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Data Envelopment Analysis에 기초한 RPI-X regulation 및 독립사업부제 운영

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RPI-X Regulation Based on Data Envelopment Analysis to Prepare Strategic Business Unit

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Abstract - 2006년 9월 1일에 제정된 독립사업부제는 각 단위별로 자율적인 운영권을 가지면서 비용 등에 대해서도 스스로 책임지도록 하는 제도이다. 배전계통의 사업구역 분할로 시작된 배전 사업부제는 독립 재무제표를 통해 경영실적이 드러나기 때문에 경영혁신과 원가절감 경쟁을 유도할 수 있다는 게 특징이다. 이런 체제의 변화는 기업의 규제 시스템에도 새로운 변화가 필요하게 될 것이다. 하지만 서로 다른 규모와 환경을 가진 사업부들을 하나의 기준으로 평가하는 것은 어려운 일이다. 그래서 본 논문에서는 배전 사업부제로 인해 나눠진 사업부들의 경제성과 상대적인 가치를 평가할 수 있는 방법 중의 하나로 세계적으로 널리 쓰이고 있는 Data Envelopment Analysis를 제안한다. 그 결과를 통해서 사업부에 대한 경영 평가나 각 사업부가 더 높은 경제성을 갖출 수 있는 RPI-X regulation을 수행하는데 하나의 모델로서 사용될 수 있을 것이다.
RPI-X regulation에서 X값을 결정하는 것은 비용 경쟁력을 향상시키는 비율을 나타내기 때문에 적절한 X값을 찾는 것이 가장 중요하다고 하겠다. 이 때 여러 개의 입력과 여러 개의 출력을 가지는 문제에 대해서 쉽게 결과를 나타낼 수 있는 Data Envelopment Analysis를 X를 결정하는 방법으로 사용하였다. 그리고 사업부들의 노동력과 선로긍장과 용량 등의 값을 입력으로 하고 고객호수와 판매량을 결과로 하여 RPI-X regulation의 적절한 X값을 찾는 예를 통하여 이 방법이 실제적으로 어떤 효과가 있는지 확인해보았다.
본 논문에서는 분화된 사업부들에 대하여 Data Envelopment Analysis 기법을 이용하여 RPI-X regulation을 수행하였고 결과적으로 본 논문에서 제안한 방법을 통하여 분화된 배전 시스템에도 적용할 수 있는 가능성을 보였다.

1. Introduction

Electricity sector reforms are transforming the structure and operating environment of the electricity industries across many countries. The central aim of these reforms are to introduce market-oriented measures in electricity generation and supply, to improve the efficiency of the natural monopoly activities of distribution and transmission through regulatory reforms.

With the electric power industry reform, regulatory reforms have tended to move away from traditional rate-of-return regulation methods and towards incentive based regulation models. A number of regulators have adopted price and revenue cap regulation based on the RPI-X formula among the incentive based regulation. The central issue in RPI-X formula is how the efficiency requirements or X-factors are to be set (Jamasb and Pollit, 2002). A widely favored approach is through the benchmarking of utilities based on their relative efficiency. Benchmarking identifies the most efficient firms in given industry sector and measures the relative performance of less efficient firms against them. Individual X-factors are then assigned to utilities based on their relative efficiencies. Generally, the more inefficient a utility is, the higher is the X-factor assigned to that firm. The aim is to provide to the firms the incentive to close their efficiency gap with the frontier firms.

Recently Strategic Business Unit (SBU) is proposed in Korea. In this paper we focus RPI-X regulation based on benchmarking technique known as Data Envelopment Analysis (DEA) model. More generally, to set the X factor we apply DEA model and show how this can be applied to encourage competition among the SBU's.

2.1 Regulation of Electricity Distribution

The various regulation regimes have been applied to electricity distribution: nationalization, cost-plus regulation, rate-of-return regulation, yardstick competition and RPI-X price/ revenue caps regulation. The idea behind nationalization is to gain an informational advantage and use this to maximize social welfare, e.g., by introducing marginal cost pricing. Anecdotal evidence of low cost efficiency and resulting high costs has caused the wide-spread abandonment of this option in the favor of privatization. Cost-plus regulation is likewise an early low-powered alternative with incentives for over-investment and inefficiency. Rate-of-return regulation is currently found in many countries, including the United States, as a low powered option that regulates the profitability of the industry. Early studies by Averch and Johnson (1962) point out the incentives for overcapitalization to increase the rate base with this regime. The yardstick competition regime is an interesting addition to the regulatory arsenal. The idea is to set an individual cost target for each distributor that equals the realized cost by other (comparable) agents.

2.1.1RPI-XRegulation

One of the most important element of monopoly regulation (inBritain) is the RPI-X method of price control. RPI-X price control is a type of price-cap regulation. In its basic form, it requires that the price index for a defined'basket'of the firm's regulated products and services should increase by no more than the rate of retail price inflation minus X per cent per annum for a period of years. In short, average price must fall by at least X per cent in real terms, or rise by at most -X per cent if X is negative [see Littlechild Report 1983].

The purpose of RPI-X regulation, like many forms of regulation, is to replicate the discipline that market forces would impose on the regulated firm if they were present, which limits the rate of growth of a firm's profit. It provides stronger incentives for cost reduction and technological innovation than rate-of-return regulation does. Price-cap regulation typically specifies a rate at which the prices (P) that a regulated firm charges for its services must decline (X), on average, after adjusting for inflation (RPI), and with an adjustment for exogenous cost changes(Z), as depicted in Equation (1).

$$P_t = P_{t-1}(1 + RPI_{t-1} - X) + Z \quad (1)$$

This is not the case under rate of-return regulation plan that consistently links authorized prices to realized costs. The rate at which the firm's inflation-adjusted output prices must decline under price-cap regulation is commonly referred to as the X-factor, which is typically the industry-level productivity margin with respect to the total economy.

3. Model of Electricity Distribution

To model the technology in electricity distribution, we have to specify the relevant measures of inputs, outputs and other (exogenous)factors. The basic design features of electricity distribution systems and the technologies used in are similar the world over, however comparative efficiency studies have adopted different input and output variables (Jamasb and Pollit, 2001c).This reflects the lack of consensus on how these utilities should be modeled. For example, a variable used as an input in one study can be used in others as output (See Table 1).

Inputs

In this paper we use as common inputs for electricity distribution models, staff (number of employee), transformer capacity (MVA) and circuit km (see Pollitt 1995).

Table1.

Variable	*Input*	*Output*
Energy delivered	2	12
No of customers	1	11
Network size	11	4
Transformer capacity	11	1
No of transformers		1
Service area	2	6
Maximum demand	1	4
Net losses	4	–
Labor	15	–
OpEx	7	–
Administrative cost	2	
Maintenance cost	1	
Capex	1	
Capital	5	
Customer density	2	

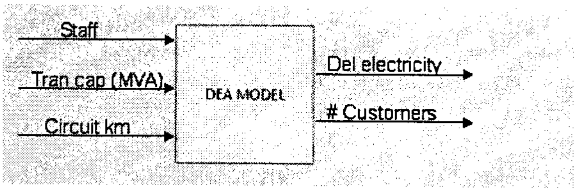
Frequency of variable classification in 20 benchmark studies (Jamasb and Pollitt, 2001) used as inputandoutput.

Outputs

It is quite difficult to define the output of electricity distribution services and to find the relevant measures. We adopt the "Separate marketability of components"property, suggested by Neuberg (1987), as a necessary defining property of a vector of outputs. Within this view, for example, the maximum demand, though often used as an output variable, cannot be priced separately and is therefore not included in our model. Two possible measures can be regarded as separately priced and sold by utilities: number of customers and the total units of electricity delivered (MWh).

And also a review of 20 efficiency studies of electricity distribution utilities showed that the most widely used output variables were units of energy delivered and number of customers(see table 1). Thus, based on the "separate marketability of components" property we adopt models that use total electricity units delivered and total number of customers as output variables.

Figure1. Illustrates preferred DEA Model.



4. Method

There are several approaches to the measuring the relative efficiency of firms with respect to the efficient frontier. These approaches can be placed into one of two broad categories of technique: programming (non-parametric) or statistical (parametric). To measure the relative performance we applythe programming technique known as Data Envelopment Analysis (DEA) model which has been used extensively in the regulation of the distribution price of electricity.

4.1Methodology-DataEnvelopmentAnalysis(DEA)

DEA has been a popular benchmarking method with electricity regulators (see Jamasb and Pollit, 2001). DEA identifies an efficient frontier made up of the best- practice firms which is then used this to measure the relative efficiency scores of the less efficient firms. The advantage of this method is that it does not require specification of a production or cost function. It allows calculation of the allocative and technical efficiencies that can be decomposed into scale, and pure technical efficiencies (Fare et al., 1985).

DEA is a non-parametric method and uses piecewise linear programming to calculate (rather than estimate) the efficient or best-practice frontier of a sample (see Farrell 1957; Seiford and Thrall, 1990). The decision-making units (DMUs) or firms that make up the frontier envelop the less efficient firms. The efficiency of firms is calculated in terms of scores on a scale of 0 to 1, with the frontier firms receiving a score of 1.

DEA models can be input and output-oriented and can be specified as constant returns to scale (CRS) or variable returns to scale (VRS). In other words, input-oriented models minimize input factors required for a given level of output. An input-oriented specification is generally regarded as the appropriate from for comparing electricity distribution utilities, since often demand for distribution services is a derived demand beyond the control of utilities.

The linear program calculating the efficiency score of the i-th firm in a sample of N firms in CRS models takes the form specified in Equation (2) where θ is a scalar (equal to the efficiency score) and λ represents an Nx1 vector of constants. Assuming that the firms use E inputs and M outputs, X and Y represents ExN input and MxN output matrices respectively. The input and output column vectors for i-th firm are represented by x_i and y_i respectively. The equation is solved once for each firm. In VRS model adds the convexity constraint, i.e., $\sum\lambda = 1$. This additional constraint ensures that the firm is compared against other firms with similar size.

$$\begin{aligned} &\min_{\theta,\lambda} \theta, \\ &s.t. \\ &-y_i + Y\lambda \geq 0, \\ &-\theta x_i - X\lambda \geq 0, \qquad (2) \\ &\lambda \geq 0 \end{aligned}$$

In equation (2) firm i is compared to a linear combination of sample firms which produce at least as much of each output as firm i does using the minimum possible amount of inputs.

5.Example

We will illustrate CRS and VRS input-oriented DEA models using firms (substation), which use three inputs (staff, transformer capacity MVA and circuit km) and two outputs (number of customers and delivered power). The data are given as follows: (Table 2)

Table2.

InputandoutputdataforDEA.

Firm	Staff	Circuit km.	Tr. Cap.	Customers	Del. Power
A	109	982	886745	222673	199825528
B	97	937	951660	289064	171663143
C	113	1279	925705	274212	270651288
D	153	1344	1227975	157076	306003599
E	90	773	980285	261505	172968481
F	98	854	839910	223846	241863430
G	111	1040	735790	272479	258301566
H	115	1087	993015	313031	220581405
I	150	1946	1320185	279980	537551544
J	122	1344	1113005	280768	400842012
K	101	790	584200	169119	190328061

To solve this problem we used LP for each firm (see Equation 2), input oriented CRS and VRS models.

Table3

Firms	CRS	VRS
A	0.8241	0.8967
B	1	1
C	0.9669	0.97
D	0. 7914	0.8
E	1	1
F	1	1
G	1	1
H	0.9975	1
I	1	1
J	1	1
K	0.9081	1

DEAefficiencyscoresforCRSandVRS

Summary:

The result presented in this paper shows that it is possible to evaluate the efficiencies of distribution sectors and to allow competition among newly developing SBU's. As shown in Table 3, firms B, E,.., J are considered the most efficient firms under CRS. Inefficient firms, such as B, C, D and K are improve their efficiencies by reducing input levels.

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