000	2001	2002	2003	2004	2005	2006
e	2	6	9	8	7	6	8
f	0	0	0	0	0	0	0
k	7	7	9	9	8	9	8
p	2	3	6	5	5	4	4
s	0	0	1	0	0	0	0

In terms of efficiency, the DEA analysis shows us that if the types f, k and p have quite the same Cost-efficiency, the types e and s get higher cost-efficiency results. If the comparison concerns the amount of efficient DSO, the percentage of efficient DSO is higher for the type e. The Type s cannot be compared since there is only one firm of this type.

Conclusion: Cooperation, State, Municipality, Private and public utility

Since the dawn of civilization, energy production and rational use has been a primordial question. If at first time, most of the energy was generated by animals (humans included), our vision of the world has changed when the fire has been discovered.

Now, in the modern times, humans have diversified the sources of energy: fossil fuels, solar, hydropower, etc. We use it in different forms: heat, light, etc. However, with the growth and development of modern technologies, the need for one kind of energy has increased sharply: electricity. And it does not seem like it is going to stop anytime soon.

The electricity sector is made of a complex relationship between producers, distributors and consumers. If the production is generally handled by large production companies and the consumers are the entire variety of electricity users, the transportation and distribution part is less known. Indeed, consumers and producers are always in contact. The one strives to get the cheapest price for his electricity, and the other one is competing to reduce his costs. Furthermore, their relation is naturally price regulated. But the distributor, the DSO, between them occupies a particular position. When a consumer connects his installation to the network, he is obliged to make a junction with the DSO that manages the territory section. That makes the DSO unavoidable. We could imagine that if the distributor has a contest with a consumer, he could just cut the connection. Here comes the necessity to put a regulator in place. The Regulator will be empowered by the state to protect the consumer’s interests.

Different approaches exist to regulate the DSO. One of them is the Benchmarking method. This technique will observe practices used by comparable firms and set prices and revenues that correspond to the real cost encountered by the distributors. The benchmarking tool DEA is used by several regulators. It allows to find the cost function by determining the best frontier within a set of comparable firms.

As the use of electricity has become almost indispensable for everyday life, it is quite essential that the access to it has to be generalised throughout the territory. The liberalization of electricity distribution has brought different players into the market. Some private actors, who will try to build a business of this activity. Some public authorities, who will invest in this facility for the benefit of their inhabitants. And sometimes, it is the consumers themselves that build the distribution network.

The subject of this paper was to look if the ownership structure has an impact on the cost-efficiency and on the decision to dedicate a larger part of the profit to the development and improvement of the network.

Based on a dataset of 152 firms acting on the Swedish market with DSOs of each ownership management. We used the benchmarking DEA tool to compare firms. The five types of ownership are: Cooperation, State owned, City owned, Private and Public utilities.

The first part of the question was to determine the difference of cost efficiency between the different ownership structures. Based on a combination of two inputs: Operational expenses and Capital, and two outputs representing the service provided: Amount connections and Total network length, tool drew a best frontier analysis. This comparison of the firms' performances with the best performing firms allowed us to rank the firms and the ownership types.

It appears that the cost efficiency is quite equal between three types of management: Private, State owned and City owned. But the Cooperation firms and the Public utility, have higher cost-efficiency results. The Cooperation firm type has also the highest number of efficient firms.

As a conclusion following the results, it seems that the ownership structure does impact the cost-efficiency on an operational way.

Future perspectives:

An analysis based solely on accounting data does not reflect the internal objectives decided upon by management. These decisions may slow down the investment trend that the company would otherwise have made.

Bibliography

ACER. (2019). *Mission & Objectives*. Retrieved from ACER: https://acer.europa.eu/en/The_agency/Mission_and_Objectives/Pages/default.aspx

Banker, R., Emrouznejad, A., Lopes, A. L., & Almeida, M. R. (2012). Data Envelopment Analysis: Theory and Applications. *Proceedings of the 10th International Conference on DEA*, (pp. 121-136). Brazil.

Bogetoft, P., & Otto, L. (2010). *Benchmarking with DEA, SFA, and R.* New York: Springer Science & Business Media.

Coelli, T., Rao, P., O'Donnell, C., & Battese, G. (2005). *An Introduction to Efficiency and Productivity Analysis.* Springer US.

Cvetkosta, V. (2011). Data envelopment analysis approach and its application in information and communication technologies. *CEUR Workshop Proceedings*, (pp. 421-430).

Dormady, N. C., Jones, D. N., Roe, B. E., & Rub, G. A. (2019, August). An intersection of privatization and public utility regulation: The Ohio State University's energy concession agreement. *Utilities Policy, 59*.

EI. (2018, January 18). *Network price regulation*. Retrieved from EI: https://www.ei.se/en/In-English/electricity/network-price-regulation/

Electricity market players. (2019, July). Retrieved from Elia: http://www.elia.be/en/about-elia/electricity-market-players

Energimarknadsinspektionen. (2010, April). *EI Documents.* Retrieved April 20, 2020, from Energimarknadsinspektionen: https://www.ei.se/Documents/Publikationer/rapporter_och_pm/Rapporter%202010/EI_PM2010_04.pdf

EuroCoop. (2012). *Consumer Co-operatives : Democraty - Development - Employment.* 25: March.

Fontan, S. (2016, Mars 25). *La "Main Invisible" d'Adam Smith*. Retrieved from Leconomiste: http://www.leconomiste.eu/decryptage-economie/218-la-main-invisible-d-adam-smith.html

Forum Nucléaire. (2019, April 8). *Le mix electrique belge en mars 2019*. Retrieved from Lesoir.be: https://www.lesoir.be/217147/article/2019-04-08/le-mix-electrique-belge-en-mars-2019

Glowacki, M. (2019, November 30). *Transmission System Operators (TSOs)*. Retrieved from Emissions - EUETS.com: https://www.emissions-euets.com/internal-electricity-market-glossary/622-transmission-system-operators-tsos

Glowacki, M. (2020, January 25). *Distribution System Operators (DSO)*. Retrieved from Emissions - EUETS.com: https://www.emissions-euets.com/internal-electricity-market-glossary/623-distribution-system-operators-dsos

Growitsch, C., Jamasb, T., Müller, C., & Wissner, M. (2010). Social cost-efficient service quality: integrating customer valuation in incentive regulation: evidence from the case of Norway. *Energy Policy*, 2536-2544.

Gustafsson, B. (2015, April 14). *Publikationer.* Retrieved April 20, 2020, from Energimarknadsinspektionen: https://www.ei.se/Documents/Publikationer/rapporter_och_pm/Rapporter 2017/Ei_R2017_07.pdf

Hase, R., & Shinomiya, N. (2016). A mathematical modeling technique with network flows for social welfare maximization in deregulated electricity markets. *Operations Research Perspectives*, 59-66.

Kenton, W. (2020, April 17). *Capital Expenditure - CapEx Definition*. Retrieved Mai 10, 2020, from Investopedia: https://www.investopedia.com/terms/c/capitalexpenditure.asp

Kuosmanen, T., Saastamoinen, A., & Sipiläinen, T. (2013). What is the best practice for benchmark regulation of electricity distribution? Comparison of DEA, SFA and StoNED methods. *Energy Policy*, 740-750.

Lampe, H., & Hilgers, D. (2015). Trajectories of efficiency measurement: bibliometric analysis of DEA and SFA. *European Journal of Operational Research*, 1-21.

Lowry, M., & Getachew, L. (2009). Statistical benchmarking in utility regulation: Role, standards and methods. *Energy Policy*, 1323-1330.

Murphy, C. (2019, May 19). *Operating Cost Definition*. Retrieved from Investopedia: https://www.investopedia.com/terms/o/operating-cost.asp

Swedish Energy Agency. (2019, February 14). *Energy in Sweden Facts and Figures 2019.* Retrieved from Energimyndigheten.se: https://www.energimyndigheten.se/globalassets/statistik/energilaget/energy-in-sweden-2019.xlsx

Tahvanainen, K., Honkapuro, S., Partenen, J., & Viljainen, S. (2012). Experience of modern rate of return regulation in Finland. *Utilities Policy*, 32-39.

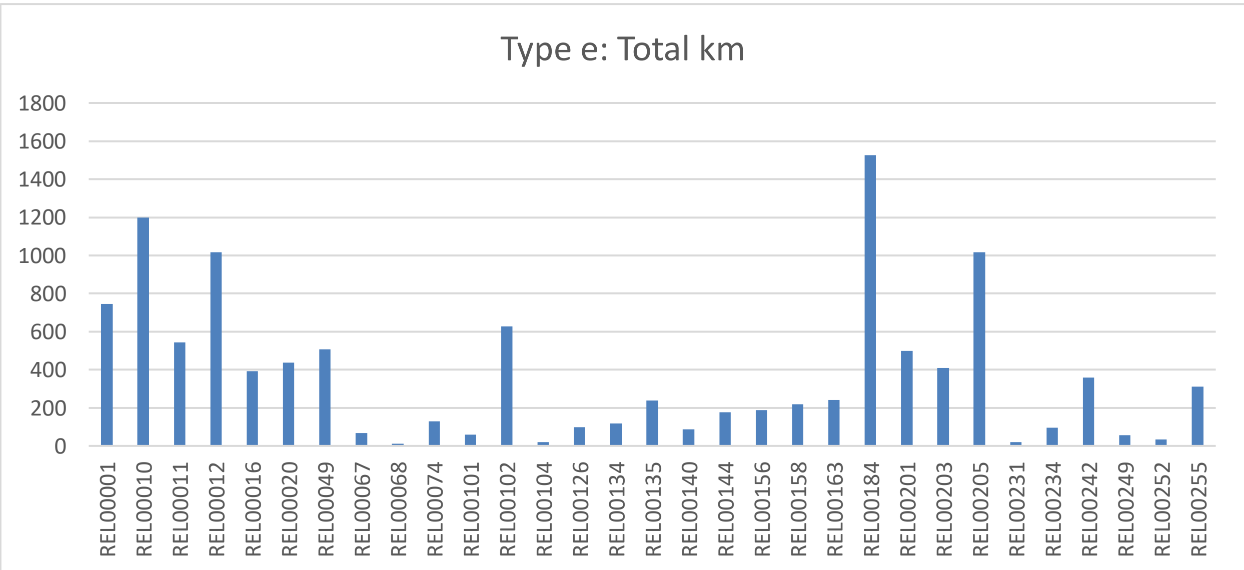
Voorn, B., Van Genugten, M., & Van Thiel, S. (2017). The efficiency and effectiveness of municipally owned corporations: A systematic review. *Local Government Studies*, 820-841.

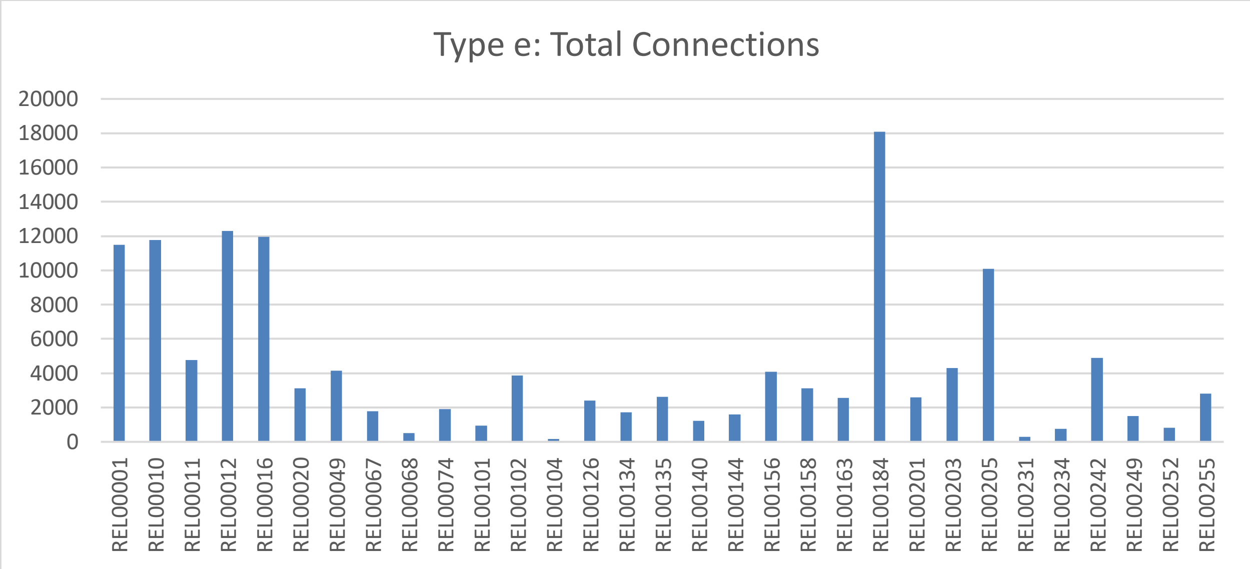
Weyman-Jones, T. (2001). Yardstick and Incentive Issues in UK Electricity Distribution Price Controls. *Fiscal Studies, 22*, 233-247.

Appendix 1 - DATASET – 152 DSOs, Heterogeneity

Ownership	DMU	kilometers	Connection
e	REL00001	746	11490
e	REL00010	1197	11757
e	REL00011	544	4779
e	REL00012	1016	12287
e	REL00016	394	11969
e	REL00020	438	3129
e	REL00049	507	4159
e	REL00067	69	1775
e	REL00068	11	523
e	REL00074	129	1910
e	REL00101	59	954
e	REL00102	628	3870
e	REL00104	21	169
e	REL00126	99	2417
e	REL00134	118	1707
e	REL00135	238	2629
e	REL00140	88	1220
e	REL00144	176	1609
e	REL00156	187	4081
e	REL00158	220	3135
e	REL00163	241	2565
e	REL00184	1527	18090
e	REL00201	498	2599
e	REL00203	408	4296
e	REL00205	1016	10094
e	REL00231	19	290
e	REL00234	96	772
e	REL00242	359	4906
e	REL00249	56	1513
e	REL00252	35	832
e	REL00255	311	2811

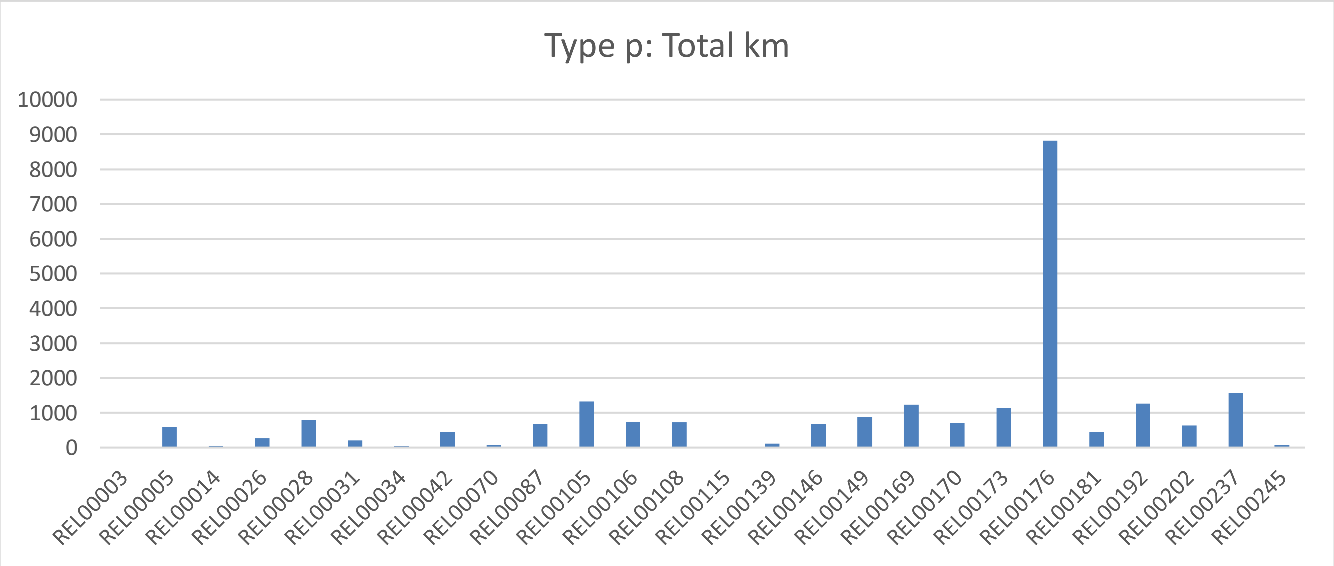
Mean value of amount kilometers of cable installed and amount of connections, period 2000-2006.

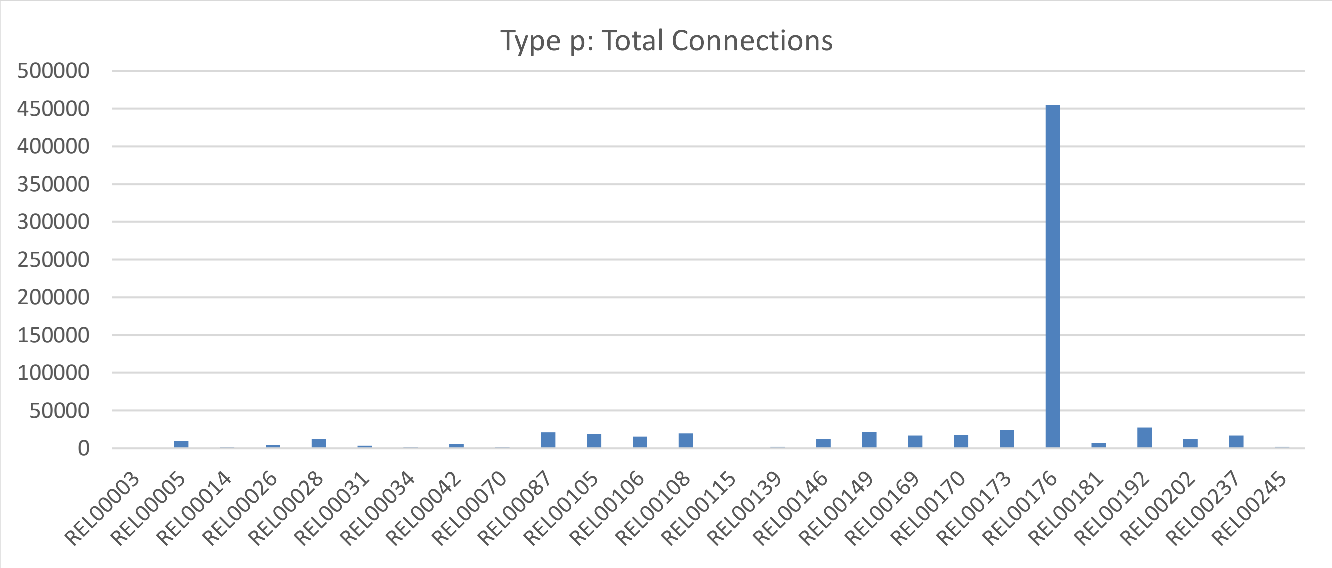



Type e: Total Connections
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
REL00001
REL00010
REL00011
REL00012
REL00016
REL00020
REL00049
REL00067
REL00068
REL00074
REL00101
REL00102
REL00104
REL00126
REL00134
REL00135
REL00140
REL00144
REL00156
REL00158
REL00163
REL00184
REL00201
REL00203
REL00205
REL00231
REL00234
REL00242
REL00249
REL00252
REL00255

Ownership	DMU	kilometers	Connection
p	REL00003	10	305
p	REL00005	589	10176
p	REL00014	54	1610
p	REL00026	269	3967
p	REL00028	791	12221
p	REL00031	201	3806
p	REL00034	43	1163
p	REL00042	454	5582
p	REL00070	67	1274
p	REL00087	682	21379
p	REL00105	1330	18816
p	REL00106	737	15262
p	REL00108	728	20050
p	REL00115	7	154
p	REL00139	113	1843
p	REL00146	684	12330
p	REL00149	873	21638
p	REL00169	1234	16879
p	REL00170	713	17624
p	REL00173	1138	24395
p	REL00176	8819	455114
p	REL00181	449	7291
p	REL00192	1266	27782
p	REL00202	639	12246
p	REL00237	1571	16780
p	REL00245	67	1966
s	REL00044	2468	37095

Mean value of amount kilometers of cable installed and amount of connections, period 2000-2006.

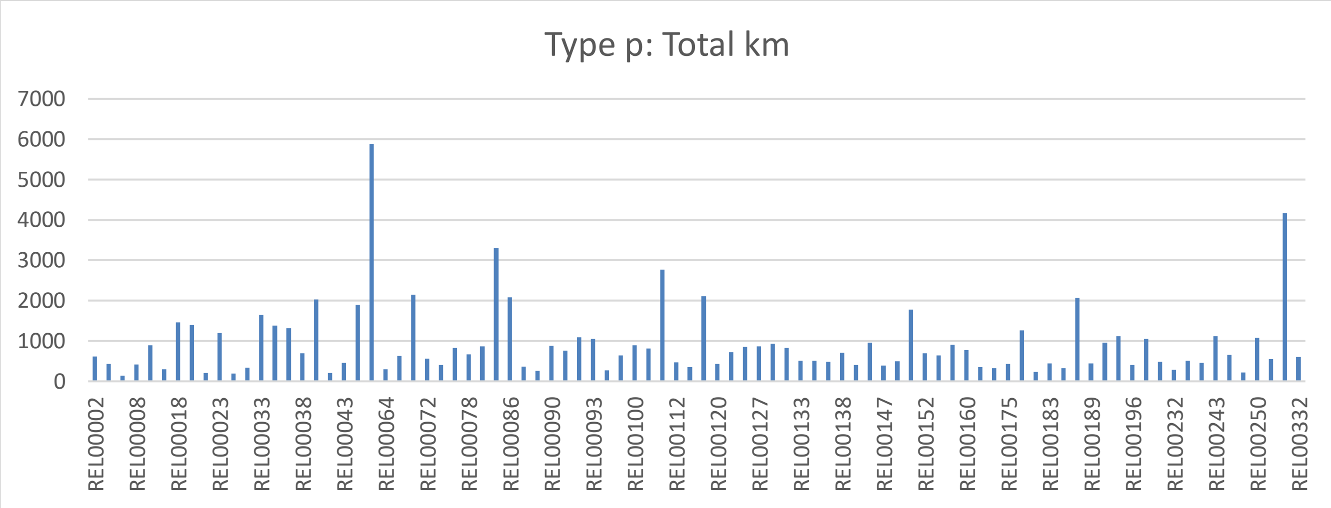


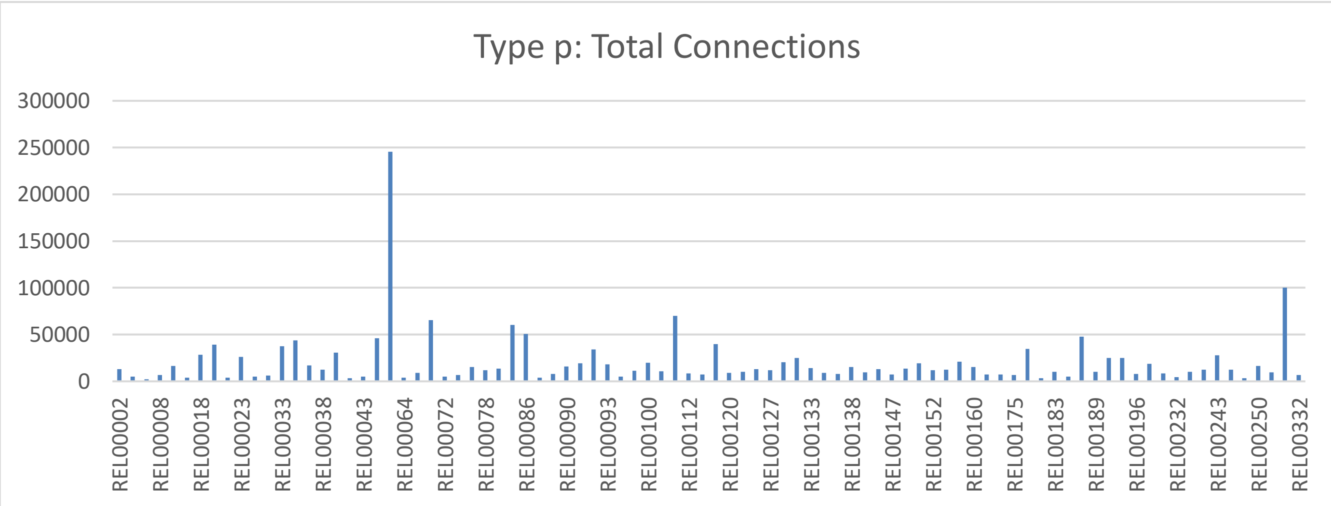

Type p: Total Connections
500000
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
REL00003
REL00005
REL00014
REL00026
REL00028
REL00031
REL00034
REL00042
REL00070
REL00087
REL00105
REL00106
REL00108
REL00115
REL00139
REL00146
REL00149
REL00169
REL00170
REL00173
REL00176
REL00181
REL00192
REL00202
REL00237
REL00245

Ownership	DMU	kilometers	Connection
k	REL00002	616	13171
k	REL00004	427	5237
k	REL00007	140	2203
k	REL00008	416	6618
k	REL00015	892	16679
k	REL00017	293	4126
k	REL00018	1459	28290
k	REL00019	1392	39281
k	REL00021	205	3875
k	REL00023	1198	26333
k	REL00025	193	4771
k	REL00030	342	5951
k	REL00033	1646	37341
k	REL00035	1383	43839
k	REL00037	1319	16870
k	REL00038	695	12598
k	REL00039	2034	30513
k	REL00040	210	3568
k	REL00043	453	4983
k	REL00061	1891	45933
k	REL00062	5882	245414
k	REL00064	300	3978
k	REL00069	629	9227
k	REL00071	2151	65386
k	REL00072	559	5017
k	REL00075	398	6705
k	REL00077	831	15340
k	REL00078	667	11714
k	REL00080	861	13523
k	REL00085	3305	60440
k	REL00086	2087	50888
k	REL00088	359	3871
k	REL00089	259	8038
k	REL00090	876	15890
k	REL00091	767	19103
k	REL00092	1096	33976
k	REL00093	1051	18343
k	REL00094	269	5310
k	REL00098	646	11359
k	REL00100	898	20075
k	REL00110	811	10704
k	REL00111	2766	69865
k	REL00112	476	8415
k	REL00113	356	7101
k	REL00118	2113	39674
k	REL00120	426	8787
k	REL00121	717	9884
k	REL00123	849	13176
k	REL00127	869	12147

k	REL00128	933	20490
k	REL00130	823	25203
k	REL00133	509	14196
k	REL00136	509	9123
k	REL00137	480	8051
k	REL00138	711	15264
k	REL00141	400	9492
k	REL00143	962	13240
k	REL00147	394	7247
k	REL00148	494	13437
k	REL00150	1772	19499
k	REL00152	692	11616
k	REL00157	638	12247
k	REL00159	902	20759
k	REL00160	774	15541
k	REL00164	346	7238
k	REL00165	326	7246
k	REL00175	426	6559
k	REL00178	1257	34406
k	REL00182	231	3324
k	REL00183	445	10279
k	REL00185	319	5115
k	REL00186	2066	47735
k	REL00189	446	10008
k	REL00191	965	24831
k	REL00195	1117	25125
k	REL00196	410	7977
k	REL00204	1045	18842
k	REL00230	480	8398
k	REL00232	288	4623
k	REL00235	507	10276
k	REL00239	454	12228
k	REL00243	1117	28046
k	REL00244	649	12526
k	REL00246	223	3266
k	REL00250	1077	16683
k	REL00257	549	9563
k	REL00267	4171	100126
k	REL00332	597	6704

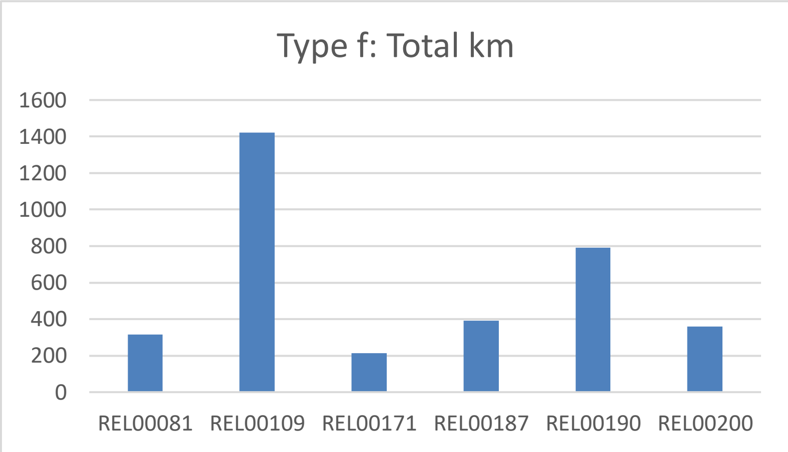
Mean value of amount kilometers of cable installed and amount of connections, period 2000-2006.

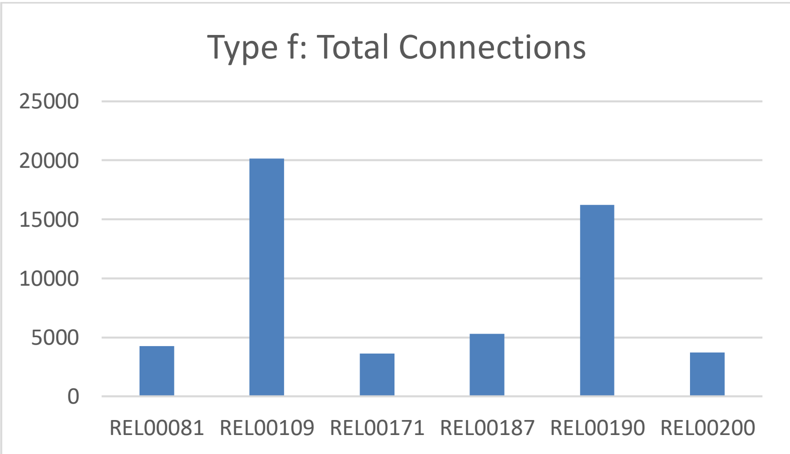

Type p: Total km
7000
6000
5000
4000
3000
2000
1000
0
REL00002
REL00008
REL00018
REL00023
REL00033
REL00038
REL00043
REL00064
REL00072
REL00078
REL00086
REL00090
REL00093
REL00100
REL00112
REL00120
REL00127
REL00133
REL00138
REL00147
REL00152
REL00160
REL00175
REL00183
REL00189
REL00196
REL00232
REL00243
REL00250
REL00332


Type p: Total Connections
300000
250000
200000
150000
100000
50000
0
REL00002
REL00008
REL00018
REL00023
REL00033
REL00038
REL00043
REL00064
REL00072
REL00078
REL00086
REL00090
REL00093
REL00100
REL00112
REL00120
REL00127
REL00133
REL00138
REL00147
REL00152
REL00160
REL00175
REL00183
REL00189
REL00196
REL00232
REL00243
REL00250
REL00332

Ownership	DMU	kilometers	Connection
f	REL00081	316	4263
f	REL00109	1422	20137
f	REL00171	213	3641
f	REL00187	392	5303
f	REL00190	790	16210
f	REL00200	360	3722

Mean value of amount kilometers of cable installed and amount of connections, period 2000-2006.





Ownership	DMU	kilometers	Connection
s	REL00044	2468	37095

Mean value of amount kilometers of cable installed and amount of connections, period 2000-2006.

Appendix 2 - DATASET : Yearly variation of amount connections

			Mean	Max				
			1%	12%				
Wowner all	DMU	2000	2001	2002	2003	2004	2005	2006
e	REL00001	0%	1%	0%	1%	1%	2%	1%
e	REL00010	0%	0%	0%	0%	1%	1%	2%
e	REL00011	0%	1%	0%	0%	0%	0%	1%
e	REL00012	0%	0%	0%	1%	0%	0%	0%
e	REL00016	0%	1%	1%	1%	1%	1%	1%
e	REL00020	0%	0%	0%	0%	0%	0%	2%
e	REL00049	0%	1%	1%	1%	0%	1%	0%
e	REL00067	0%	0%	0%	0%	0%	0%	1%
e	REL00068	0%	0%	0%	1%	0%	0%	1%
e	REL00074	0%	0%	0%	0%	0%	0%	0%
e	REL00101	0%	0%	0%	0%	1%	0%	1%
e	REL00102	0%	0%	0%	1%	0%	0%	0%
e	REL00104	0%	0%	0%	1%	1%	0%	0%
e	REL00126	0%	0%	0%	0%	0%	0%	0%
e	REL00134	0%	1%	2%	0%	2%	0%	0%
e	REL00135	0%	0%	1%	0%	3%	1%	1%
e	REL00140	0%	0%	0%	0%	0%	0%	0%
e	REL00144	0%	0%	1%	1%	1%	1%	1%
e	REL00156	0%	0%	2%	0%	1%	1%	0%
e	REL00158	0%	0%	0%	1%	1%	2%	1%
e	REL00163	0%	0%	0%	0%	0%	0%	0%
e	REL00184	0%	0%	0%	0%	0%	1%	0%
e	REL00201	0%	0%	0%	0%	1%	1%	2%
e	REL00203	0%	0%	2%	2%	0%	0%	0%
e	REL00205	0%	0%	0%	1%	1%	0%	1%
e	REL00231	0%	0%	0%	0%	0%	0%	0%
e	REL00234	0%	0%	0%	0%	0%	0%	1%
e	REL00242	0%	2%	1%	1%	1%	2%	2%
e	REL00249	0%	0%	0%	0%	0%	0%	0%
e	REL00252	0%	0%	0%	1%	0%	0%	0%
e	REL00255	0%	0%	0%	1%	1%	0%	0%
f	REL00081	0%	1%	1%	0%	1%	0%	1%
f	REL00109	0%	1%	4%	1%	1%	1%	0%
f	REL00171	0%	3%	0%	2%	1%	2%	1%
f	REL00187	0%	0%	1%	1%	1%	1%	1%
f	REL00190	0%	10%	0%	0%	1%	0%	1%
f	REL00200	0%	0%	1%	1%	1%	1%	1%
k	REL00002	0%	0%	0%	0%	3%	0%	1%
k	REL00004	0%	0%	12%	10%	1%	0%	0%
k	REL00007	0%	0%	0%	0%	0%	1%	0%
k	REL00008	0%	0%	0%	0%	1%	1%	1%
k	REL00015	0%	2%	3%	0%	0%	1%	0%
k	REL00017	0%	1%	0%	2%	0%	1%	6%
k	REL00018	0%	0%	0%	1%	0%	0%	0%
k	REL00019	0%	0%	1%	0%	1%	0%	1%

k	REL00021	0%	0%	0%	1%	1%	2%	1%
k	REL00023	0%	0%	0%	0%	2%	1%	1%
k	REL00025	0%	6%	0%	1%	0%	1%	1%
k	REL00030	0%	0%	1%	2%	2%	1%	0%
k	REL00033	0%	2%	0%	0%	1%	1%	3%
k	REL00035	0%	2%	1%	1%	0%	0%	1%
k	REL00037	0%	1%	4%	2%	2%	1%	0%
k	REL00038	0%	0%	1%	0%	1%	0%	1%
k	REL00039	0%	0%	0%	2%	2%	1%	1%
k	REL00040	0%	8%	5%	2%	1%	5%	3%
k	REL00043	0%	3%	1%	5%	0%	0%	1%
k	REL00061	0%	0%	1%	1%	2%	1%	1%
k	REL00062	0%	1%	1%	1%	1%	1%	0%
k	REL00064	0%	1%	1%	1%	2%	1%	3%
k	REL00069	0%	2%	0%	0%	0%	1%	0%
k	REL00071	0%	1%	0%	0%	0%	1%	1%
k	REL00072	0%	0%	0%	0%	0%	1%	1%
k	REL00075	0%	1%	1%	1%	0%	0%	0%
k	REL00077	0%	1%	2%	1%	2%	3%	3%
k	REL00078	0%	1%	1%	1%	2%	7%	1%
k	REL00080	0%	0%	1%	1%	0%	1%	2%
k	REL00085	0%	0%	0%	2%	0%	0%	0%
k	REL00086	0%	0%	0%	2%	1%	2%	1%
k	REL00088	0%	0%	2%	2%	2%	0%	0%
k	REL00089	0%	2%	1%	1%	0%	1%	0%
k	REL00090	0%	8%	5%	3%	0%	1%	0%
k	REL00091	0%	1%	2%	0%	0%	1%	0%
k	REL00092	0%	1%	0%	3%	0%	1%	0%
k	REL00093	0%	1%	6%	2%	0%	0%	0%
k	REL00094	0%	1%	11%	1%	1%	0%	0%
k	REL00098	0%	7%	1%	3%	2%	2%	0%
k	REL00100	0%	1%	0%	0%	1%	1%	2%
k	REL00110	0%	3%	1%	0%	0%	0%	2%
k	REL00111	0%	0%	0%	0%	1%	0%	0%
k	REL00112	0%	0%	1%	0%	1%	1%	1%
k	REL00113	0%	0%	0%	0%	0%	0%	0%
k	REL00118	0%	1%	0%	0%	1%	1%	1%
k	REL00120	0%	0%	0%	0%	1%	1%	0%
k	REL00121	0%	0%	0%	0%	0%	0%	1%
k	REL00123	0%	0%	1%	2%	0%	1%	0%
k	REL00127	0%	1%	0%	0%	0%	0%	0%
k	REL00128	0%	1%	1%	1%	1%	0%	1%
k	REL00130	0%	2%	1%	2%	1%	2%	1%
k	REL00133	0%	1%	1%	0%	1%	4%	1%
k	REL00136	0%	1%	0%	0%	0%	0%	1%
k	REL00137	0%	1%	5%	1%	2%	0%	1%
k	REL00138	0%	1%	1%	1%	0%	1%	1%
k	REL00141	0%	1%	1%	2%	2%	1%	0%
k	REL00143	0%	1%	0%	0%	0%	0%	0%
k	REL00147	0%	1%	0%	1%	1%	0%	0%
k	REL00148	0%	0%	1%	1%	1%	1%	0%

k	REL00150	0%	0%	2%	0%	0%	1%	1%
k	REL00152	0%	0%	1%	1%	0%	1%	1%
k	REL00157	0%	0%	1%	1%	1%	0%	1%
k	REL00159	0%	2%	1%	0%	1%	1%	2%
k	REL00160	0%	1%	0%	1%	1%	1%	1%
k	REL00164	0%	1%	0%	0%	0%	0%	1%
k	REL00165	0%	0%	0%	0%	1%	1%	1%
k	REL00175	0%	0%	0%	0%	0%	1%	1%
k	REL00178	0%	0%	2%	1%	3%	5%	4%
k	REL00182	0%	0%	0%	0%	1%	0%	0%
k	REL00183	0%	2%	0%	1%	2%	2%	3%
k	REL00185	0%	0%	0%	0%	0%	1%	3%
k	REL00186	0%	1%	1%	0%	0%	1%	1%
k	REL00189	0%	0%	0%	1%	0%	2%	1%
k	REL00191	0%	0%	0%	0%	1%	0%	0%
k	REL00195	0%	2%	1%	1%	0%	0%	0%
k	REL00196	0%	0%	0%	0%	0%	0%	0%
k	REL00204	0%	1%	1%	0%	0%	2%	2%
k	REL00230	0%	0%	2%	2%	0%	0%	0%
k	REL00232	0%	1%	0%	0%	2%	0%	1%
k	REL00235	0%	0%	0%	0%	1%	4%	3%
k	REL00239	0%	3%	1%	2%	0%	1%	0%
k	REL00243	0%	1%	0%	3%	2%	4%	0%
k	REL00244	0%	1%	1%	1%	1%	0%	1%
k	REL00246	0%	1%	1%	1%	1%	0%	0%
k	REL00250	0%	1%	1%	1%	0%	1%	1%
k	REL00257	0%	3%	5%	1%	0%	0%	3%
k	REL00267	0%	1%	0%	0%	1%	0%	0%
k	REL00332	0%	0%	1%	0%	1%	1%	1%
p	REL00003	0%	0%	0%	0%	0%	0%	0%
p	REL00005	0%	0%	1%	0%	0%	0%	1%
p	REL00014	0%	2%	0%	0%	3%	2%	0%
p	REL00026	0%	0%	0%	0%	0%	0%	0%
p	REL00028	0%	1%	1%	2%	1%	1%	1%
p	REL00031	0%	0%	0%	0%	0%	4%	5%
p	REL00034	0%	0%	0%	1%	0%	1%	0%
p	REL00042	0%	0%	0%	1%	0%	1%	0%
p	REL00070	0%	0%	0%	0%	0%	0%	0%
p	REL00087	0%	0%	1%	1%	0%	0%	0%
p	REL00105	0%	0%	0%	0%	0%	0%	1%
p	REL00106	0%	0%	1%	1%	1%	1%	1%
p	REL00108	0%	1%	1%	1%	1%	0%	0%
p	REL00115	0%	10%	0%	1%	12%	0%	8%
p	REL00139	0%	0%	4%	0%	0%	7%	6%
p	REL00146	0%	2%	0%	0%	0%	0%	0%
p	REL00149	0%	1%	0%	2%	1%	0%	0%
p	REL00169	0%	0%	1%	1%	2%	1%	1%
p	REL00170	0%	0%	2%	0%	0%	0%	1%
p	REL00173	0%	1%	1%	1%	0%	1%	1%
p	REL00176	0%	2%	1%	0%	0%	0%	0%
p	REL00181	0%	0%	0%	1%	0%	0%	0%

p	REL00192	0%	1%	0%	0%	2%	0%	0%
p	REL00202	0%	1%	1%	1%	1%	2%	1%
p	REL00237	0%	0%	1%	1%	0%	0%	0%
p	REL00245	0%	0%	1%	0%	0%	3%	3%
s	REL00044	0%	0%	0%	1%	1%	1%	1%

Appendix 3 - DATASET – 152 DSOs, DEA results

Ownership	DMU	2000	2001	2002	2003	2004	2005	2006
e	REL00001	45%	59%	73%	60%	50%	51%	47%
e	REL00010	70%	100%	100%	100%	100%	100%	100%
e	REL00011	44%	52%	75%	78%	81%	76%	72%
e	REL00012	47%	45%	66%	67%	59%	65%	62%
e	REL00016	67%	68%	62%	65%	61%	59%	59%
e	REL00020	46%	79%	83%	78%	78%	59%	70%
e	REL00049	57%	59%	79%	72%	77%	77%	84%
e	REL00067	27%	27%	55%	55%	54%	55%	52%
e	REL00068	57%	59%	35%	35%	50%	45%	50%
e	REL00074	42%	43%	51%	54%	53%	59%	56%
e	REL00101	22%	24%	47%	50%	49%	68%	100%
e	REL00102	48%	52%	78%	100%	100%	100%	100%
e	REL00104	76%	100%	100%	100%	100%	100%	100%
e	REL00126	53%	56%	72%	74%	71%	74%	71%
e	REL00134	100%	100%	92%	91%	68%	75%	74%
e	REL00135	47%	52%	55%	62%	59%	60%	65%
e	REL00140	43%	43%	58%	57%	59%	59%	63%
e	REL00144	59%	67%	100%	100%	96%	100%	100%
e	REL00156	61%	80%	100%	100%	100%	100%	100%
e	REL00158	55%	56%	74%	70%	72%	71%	70%
e	REL00163	57%	63%	73%	68%	70%	77%	79%
e	REL00184	70%	100%	100%	99%	100%	100%	100%
e	REL00201	100%	100%	100%	100%	84%	75%	72%
e	REL00203	49%	62%	66%	63%	66%	64%	69%
e	REL00205	68%	83%	100%	100%	100%	100%	100%
e	REL00231	94%	100%	100%	100%	100%	71%	78%
e	REL00234	57%	67%	100%	66%	86%	81%	88%
e	REL00242	67%	61%	70%	69%	67%	65%	64%
e	REL00249	79%	70%	72%	72%	74%	65%	62%
e	REL00252	42%	43%	40%	41%	41%	50%	51%
e	REL00255	33%	35%	52%	53%	51%	54%	55%
f	REL00081	44%	66%	84%	83%	76%	65%	62%
f	REL00109	69%	75%	79%	75%	79%	83%	80%
f	REL00171	50%	51%	59%	57%	57%	59%	63%
f	REL00187	46%	54%	70%	73%	76%	71%	81%
f	REL00190	84%	76%	91%	82%	72%	66%	66%
f	REL00200	25%	29%	42%	44%	41%	41%	46%
k	REL00002	67%	69%	100%	100%	100%	100%	100%
k	REL00004	36%	39%	34%	35%	36%	51%	51%
k	REL00007	46%	45%	69%	62%	64%	55%	56%
k	REL00008	76%	64%	64%	46%	50%	51%	46%
k	REL00015	82%	89%	73%	72%	75%	88%	92%
k	REL00017	56%	61%	75%	74%	74%	72%	74%
k	REL00018	87%	81%	92%	90%	96%	100%	100%
k	REL00019	79%	83%	87%	86%	91%	84%	86%
k	REL00021	48%	50%	52%	52%	51%	52%	55%
k	REL00023	62%	87%	93%	93%	94%	90%	84%

k	REL00025	52%	48%	55%	59%	59%	52%	57%
k	REL00030	62%	71%	58%	61%	60%	57%	60%
k	REL00033	66%	67%	71%	68%	61%	55%	60%
k	REL00035	100%	100%	100%	100%	97%	95%	96%
k	REL00037	53%	53%	84%	72%	70%	74%	75%
k	REL00038	56%	66%	75%	67%	70%	70%	67%
k	REL00039	54%	54%	71%	72%	92%	97%	84%
k	REL00040	42%	42%	46%	48%	45%	45%	44%
k	REL00043	55%	53%	56%	46%	47%	51%	52%
k	REL00061	77%	82%	100%	100%	100%	100%	99%
k	REL00062	100%	100%	100%	100%	100%	100%	100%
k	REL00064	42%	42%	52%	52%	56%	55%	53%
k	REL00069	54%	54%	73%	66%	65%	68%	66%
k	REL00071	87%	92%	83%	78%	79%	77%	78%
k	REL00072	54%	74%	81%	82%	78%	76%	85%
k	REL00075	64%	62%	68%	66%	66%	64%	66%
k	REL00077	83%	63%	68%	61%	61%	58%	61%
k	REL00078	43%	52%	47%	44%	45%	46%	50%
k	REL00080	59%	59%	68%	64%	63%	63%	63%
k	REL00085	100%	100%	75%	62%	80%	77%	88%
k	REL00086	64%	67%	66%	66%	68%	67%	69%
k	REL00088	52%	69%	82%	88%	86%	87%	81%
k	REL00089	74%	83%	78%	75%	76%	72%	68%
k	REL00090	51%	48%	55%	51%	49%	49%	52%
k	REL00091	64%	75%	71%	69%	66%	62%	61%
k	REL00092	77%	79%	83%	81%	80%	82%	88%
k	REL00093	61%	62%	78%	67%	66%	65%	65%
k	REL00094	63%	61%	60%	53%	61%	56%	70%
k	REL00098	49%	42%	60%	53%	49%	51%	48%
k	REL00100	75%	64%	54%	52%	49%	51%	51%
k	REL00110	46%	51%	63%	61%	58%	59%	59%
k	REL00111	100%	96%	100%	100%	100%	100%	100%
k	REL00112	56%	71%	76%	71%	73%	72%	68%
k	REL00113	87%	89%	86%	80%	84%	87%	84%
k	REL00118	100%	100%	100%	100%	100%	98%	100%
k	REL00120	54%	55%	57%	58%	58%	50%	50%
k	REL00121	59%	64%	68%	66%	66%	71%	66%
k	REL00123	38%	49%	50%	48%	50%	51%	52%
k	REL00127	73%	100%	95%	93%	91%	88%	89%
k	REL00128	64%	74%	73%	70%	63%	68%	73%
k	REL00130	61%	69%	61%	65%	63%	67%	63%
k	REL00133	57%	59%	66%	66%	62%	64%	59%
k	REL00136	23%	23%	28%	30%	27%	27%	27%
k	REL00137	52%	56%	60%	61%	58%	55%	52%
k	REL00138	62%	62%	65%	65%	62%	54%	59%
k	REL00141	93%	92%	61%	57%	52%	56%	56%
k	REL00143	48%	47%	62%	58%	51%	51%	61%
k	REL00147	94%	100%	100%	100%	100%	100%	100%
k	REL00148	63%	62%	69%	71%	73%	64%	64%
k	REL00150	89%	73%	100%	100%	93%	100%	94%
k	REL00152	54%	57%	53%	54%	54%	53%	54%

k	REL00157	63%	62%	80%	70%	67%	75%	71%
k	REL00159	77%	82%	77%	80%	75%	72%	68%
k	REL00160	54%	59%	60%	59%	57%	59%	59%
k	REL00164	47%	47%	55%	51%	46%	49%	51%
k	REL00165	44%	45%	52%	49%	49%	46%	46%
k	REL00175	56%	64%	73%	69%	68%	66%	64%
k	REL00178	78%	89%	79%	81%	90%	81%	80%
k	REL00182	47%	54%	67%	69%	65%	61%	69%
k	REL00183	66%	73%	68%	73%	70%	69%	65%
k	REL00185	44%	45%	43%	40%	53%	56%	55%
k	REL00186	100%	91%	89%	100%	100%	100%	100%
k	REL00189	63%	62%	64%	64%	63%	62%	60%
k	REL00191	85%	100%	98%	100%	98%	93%	90%
k	REL00195	74%	76%	70%	72%	71%	71%	74%
k	REL00196	44%	38%	54%	47%	45%	46%	46%
k	REL00204	66%	66%	80%	74%	73%	76%	69%
k	REL00230	46%	49%	55%	49%	53%	58%	55%
k	REL00232	52%	55%	60%	60%	52%	50%	44%
k	REL00235	40%	38%	31%	31%	30%	39%	40%
k	REL00239	58%	56%	65%	64%	56%	59%	61%
k	REL00243	65%	63%	66%	66%	59%	65%	58%
k	REL00244	47%	46%	63%	54%	49%	53%	53%
k	REL00246	51%	53%	73%	66%	61%	71%	59%
k	REL00250	62%	68%	85%	66%	53%	61%	68%
k	REL00257	66%	66%	68%	62%	61%	63%	57%
k	REL00267	96%	97%	100%	100%	100%	100%	100%
k	REL00332	100%	50%	81%	66%	65%	67%	66%
p	REL00003	44%	50%	100%	100%	100%	90%	51%
p	REL00005	71%	85%	100%	93%	89%	83%	85%
p	REL00014	88%	72%	55%	49%	55%	59%	60%
p	REL00026	51%	49%	62%	62%	60%	50%	44%
p	REL00028	39%	36%	60%	56%	55%	61%	57%
p	REL00031	32%	33%	50%	40%	38%	34%	35%
p	REL00034	51%	55%	79%	78%	70%	67%	78%
p	REL00042	49%	47%	66%	61%	72%	73%	76%
p	REL00070	45%	43%	57%	58%	55%	55%	57%
p	REL00087	78%	93%	100%	100%	100%	100%	100%
p	REL00105	58%	57%	67%	71%	69%	77%	74%
p	REL00106	69%	69%	71%	67%	62%	53%	58%
p	REL00108	57%	56%	62%	65%	53%	54%	58%
p	REL00115	100%	100%	100%	100%	100%	100%	100%
p	REL00139	49%	51%	85%	89%	57%	63%	54%
p	REL00146	50%	47%	63%	63%	56%	62%	56%
p	REL00149	66%	68%	64%	64%	70%	66%	68%
p	REL00169	50%	49%	67%	62%	56%	62%	63%
p	REL00170	69%	66%	87%	59%	58%	93%	92%
p	REL00173	90%	100%	69%	66%	63%	64%	64%
p	REL00176	100%	100%	100%	100%	100%	100%	100%
p	REL00181	40%	45%	69%	64%	62%	73%	63%
p	REL00192	50%	45%	52%	55%	49%	48%	51%
p	REL00202	52%	51%	56%	50%	51%	58%	55%

p	REL00237	51%	39%	53%	74%	50%	35%	55%
p	REL00245	58%	62%	100%	100%	100%	100%	100%
s	REL00044	66%	63%	100%	84%	85%	83%	88%

REL00069	242,4	10019,6	4120,7	100%	pu
REL00070	13210,5	59691,5	260,1	69%	p
REL00071	723,9	16364,0	22653,2	93%	pu
REL00072	103653,7	274166,1	1417,4	77%	pu
REL00074	9121,7	53864,9	705,6	81%	e
REL00075	4792,6	32980,0	2081,0	71%	pu
REL00077	1416,9	20765,5	3370,0	76%	pu
REL00078	8838,8	38224,5	4286,1	50%	pu
REL00080	26224,5	124295,3	4056,8	85%	pu
REL00081	22448,2	119833,7	1164,8	99%	pu
REL00085	22799,6	107998,3	35449,5	79%	pu
REL00086	6588,5	42578,4	17608,7	79%	pu
REL00087	109228,5	315277,3	2964,2	88%	p
REL00088	83747,4	283453,8	1218,6	100%	pu
REL00089	32718,0	118027,5	1760,4	67%	pu
REL00090	5423,1	35977,2	5259,6	73%	pu
REL00091	10342,2	49983,3	6170,4	64%	pu
REL00092	33768,1	131128,5	9166,8	71%	pu
REL00093	38776,6	127998,7	5977,9	60%	pu
REL00094	46447,6	146936,6	661,6	63%	pu
REL00098	33267,5	143925,0	5729,7	82%	pu
REL00100	7626,1	34061,2	11957,0	47%	pu
REL00101	20295,4	92208,8	1,6	100%	e
REL00102	8843,6	44049,0	1879,4	62%	e
REL00104	37782,0	182774,2	13,6	100%	e
REL00105	1560,8	18940,7	7946,8	55%	p
REL00106	7336,9	46302,6	5214,8	81%	p
REL00108	26843,0	136687,8	21842,5	95%	p
REL00109	123,4	3788,1	6526,4	98%	pu
REL00110	33000,0	124985,0	4300,0	68%	pu
REL00111	22883,6	116163,3	18220,5	87%	pu
REL00112	30291,1	106896,3	1290,0	64%	pu
REL00113	25316,9	115875,4	1783,4	84%	pu
REL00115	21968,7	83960,9	5,8	83%	p
REL00118	91125,4	209011,4	10342,7	51%	pu
REL00120	13599,1	64563,1	4047,4	70%	pu
REL00121	8978,8	36602,7	3590,1	45%	pu
REL00123	111,4	3289,6	5500,0	100%	pu
REL00126	42374,3	119974,5	269,0	54%	e
REL00127	75310,6	248975,0	2029,3	86%	pu
REL00128	14080,5	67682,5	5660,4	72%	pu
REL00130	15820,9	70872,3	8726,9	68%	pu
REL00133	30958,8	138765,3	4278,7	84%	pu
REL00134	2952,2	27646,4	1110,7	81%	e
REL00135	18932,0	67987,0	1200,3	55%	e

REL00136	32595,4	99497,7	7759,6	50%	pu
REL00137	40479,8	163826,0	2186,3	81%	pu
REL00138	27739,0	119759,1	4964,9	76%	pu
REL00139	1844,2	13888,8	426,4	33%	p
REL00140	3645,9	27555,3	386,2	65%	e
REL00141	35914,6	131859,6	4126,2	68%	pu
REL00143	13452,3	75197,2	7041,2	86%	pu
REL00144	23270,3	121606,7	191,3	100%	e
REL00146	2152,2	18547,2	5860,2	38%	p
REL00147	752,9	17252,6	703,4	100%	pu
REL00148	14858,2	57622,2	3896,4	54%	pu
REL00149	28766,9	77537,8	6806,8	42%	p
REL00150	1511,0	18219,9	8254,3	53%	pu
REL00152	21979,4	73436,6	3114,7	51%	pu
REL00156	5732,6	31329,2	366,1	56%	e
REL00157	18890,0	59304,1	3945,4	45%	pu
REL00158	32145,9	116399,5	862,4	68%	e
REL00159	39445,2	124357,4	6130,7	56%	pu
REL00160	23012,5	111331,0	5370,6	81%	pu
REL00163	5286,0	35906,7	891,1	75%	e
REL00164	15522,1	78387,0	4542,0	78%	pu
REL00165	3633,4	25102,8	3092,9	52%	pu
REL00169	26753,7	120943,9	14858,2	79%	p
REL00170	29271,4	114125,2	6189,9	67%	p
REL00171	2850,8	26583,8	910,7	77%	pu
REL00173	14501,4	54103,1	8643,7	51%	p
REL00175	13070,0	62641,0	1743,1	70%	pu
REL00176	6457,2	32381,4	325245,1	51%	p
REL00178	39979,7	106264,6	7859,8	45%	pu
REL00181	22305,7	61373,3	4920,6	40%	p
REL00182	5142,1	20657,8	441,6	32%	pu
REL00183	38466,6	151495,6	2274,5	77%	pu
REL00184	11461,8	56700,5	5191,3	69%	e
REL00185	978642,0	1513106,0	1926,2	100%	pu
REL00186	49663,4	197811,9	8094,8	86%	pu
REL00187	12327,0	56255,2	883,2	64%	pu
REL00189	5971,5	34324,3	3589,7	61%	pu
REL00190	13290,6	55745,6	4491,8	58%	pu
REL00191	29837,2	132242,8	4844,0	81%	pu
REL00192	9365,1	41863,8	35096,6	54%	p
REL00195	74915,2	300852,8	6609,0	100%	pu
REL00196	7684,5	43253,6	4244,8	70%	pu
REL00200	15346,3	77193,9	2017,1	79%	pu
REL00201	21133,0	109620,1	1748,9	93%	e
REL00202	31473,4	126855,4	4702,9	73%	p

REL00203	42004,0	171282,7	1083,0	83%	e
REL00204	612,4	7314,5	6506,8	38%	pu
REL00205	37874,2	131047,7	1083,7	67%	e
REL00230	15007,9	76696,8	2200,8	79%	pu
REL00231	11809,9	59072,1	45,8	92%	e
REL00232	3904,2	28242,9	1518,7	64%	pu
REL00234	22394,1	98621,5	192,9	80%	e
REL00235	8248,4	47638,6	4449,0	75%	pu
REL00237	29107,7	104506,1	14736,5	59%	p
REL00239	18079,4	108385,6	3987,8	100%	pu
REL00242	17572,5	71000,7	1528,1	62%	e
REL00243	193,4	5709,3	12235,3	82%	pu
REL00244	8465,6	43912,3	6334,4	65%	pu
REL00245	459,7	10479,5	105,5	96%	p
REL00246	24564,2	80804,2	1677,8	54%	pu
REL00249	53808,2	168892,4	207,9	64%	e
REL00250	17761,7	73188,0	8234,5	63%	pu
REL00252	7346,0	53806,9	218,6	100%	e
REL00255	49182,6	157651,5	1918,3	63%	e
REL00257	24094,9	91821,4	2994,4	64%	pu
REL00267	2081,2	22008,3	50315,5	63%	pu
REL00332	4758,8	31633,6	3431,8	66%	pu

LOUVAIN-LA-NEUVE | BRUXELLES | MONS | TOURNAI | CHARLEROI | NAMUR
Place des Doyens, 1 bte L2.01.01, 1348 Louvain-la-Neuve, Belgique | **www.uclouvain.be/lsm**