Productivity Benchmarking in Incentive Regulation of Public Utilities: Evidence from Czech Gas Utilities and Implications for Post-Communist Countries

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Abstract: - Incentive regulation and regulatory benchmarking are becoming frequently used tools in tariff regulation of public utilities, including natural gas distribution companies. The first part of the article deals with the principles of incentive regulation and total factor productivity measurement. The second part is focused on measurement of the productivity development of the Czech regional gas distribution companies in the period 2001-2011 using Fisher index. The authors do not recommend using TFP-based tariff setting in the Czech Republic, nor in other post-communist countries. In particular, the events which took place in the period under consideration resulted in a distortion of available data which disallow their efficient use in tariff regulation at the present time and in the near future. The authors suggest using the TFP approach rather as an underlying method for further analysis and tariff setting.

Key-Words: - Total factor productivity; benchmarking; gas utilities; post-communist countries.

1 Introduction

Public utilities such as energy and natural gas distribution companies, water and sewerage utilities, or telecommunications are often considered to be affected with public interest and the protection and stability of these industries are of high importance for governments and their environmental, social, and economic policy. Therefore, in most countries in the world, network industries are regulated by government regulatory bodies. The firms operating in price-regulated industries do not face competitive pressures, but regulatory constraints. Their profits depend on the choice of the regulatory method and its parameters. Classical methods of regulation which are based on the coverage of eligible costs and a "reasonable" return on invested capital do not provide sufficient incentives to reduce costs and increase productivity. For that reason, a more modern approach called regulatory benchmarking is getting increasingly popular. Total factor productivity (TFP) benchmarking has recently become an important tool of tariff regulation in some countries. Under this regulatory regime, the maximum price of services is set according to the relative productivity of the firms.

Regulatory agencies do not have a great deal of experience in the field of TFP benchmarking and the benefits of this regulatory regime are not clear-cut. The application of TFP benchmarking in practice requires a rigorous analysis of assumptions and possible consequences, since an improperly set regulatory regime can have even more serious consequences.

The aim of this article is to examine the possibilities of using TFP benchmarking in post-communist European countries. To achieve this goal, the authors determined the productivity development of the Czech regional gas distribution companies and discuss the possibilities of using the available data in tariff setting. Finally, the authors summarized the assumptions and measures which should be taken in order to efficiently apply TFP benchmarking in practice.

2 Theoretical Framework

The fundamental goal of economic regulation is to achieve competitive results in an environment where competition is not feasible. In connection with the goals of regulation, it is important to mention the tendencies to liberalize network industries arising from the European Union legislation. A number of post-communist countries have become members of EU, including the Czech Republic, and have to comply with its legal obligations [8]. The liberalization process has multiple goals, for

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instance, the long-term security of energy markets, the reduction of energy prices and improvement of service quality (for a comprehensive discussion of all the aspects of the liberalization of EU energy markets, see [3]). One of the requirements arising from the EU legislation is to separate regulated and non-regulated activities of vertically integrated companies (*unbundling*). The goal of unbundling was to introduce competition and increase transparency within the regulated sectors. In the Czech Republic, the legal unbundling of energy industries took place in 2005-2006, which led to a considerable reorganization of market structure and relationships among firms. However, despite the ambitious goals of unbundling, the prices of energy did not decrease and the benefits of unbundling are not clear-cut (see e.g. [17]).

2.1 Tariff Regulation

All methods of economic regulation are based on the principle that a company should be allowed to recover its costs and earn a reasonable return on its investments [11]. Allowed revenues, often referred to as *revenue requirements* (RR), can be calculated as

$$RR = O\&M + D + T + (RB \times RoR) \qquad (1)$$

where *O&M* are operating, administrative and maintenance costs, *D* denotes depreciation, *T* denotes taxes, *RB* is the regulatory asset base (the assets used in providing regulated services) and *RoR* is the rate of return.

Cost-of-service regulation is a classical method which is based on summing eligible expenses and calculating a required rate of return. This approach has several disadvantages such as information asymmetries between regulatory bodies and regulated companies, incentive to overinvest (A-J-W effect [2]) or to invest imprudently and last but not least, the tariff level has to be reviewed frequently which makes this method expensive.

The purpose of *incentive regulation* is to reduce the negative impact of information asymmetries and to induce a company to behave efficiently. In general, two basic alternatives of incentive regulation are distinguished: price-cap and revenue-cap. The price-cap method is based on setting maximum tariffs for services provided. A general formula is

$$P(t) = (1 + RPI - X).\ P(t-1) \qquad (2)$$

where $P(t)$ is the tariff in time t, RPI is the inflation rate, X is the efficiency factor and $P(t-1)$ denotes tariff in time $t-1$. The revenue-cap method is based on the same principle, but it sets a cap on total revenues. Since the tariffs or revenues are capped according to the inflation rate (*RPI-factor*) and required efficiency growth (*X-factor),* the incentive regulation is also often referred to as RPI-X regulation.

The idea that revenue requirements should not be based only on the regulated firm’s costs is the main principle of regulatory benchmarking. If properly applied, benchmarking strengthens the incentives for the regulated firms to behave efficiently. The regulated firm’s productivity growth (X-factor) is compared with the productivity growth of other firms within the industry. If a regulated firm achieves to improve its productivity more than other firms, it is rewarded by greater earnings.

2.2 Productivity and it’s Measurement

Productivity is defined as the ratio of input over input. The total factor productivity (TFP) approach takes into account all possible inputs and outputs of the firm. In economic practice, TFP change is measured by productivity indexes. Since in TFP calculations, analysts deal with the ratio of output and input quantities, quantity indexes are employed. Indexes can be based on distance function or on price aggregation (for detailed discussion, see e.g. [6]). Ttwo most frequently used representatives will be discussed; the Malmquist index [5], and indexes based on price aggregation, for instance, the Törnqvist index [16] and Fisher index [7].

Indexes based on distance function (Malmquist index) are theoretically sound but it is necessary to estimate the production technology, which requires the employment of efficient frontier and its parameters. One of the indisputable advantages is the fact that no assumptions on the behaviour of the firms have to be made and the prices of inputs and outputs are included implicitly in the model. Also, these indexes can be decomposed in changes of technical efficiency and technology.

Indexes based on price aggregation (Fisher or Törnqvist index) may be calculated based on two observations only. In the case of a small number of observations, the use of these indexes becomes practical. However, it is necessary to assume the constant returns to scale and optimizing behavior of the firms, which are strong assumptions.

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3 Estimation of TFP Development in the Czech Republic: Natural Gas Distribution Sector

The regional distribution of natural gas in the Czech Republic is operated by six companies: PP Distribuce, E.ON Distribuce, RWE GasNet (formed as a merger of STP Net, SČP Net, ZČP Net in 2009), VČP Net, JMP Net, and SMP Net.

3.1 Methodology

To measure productivity changes, the Fisher index formula [7] has been used. Fisher index is a ratio of geometric averages of Laspeyres and Paasche indexes of output and output. The Laspeyres output quantity index Y_L, resp. input quantity index X_L can be specified as

$$Y_L = \frac{\sum_{n=1}^{N} p_{n,t} y_{n,t+1}}{\sum_{n=1}^{N} p_{n,t} y_{n,t}}, \quad X_L = \frac{\sum_{m=1}^{M} w_{m,t} x_{m,t+1}}{\sum_{m=1}^{M} w_{m,t} x_{m,t}} \tag{3}$$

The Paasche index weights quantities by the prices of the current period. The Paasche output index Y_P, resp. input quantity index X_P may be specified as

$$Y_P = \frac{\sum_{n=1}^{N} p_{n,t+1} y_{n,t+1}}{\sum_{n=1}^{N} p_{n,t+1} y_{n,t}}, \quad X_P = \frac{\sum_{m=1}^{M} w_{m,t+1} x_{m,t+1}}{\sum_{m=1}^{M} w_{m,t+1} x_{m,t}} \tag{4}$$

Since productivity is defined as the ratio of outputs over inputs, the Fisher index of productivity can be calculated as the geometric average of Laspeyres and Paasche output and input quantity indexes:

$$\Pi_F = \frac{Y_F}{X_F} = \frac{\sqrt{Y_L Y_P}}{\sqrt{X_L X_P}} \tag{5}$$

3.2 Data

The data were collected from the accounting statements and annual reports of the companies and reported such as the maximum year-to-year consistency is ensured. The period under consideration was 2001-2011.

Input Definitions

The following inputs have been identified:

- X_1 – OPEX (operating expenses) of distribution (Czech crowns, CZK),
- X_2 – High pressuse network (km),
- X_3 – Low and medium pressure network (km),
- X_4 – Number of regulator stations (-),
- X_5 – Other tangible assets (CZK).

The input "OPEX" reflects the operating expenses of distribution and incorporates personnel, material and services costs and depreciation. The OPEX values are reported at 2001 constant prices (costs have been deflated using the Czech CPI price index).

The inputs "high pressure network" and "low pressure network" represent the length of pipelines in kilometers. "Regulator stations" are devices which regulate ensure the supply a certain quantity of gas at a specific operating pressure (very large pressure, large pressure, medium pressure). The input "Other tangible assets" captures other assets necessary for a successful running of the company (for example, IT, automobiles or furniture).

The determination of input weights is not trivial and it is always associated with a certain degree of subjective judgment. In this research, the weights of inputs were determined as follows. The weight of OPEX was calculated as the ratio of OPEX over revenues (see [10] for a rationale of this approach). The remaining proportion (1 – OPEX)/revenues were attributed to other inputs according to their relative share on total assets of the company. In this case, an expert estimate of technicians of the firms involved on such shares was necessary.

Output Definitions

The following outputs have been identified:

- Y_1 – Throughput – small customers (1,000 MWh),
- Y_2 – Throughput – large customers (1,000 MWh),
- Y_3 – No. of small customers,
- Y_4 – No. of large customers,
- Y_5 – Reserved capacity (1,000 m^3).

The volume of distributed gas in megawatt hours (MWh) is a measure of the network's throughput, i.e. the ability of the operator to distribute the maximum possible volume of gas with given quantities of inputs. The number of customers represents an important input, since the operator doesn't operate the pipelines only, but he has to serve a large number of customers, including customer support and ensuring the system's capacity and reliability. The third output is the capacity of the distribution system proxied by the reserved capacity. The capacity should reflect the operator's ability to provide a sufficient capacity to cover the fluctuations of demand.

The weights of output reflect the cost of provision of such outputs and their relative importance in the generation of revenues. Usually, it is impossible to observe the prices of outputs directly, in which case there are basically two approaches: an expert estimate or econometric estimation. The authors adopted the latter approach and estimated the weights using the Leontief multi-output function. This approach has been used in a number of TFP studies elaborated by the Economic Insights company (see [10]). The Leontief multi-output cost function assumes a fixed ratio of inputs and outputs. It is defined as

$$C(y^t, w^t, t) = \sum_{i=1}^{M} w_i^t \left[\sum_{j=1}^{N} (a_{ij})^2 y_j^t (1 + b_i t) \right] \quad (6)$$

where M denotes the number of inputs, N is the number of outputs, w_i is the price of i-th input, a_{ij} is the input-output coefficient (the power of two is used to ensure the non-negativity), y_j is the quantity of j-th output, t is the number of period and b captures the change of technology. Using the Shephard's lemma (see e.g. [6]) it is possible to derive the input demand equations as

$$x_i = \sum_{j=1}^{N} (a_{ij})^2 y_j^t (1 + b_i t) \quad (7)$$

Since this expression allows to express the relationship between inputs and outputs, it is possible to estimate the coefficients a_{ij} and b_i using non-linear regression which was carried out using the MATLAB Statistics Toolbox. Then, the weights of j-th output in time t can be estimated as

$$h_j^t = \frac{\sum_{i=1}^{M} w_i^t \left[(a_{ij})^2 y_j^t (1 + b_i t) \right]}{\sum_{i=1}^{M} w_i^t \left[\sum_{j=1}^{N} (a_{ij})^2 y_j^t (1 + b_i t) \right]} \quad (8)$$

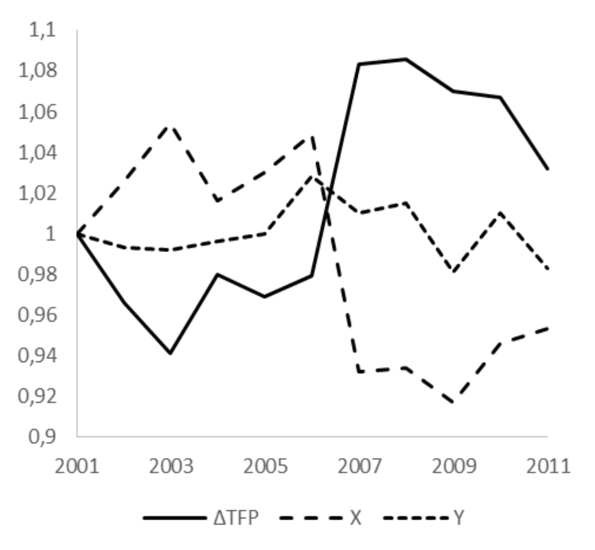
To ensure a greater robustness, an aggregate weight of the given output as a weighted average for all observations for the given firm has been calculated (following [10]), where the weight of the k-th observation was determined as

$$s_k^t = \frac{C(k, y_k^t, w_k^t, t)}{\sum_{k,t} C(k, y_k^t, w_k^t, t)} \quad (9)$$

4 Results and Discussion

The TFP development in the Czech natural gas distribution sector is summarized in the following figure. To estimate productivity changes, the fixed-based Fisher productivity index have been employed. The year 2001 is chosen as the basic year, ΔTFP denotes the productivity growth, X is the input quantity index and Y is the output quantity index. A value of ΔTFP greater than 1 means that the TFP is above the level of 2001 and vice versa. Similarly, it is possible to construe the aggregate input index X and the aggregate output index Y; the influence of X on total factor productivity is negative, while the impact of Y on the aggregate productivity is positive.

Fig. 1 TFP development of the Czech natural gas distribution sector



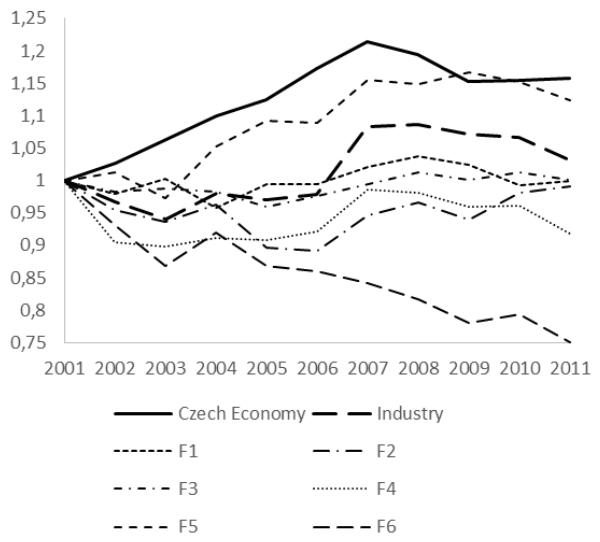
The aggregate output index is decreasing until 2003. This due to an aggregate growth of inputs, since the volume of outputs does not change significantly. The growth of inputs is caused by a large growth of „Other tangible assets“ and grid length, especially the low and medium pressure network. In 2004, the operating expenses and „Other assets“ decrease which has a positive effect on the overall TFP development. In 2005, it's possible to observe a considerable growth of reserved capacity which is possibly due to the speculation facilitated by low sanctions for exceeding the reserved limit. The number of customers connected to the network is considerably increasing, so despite a drop in the volume of distributed natural gas, the aggregate output increases thus having a positive effect on TFP growth.

The most interesting point is the period 2006/2007. In this year, the unbundling of distribution took place. This resulted in a substantial change in TFP, since the volume of "Other tangible assets" decreased significantly and the growth of operating expenses associated with the increasing use of affiliated companies did not compensate this sharp drop. So, even if the aggregate output decreased, the TFP increased considerably.

In the following years, the productivity keeps decreasing and a tendency of the aggregate output to decrease can be observed. This was caused, among others, by the economic crisis [4], which began around 2008 and which resulted in a considerable drop of volume of distributed gas and reserved capacity.

It is also possible to illustrate the development of the six gas distribution companies' total factor productivity. However, for data privacy reasons, the identities of the companies are not revealed and there are denoted by F_1, F_2, F_3, F_4. F_5, and F_6. The TFP development of the Czech economy is based on the data provided by the Czech statistical agency; the "Natural gas distribution industry" represents the aggregated development of all the companies described above.

Fig. 2 Total Factor Productivity Development in the Czech Natural Gas Distribution Sector



The TFP growth of the natural gas distribution industry is under the growth of the economy; however, the possibilities of the regulated companies to reverse the course of events are debatable. It is also possible to identify two "outliers" – the companies F_5 and F_6. The company F_5 is performing well due to a successful cost management, while the company F_6 is being "penalized" for its intensive investment and extension of the grid length. This is one of the issues of the benchmarking-based tariff regulation: companies are motivated to savings which may result in the postponement of investments.

Conclusion

The authors would not recommend using TFP-based tariff setting in the Czech Republic, nor in other post-communist countries. The main reason is the absence of long-term and reliable data. The evolution in the Czech Republic has been affected by fundamental events which resulted in a distortion of available data which disallow their efficient use in tariff regulation. The available data cause a bias in productivity change which could not be affected by the regulated firms themselves. The development is however not likely to be steady in the near future. It the regulatory agency insisted on using benchmarking methods, it is possible to recommend the methods which don't require large amount of cross-sectional data and the authors would suggest using foreign data. However, it is necessary to take into consideration all the issues associated with the use of international data described in this article.

The international experience with the use of TFP-based tariff regulation in practice is limited. It is possible to suggest starting to collect the data for a possible use of TFP in the future if the costs of collecting and maintaining such data weren't too high. If the use of TFP method abroad proves good and if there is a sufficient data base, it is possible to initiate a negotiated settlement process with all parties involved, ideally in cooperation with reputable consultancy firms or academic sites. Within the settlement process, as well as in the eventual regulatory regime, the regulated firms should be allowed to propose suggestions and remarks. The regulator itself should be bound by unambiguous rules.

To sum up, it is possible to recommend the TFP approach rather as an underlying method for further analysis, not as a pure regulatory method. An example of such a successful use is the buildingblock approach used in the United Kingdom. An interesting alternative is to use TFP in threshold setting, i.e. setting the moment when regulation and negotiation takes place.

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References:

[1] AEMC, *Total factor productivity for distribution network regulation*, Australian Energy Market Commission, 2011.
[2] Averch, H., Johnson, L. L., Behavior of the firm under regulatory constraint, *American Economic Review*, Vol.52, No.5, 1962, pp. 1052–1069.
[3] Baláž, P., Margan, F., Ružeková, V., Zábojník, S., *Energetická bezpečnosť v období globalizácie a jej vplyv na konkurenceschopnosť EÚ*, Ekonóm, 2011.
[4] Baláž, P., Ekonomická kríza a jej vplyv na energetickú bezpečnosť EU, *Studia commercialia Bratislavensia*, 2011, Vol.4, No.15, 2011, pp. 335-344.
[5] Caves, D. W., Christensen, L. R., Diewert, W. E., Multilateral comparisons of output, input, and productivity using superlative index numbers, *Economic Journal*, Vol.92, No.365, (1982). pp. 73–86.
[6] Coelli, T.J., Prasada Rao, D.S., O'Donnell, C.J., Battese, G.E., *An introduction to efficiency and productivity analysis*, Springer, 2005.
[7] Fisher, I., *The making of index numbers*, Houghton-Mifflin, 1922.
[8] Helisek, M., How Far Along is Euro Adoption in the Czech Republic? Benefits for Businesses Still Remain, *Central European Business Review*, Vol.2, No.1, 2013, pp. 21-27.
[9] Lawrence, D., *Regulation of electricity lines businesses, analysis of lines business performance 1996–2003*. Report prepared for Commerce Commission, Wellington, New Zealand, Meyrick and Associates, 2003.
[10] Lawrence, D., Diewert, E. *Regulating electricity networks: The ABC of setting X in New Zealand*. In T. J. Coelli, D. Lawrence (Ed.), Performance measurement and regulation of network utilities (pp. 207–241), Edward Elgar, 2006.
[11] Lesser, A., Giacchino, L., *Fundamentals of energy regulation*, Public Utilities Reports, 2007.
[12] Machek, O., Data issues in total factor productivity benchmarking: A Central European perspective, *The Annals of the University of Oradea. Economic Sciences*, Vol.21, No.2, 2012, pp. 224–230.
[13] Machek, O., Hnilica, J., Total Factor Productivity Approach in Competitive and Regulated World, *Procedia – Social and Behavioral Sciences*, Vol.57, 2012, pp. 223-230
[14] Machek, O., Hnilica, J., *International experience with productivity benchmarking in the regulation of public utilities*, In: Financial Management of Firms and Financial Institutions: 9th International Scientific Conference Proceedings, Ostrava, 9-10th September 2013.
[15] Makholm, J. D., *Elusive efficiency and the X-factor in incentive regulation: The Törnqvist v. DEA/Malmquist dispute*, Nera Publications, 2007.
[16] Törnqvist, L., The Bank of Finland's Consumption Price Index, *Bank of Finland Monthly Bulletin*, Vo.10, 1936, pp. 1–8.
[17] Vondráček, M., Skuček, T., Unbundling costs in the energy sector: competitive environment for the customers´ benefits or too costly experiment? (in Czech language), *Ekonomika a management*, Vol.4, No.3, 2010.