The Role of Productivity Benchmarking in Tariff Regulation of Public Utilities: Evidence from Czech Gas Distribution Industry and Implications for Post-Communist European Countries

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***Abstract*—**Regulatory benchmarking is becoming a frequently used tool in tariff regulation of public utilities, including natural gas distribution companies. One of the possible approaches is based on total factor productivity (TFP) benchmarking. However, regulatory agencies do not have a great deal of experience in this field and the benefits of this regulatory regime are not clear-cut. The article starts with the discussion of principles of incentive regulation and total factor productivity measurement. Then, the international experience with TFP benchmarking and possible weaknesses of the TFP approach have been discussed. Further, the authors determined the productivity development of the Czech regional gas distribution companies in the period 2001-2011 using Fisher index and partial factor productivity analysis. Finally, the authors summarized the assumptions and measures which should be taken in order to apply TFP benchmarking in practice. The authors do not recommend using TFP-based tariff setting in the Czech Republic, nor in other post-communist countries. In particular, it has been shown that 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.

***Keywords*—** benchmarking, gas utilities, post-communist countries, total factor productivity

I. Introduction

Public utilities such as energy and natural gas distribution companies 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. Companies operating in price-regulated industries do not face competitive pressures; instead, they face regulatory constraints. Their profits depend on the choice of regulatory method and its parameters.

Classical methods of regulation 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. This approach is based on comparing performance of regulated firms with other firms. Firms which manage to improve their performance more than the firms in the benchmark are rewarded through a higher level of earnings, while less efficient firms are penalized by a reduced level of earnings.

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 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 a bad setting of regulatory method can result not only in higher costs of regulation (deadweight loss), but with regard to the strategic importance of regulated industries, 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. In particular, the authors will focus on the Czech Republic. In line with this aim, it is necessary to consider the international experience with TFP benchmarking and possible weaknesses of the TFP approach and sources of errors and misinterpretation of results. Further, the authors will

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determine the productivity development of the Czech regional gas distribution companies and discuss the possibilities of using the available data in tariff setting. Finally, the assumptions and measures which should be taken in order to efficiently apply TFP benchmarking in practice will be summarized.

II. Literature Review

Network industries have certain inherent properties due to which they are often classified as natural monopolies affected with public interest (see e.g. [1]). The protection and stability of such industries are of strategic importance for the government and its environmental, social and economic policy. The regulation concerns not only the tariffs of services, but also the scope and quality of services provided.

The fundamental goal of economic regulation is to achieve competitive results in an environment where competition is not feasible. Besides economic goals, regulation of network utilities may have other goals, such as to advance the availability of services to all consumers, including those in low income or in rural areas (universal service), or to develop national infrastructure and promote national security. In connection with the goals of regulation, it is important to mention the tendencies to liberalize network industries arising from the European Union legislation. The liberalization process has multiple goals, for instance, 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 [2]). One of the requirements arising from the EU legislation is to separate regulated and non-regulated activities of vertically integrated companies. This process is called 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.

A. Basic Principles of 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 (see e.g. [4]). Allowed revenues, often referred to as revenue requirements (RR), can be calculated as

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

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 (usually approximated using weighted average cost of capital, WACC).

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 – information asymmetries between regulatory bodies and regulated companies, incentive to overinvest (A-J-W effect [5]) or to invest imprudently (*gold plating*); the tariff level has to be reviewed frequently which makes this method somehow expensive. However, in a number of states, especially in North America, these methods are constructed on institutional foundations that are deep and longstanding.

The purpose of incentive regulation (performance-based regulation) is to reduce the negative impact of information asymmetries and to induce a company to behave efficiently, i. e. reduce its costs in order to increase earnings. In general, two basic alternatives of incentive regulation may be distinguished: price-cap and revenue-cap.

The price-cap method is based on setting maximum tariffs for services provided. A general formula is

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

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 level in the previous period.

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. In general, benchmarking means comparing performance of a firm against a relative performance measurement. If properly applied, benchmarking strengthens the incentives for the regulated firms to behave efficiently. The regulated firm's productivity growth is compared with the productivity growth of other firms within the industry. If a regulated firm achievers to improve its productivity more than other firms, it is rewarded though greater allowed revenues. In order to apply incentive regulation, it is necessary to determine the X-factor of efficiency; among others, it can be calculated as the required total factor productivity change. It can be shown [6] that

$$\Delta p = \Delta p_N - (\Delta TFP - \Delta TFP_N + \Delta w_N - \Delta w) = \Delta p_N - X \quad (3)$$

where Δp_N is the price growth of economy outputs, Δw_N is the price growth of economy inputs, ΔTFP_N is the change of productivity of the whole economy and X is the required productivity growth (X-factor).

B. Productivity and it's Measurement

Productivity is traditionally defined as the ratio of input over input. Total factor productivity takes into consideration all the company's inputs and output. In the case of only one output and one input, the situation is straightforward. In a more realistic situation when a firm produces multiple products and uses multiple inputs, it is necessary to aggregate the set of outputs and inputs so that the expression in numerator and denominator are scalar values.

The total factor productivity (TFP) approach takes into account all possible inputs and outputs of the firm. In economic theory, total factor productivity is measured indirectly. It is the output growth not explicable by changes in the amount of inputs (often referred to as Solow residual). In economic practice, TFP change is measured by productivity indexes. Indexes are a common tool to measure quantity changes between two periods. They may be based on distance function or on price aggregation (for detailed discussion, see e.g. [7]). Two most frequently used representatives will be discussed: the Malmquist index [8], and indexes based on price aggregation, for instance, the Törnqvist index [9] and Fisher index [10].

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 (for example, OLS, COLS, MOLS, SFA or DEA). 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 [11]. However, if the Malmquist index is to be approximated, it is necessary to assume the constant returns to scale and optimising behaviours of the firms, which are strong assumptions.

Table 1 Properties of Malmquist and Törnqvist indexes

Malmquist	**Törnqvist**
- it is necessary to estimate the efficient frontier	- it is not necessary to estimate the efficient frontier
- necessity of a large sample of cross-sectional data	- can be based on two observations
- no assumptions of the firms' behaviour	- assumption of an optimizing behaviour of firms
- no assumption on returns to scale	- assumption on constant returns to scale
- no necessity of knowing prices of inputs and outputs	- it is necessary to know prices of inputs and outputs
- it is possible to decompose the index into efficiency and technology changes	- no possibility of decomposing into efficiency and technology changes

Source: Authors

C. International Experience with Total Factor Productivity Benchmarking

Methods of TFP benchmarking have been successfully used in New Zealand (the TFP method is well described in [12]), USA and Canada [13], United Kingdom ([14], [15]) and Netherlands [16]. They had only a limited use in Australia [17]. It is not in the scope of this article to describe the use of TFP in individual countries in detail; see [18] for a detailed description of the current use of TFP at the international level. However, it is possible to summarize the experiences and propose some suggestions arising there from.

In general, a productivity analysis has been used in tariff setting in particular in Anglo-Saxon countries headed by the UK, USA (California, Maine and Massachusetts), Canada (Ontario) and New Zealand. By 2011, Australia decided not to apply the TFP methodology because of the absence of relevant market conditions necessary for an efficient implementation of the TFP approach [17]. In New Zealand, TFP is being used in practice; the legislation allows to regulate tariffs and revenues of distribution and transmission companies, but only if they do not satisfy certain requirements on quality of service and level of revenues (*threshold*); the regulation takes place if the quality becomes too low or the revenues become too high.

Energy regulatory agencies in Europe prefer using frontier-based methods in X-factor setting, except of Netherlands, where the TFP approach is applied thoroughly. However, the Dutch regulatory framework has been subject to many legal disputes which led to subsequent corrections of individual X-factors. It seems that for a successful adopting of the TFP approach, a broader social consensus in needed. In those countries where TFP method has been adopted, it has been used mostly as an underlying method to price decisions [19]. Further, it seems that the design of TFP-based regulatory framework is an area where regulatory agencies rely on external consulting companies.

Naturally, the choice of the parameters of TFP method may be subject to disputes (for example, the choice of outputs and inputs), especially when the variables are difficult to measure (e.g. quality of service). Data issues are probably a general obstacle for a successful implementation of TFP-based regulatory framework [20].

III. 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. The Czech energy regulatory agency (Energetický regulační úřad, ERÚ) is currently employing a revenue-cap incentive regulation.

A. Methodology

To measure productivity changes, the authors used the Fisher index formula [10]. The Fisher index is a ratio of geometric averages of Laspeyres and Paasche indexes of output and output. The Laspeyres output, resp. input quantity index can be specified as

$$Y_L = \frac{\sum_{n=1}^{N} p_{n,t} y_{n,t+1}}{\sum_{n=1}^{N} p_{n,t} y_{n,t}} \qquad X_L = \frac{\sum_{m=1}^{M} w_{m,t} x_{m,t+1}}{\sum_{m=1}^{M} w_{m,t} x_{m,t}} \tag{4}$$

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

$$Y_P = \frac{\sum_{n=1}^{N} p_{n,t+1} y_{n,t+1}}{\sum_{n=1}^{N} p_{n,t+1} y_{n,t}} \qquad X_P = \frac{\sum_{m=1}^{M} w_{m,t+1} x_{m,t+1}}{\sum_{m=1}^{M} w_{m,t+1} x_{m,t}} \tag{5}$$

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:

$$\Pi_F = \frac{Y_F}{X_F} = \frac{\sqrt{Y_L Y_P}}{\sqrt{X_L X_P}} \tag{6}$$

Productivity analysis should be accompanied by a deeper analysis of each factor's contribution to the total TFP development, including factors of uncertainty (see e.g. [21], [22]). The next step is to analyse the partial factor productivities. Partial factor productivity is the ratio of one or more outputs over a particular input. It is the quantitative expression of how the amount of output varies with an additional unit of input, which allows us to measure the efficiency of the given input usage. Formally, partial factor productivity can be specified as

$$PFP_i = \frac{Y}{X_i} \tag{7}$$

where Y is the output quantity index and X_i is the quantity index of the particular input. Partial factor productivity analysis is suitable for a deeper analysis of TFP growth sources. However, it is necessary take into consideration a possible substitution among inputs.

B. 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. In the context of input and output definitions, some ambiguities may arise; for example, whether the length of pipelines represents one of the inputs (assets which is used to generate outputs) or whether it is one of the outputs (a measure of the system's capacity). In this research, the authors follow the approach of Lawrence [12].

1) Input Definitions

The following inputs have been identified:

- X_1 – OPEX (operating expenses) of distribution (Czech crowns, CZK [3])
- 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. The input "OPEX" has been corrected so that it doesn't include retail costs associated with the sales of natural gas before 2006.

The inputs "high pressure network" and "low pressure network" represent the length of pipelines in kilometres. "Regulator stations" are devices which regulate ensure the supply a certain quantity of a gas at a specific operating pressure (very large pressure, large pressure, medium pressure). The input "Other tangible assets" captures other assets which are necessary for a successful running of the company. It includes, for instance, IT devices, automobiles or furniture. In connection with the salvage value of assets, it should be noted that in 2006, the accounting economic life has been virtually extended so it was necessary to report them based on their value before 2006 in order to maintain the consistency of data.

2) Input Weights

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 [12] 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.

3) Output Definitions

The following outputs have been identified:

- Y_1 – Throughput – small customer class (thousands of MWh),
- Y_2 – Throughput – large customer class (thousands of MWh),
- Y_3 – Number of customers - small customer class (thousands),
- Y_4 – Number of customers - large customer class (thousands),
- Y_5 – Reserved capacity (thousands of 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. This volume can also be measured in m^3 of natural gas distributed, while there is a conversion formula between the two.

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. This kind of output reflects the fact that some of the real outputs are associated with the very existence of customers, not with the distribution grid itself.

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. An ideal measure would be the real capacity; however, since we are unable to measure it directly, we used the reserved capacity in m^3 (converted from MWh).

4) Output Weights

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. We 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 [19]. The Leontief multi-output cost function assumes a fixed ratio of inputs and outputs. It is defined as

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

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. [7]) we can derive the input demand equations as

$$x_i = \sum_{j=1}^{N} (a_{ij})^2 y_j^t (1 + b_i t) \quad (9)$$

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. We used the MATLAB Statistics Toolbox. Then, we can estimate the weights of j-th output in time t as

$$h_j^t = \frac{\sum_{i=1}^{M} w_i^t \left[(a_{ij})^2 y_j^t (1 + b_i t) \right]}{\sum_{i=1}^{M} w_i^t \left[\sum_{j=1}^{N} (a_{ij})^2 y_j^t (1 + b_i t) \right]} \quad (10)$$

To ensure a greater robustness, we calculate an aggregate weight of the given output as a weighted average for all observations for the given firm (following Lawrence, 2003), where the weight of the k-th observation was determined as

$$s_k^t = \frac{C(k, y_k^t, w_k^t, t)}{\sum_{k,t} C(k, y_k^t, w_k^t, t)} \quad (11)$$

C. Key Events and their Impact on Productivity

The data had to be adjusted in order to take into account some specific events which would otherwise result in fictitious changes in productivity. One of the most important events was the unbundling in 2006, which resulted in:

- The decrease of the input "Other tangible assets" since these assets were transferred to other (service) companies. Such assets include automobiles, furniture or computers.
- The increase of the input „OPEX" which was associated of a more intensive cooperation with service companies after the unbundling, as well as the costs of unbundling themselves (for example, consultants and law services). Also, we had to subtract the sales of natural gas from the operating expenses in order to ensure consistency in the course of the period 2001-2011.
- A virtual extension of accounting useful life of some assets, for example, from 33 to 40 years in the case of pipelines in 2006.

Further, the following issues should be mentioned:

- From 2008, the company E.ON Distribuce incorporates the distribution of electricity and natural gas. In the case of this firm, it was impossible to differentiate the costs and assets of electricity and natural gas distribution.
- Numerous fusions and mergers. For example, the company RWE simplified its structure and in 2009, when three firms (STP Net, ZČP Net a SČP Net) merged into RWE GasNet. The company E.ON Distribuce is a results of a merger of two companies (Jihočeská energetika a Jihomoravská energetika) from 2005.
- Possible measurement errors of inputs X_2 and X_3 due to the possible inaccuracy of the geographic information system (GIS).
- It is necessary to stress that the output Y_5 (reserved capacity) is just an approximation of the real network's capacity.
- A certain trend in the decrease of the input "High pressure network" (X_2). This is due to the continuous reconstruction of the distribution grid, where a new topology is being installed (ring network) in order to make the distribution more efficient. The main reason

is that only a few of customers are connected directly to the high-pressure network.

- A difficult optimisation of costs in a situation where the regulated firms are obliged to serve non-profitable segments.
- An impact of speculation to the output Y_5 (reserved capacity) in the years 2004-2005. This was due to low sanctions for exceeding the reserved capacity limit. Furthermore, from 2008, new products for capacity optimisation (flexible capacity) have been available.

IV. RESULTS

We summarize the TFP development in the Czech natural gas distribution sector in Fig. 1 and Table 2. To estimate productivity changes, we used the Fisher productivity index (see section 3.1) in the form of fixed-base index. 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. If the value of ΔTFP is greater than 1, it means that the total factor productivity is above the level of 2000 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.

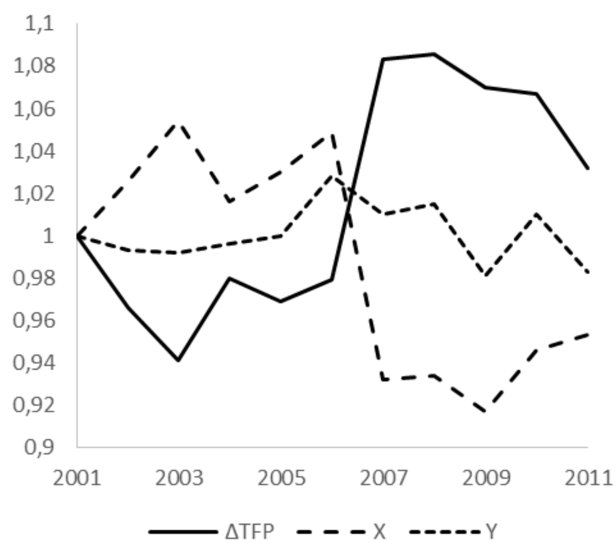

Fig. 1 TFP development of the Czech natural gas distribution sector

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, we can 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.

Table 2 TFP development of the Czech natural gas distribution sector

	ΔTFP	X	Y
2001	1.000	1.000	1.000
2002	0.966	1.026	0.993
2003	0.941	1.054	0.992
2004	0.980	1.016	0.996
2005	0.969	1.030	1.000
2006	0.979	1.049	1.028
2007	1.083	0.932	1.010
2008	1.086	0.934	1.015
2009	1.070	0.917	0.981
2010	1.067	0.946	1.010
2011	1.032	0.953	0.983

The most interesting point is the period 2006/2007. In this year, unbundling of distribution from other activities took place. This resulted in a substantial change in productivity, 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 we can observe a tendency of the aggregate output to decrease. This was caused, among others, by the economic crisis, which began around 2008 and which resulted in a considerable drop of volume of distributed gas and reserved capacity.

We can also analyse the partial productivities of the individual inputs which explains the development described above. In particular, note the jump of the “Other tangible assets” productivity in 2006/2007.

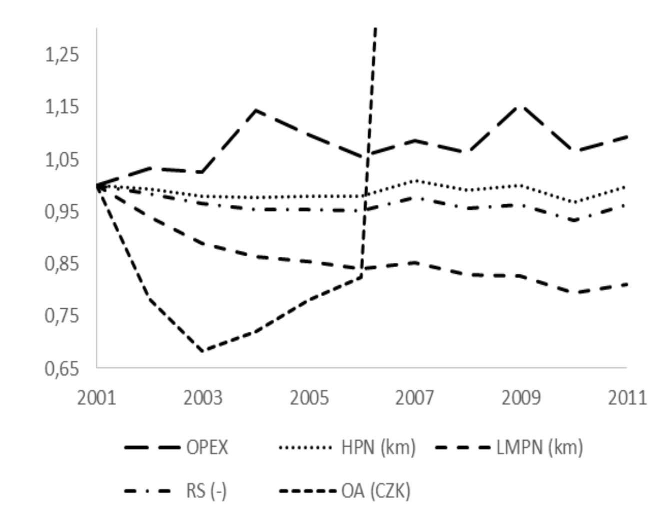

Fig. 2 Partial factor productivities of inputs
OPEX = operating expenses, HPN = high-pressure network, LMPN = low and medium pressure network, RS = regulator stations, OA = other tangible assets.

We can also illustrate the development of the six gas distribution companies' total factor productivity (see Table 3 and Fig. 3). However, for data privacy reasons, we don't reveal the identities of the companies and we denote them 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. 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. We can see 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 "penalised" 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.

Table 3 Comparison of individual firms, industry and the Czech economy

	Econ	Ind	F1	F2	F3	F4	F5	F6
2001	1.000	1.000	1.00	1.00	1.00	1.00	1.00	1.00
2002	1.026	0.967	.979	.955	.982	.905	1.01	.932
2003	1.063	0.941	1.00	.936	.987	.898	.973	.868
2004	1.100	0.980	0.95	.963	.982	.911	1.05	.920
2005	1.124	0.970	0.99	.897	.960	.908	1.09	.868
2006	1.173	0.979	.994	.891	.976	.922	1.08	.860
2007	1.214	1.083	1.02	.946	.994	.986	1.15	.841
2008	1.194	1.086	1.03	.966	1.01	.981	1.14	.817
2009	1.153	1.071	1.02	.939	1.00	.959	1.16	.781
2010	1.154	1.067	.993	.981	1.01	.961	1.15	.794
2011	1.157	1.032	.999	.991	1.00	.918	1.12	.750

Note: Econ – economy, Ind – industry.

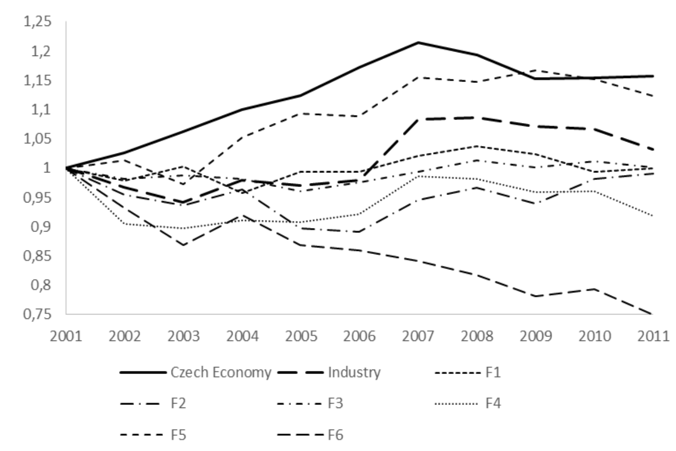

Fig. 3 Comparison of individual firms, industry and the Czech economy

V. Discussion

The discussion of the possibilities of using TFP benchmarking in post-communist countries is based on the theoretical issues of TFP regulation, on the experiences from other counties and on the calculation of TFP development of natural gas distribution companies in the Czech Republic.

A. Technical Aspects

The choice of productivity indexes based on price aggregation is connected with all the potential issues we mentioned in section 2.2. In particular, we implicitly make the assumption of optimising behaviour of companies which is a debatable condition in the regulated business environment. However, with respect to a limited number of observations in post-communist countries (see the following subsection), the use of Fisher or Törnqvist indexes seems to be a more practical choice than using indexes based on distance function.

Ideally, the TFP-based regulation should incorporate the quality aspect. However, according to the current state-of-the-art, it seems that

- The issues of definition and measurement of quality is still not resolved in the case of TFP methods.
- Companies are motivated to savings which results in postponement of investments, which has eventually a negative impact on the quality-of-service.

B. Data Issues

TFP-based regulation requires the availability of relevant data, a sufficient number of comparable firms and a steady state. The productivity should be evaluated in longer time series since TFP may fluctuate substantially between years [23]. The selected time period should be representative, should not include exceptional events which are unlikely to repeat again and should contain the whole economic cycle. However, it is impossible to classify the situation in regulated energy industries as “steady”, especially with regard to the progressive development in the electricity industry and the increasing support of renewable sources of energy in the European Union. The development of electricity industries is interconnected with the development in the natural gas sector. However, even if in the contemporary turbulent and globalised business environment a “steady state” is not realistic, the government can support it by minimising the administrative interventions which alter substantially the market and its constitution. Last but not least, even in the presence of good-quality historical data, it is necessary to keep in mind that they do not ensure and equivalent development in the future.

1) Using Domestic Data

Modern economic regulation of public utilities in post-communist countries begins by the beginning of the 21th century, which means that domestic time series are usually not long enough. Moreover, in such a short time period, a continuous liberalisation of markets took place, including important events such as unbundling, mergers and acquisitions etc., which further precludes the collection of solid underlying materials for a solid method of regulation. A number of assets had to be transferred to affiliated service companies, which resulted in changes of asset structures and resulted in increased operating costs. Further, some other aspects have to be mentioned: adverse weather conditions and temperature fluctuations, gas stoppage from Russia, the support of renewable sources of energy, which are resulted in a deformation of available data. Even the data which seem to be easily measurable may be burdened by measurement or evidence errors (for example, reclassification of pipelines to other category). These issues are further supported by limited number of companies operating in most countries and their heterogeneity. So, we argue that in post-communist countries, domestic data only are not applicable for a solid TFP benchmarking tariff regulation.

However, domestic data would be ideal for benchmarking of companies. If the regulation had to be based on domestic data only, it is possible to make use of the experiences from Australia and New Zealand and recommend collecting data long before the beginning of the first TFP-based regulatory period. This can be supported by constitution an obligation to collect relevant data and apply the TFP regulation after having gathered a solid data base. However, it is necessary to consider the costs incurred by maintaining such a database, both for regulated firms and regulatory agencies (including IT costs, data collection and migration costs).

2) Using Foreign Data

Foreign data are being frequently used by regulators in small countries. The choice of a foreign benchmark may be dubious since it contains a substantial heterogeneity in terms of geographic conditions (such as mountainous vs. flat countries, water flows, or natural reservations), political, legal or economic environment (accounting standards [24], regulatory regimes, tax burden etc.), customer characteristics (purchasing power, availability of substitutes etc.) More importantly, there is a significant difference between developed countries and post-communist countries in terms of quality and characteristics of the distribution network. Post-communist distributors operate a system which was built on a centrally-planned base and have to catch up the investment debt from the past.

C. Overall Acceptance of the Regulatory Method

If the regulated firms have to be motivated to increase their performance, it is necessary that the regulatory regime be accepted at the broadest level possible. Otherwise, as we know from the Dutch experience with TFP benchmarking, the regulatory method and its parameters may be subject to disputes which can become costly. An overall acceptance of TFP-based regulation can be supported by a successful use of this method in other countries and promotion of such success. We can suggest surveying the success of TFP-based regulation in other countries.

D. Individual Approach

The acceptance of regulatory method may be supported by an individual approach to regulated firms, since a general X-factor creates potential for further disputes. Generally, firms tend to accept such solution on which they can participate, which can be assumed according to the experiences from Australia and New Zealand as well as the Czech Republic. A negotiated settlement process seems to be a necessary condition of the acceptance of the regulatory methods from all stakeholders.

E. Transparency

The regulatory methods and the way of setting its parameters have to be transparent. As follows from the consultancy process in the Czech Republic, the Czech regulatory agency is often using ambiguous and general terms, sometimes completely omitting to state the rationale for setting some parameters (such as the X-factor). The regulatory agency itself should be bound by clear-cut rules and obligations. Further, transparency is often reduced by normalising operating conditions resulting from the heterogeneity of companies in the benchmark (see the previous subsections).

F. Using External Consultants

Robust and reliable TFP estimates require analytical work which can be at best carried out by experts in the field. The Czech regulatory agency employs some specialist but a use of reputable, even foreign consultants from the practice or from the academic sphere is likely to improve the transparency of the regulatory regime and the overall acceptance, since TFP studies elaborated by independent consultants provide less space to political influences in the decision-making by the regulatory agency. When employing external consultants, it is however necessary to keep in mind that TPF studies written by regulator’s and regulated companies’ consultants will most probably present different outcomes. Ideally, the consultant should be independent on both the regulator and regulated companies and its remuneration should not depend on the outcome of the TFP study. Among reputable firms involved in TFP regulation, we can mention the companies Pacific Economics Group, London Economics, or Economic Insights.

VI. Conclusion

We 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, we would recommend the methods which don't require large amount of cross-sectional data and we 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. We would 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 building-block 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.

References

[1] A. Kahn, *The economics of regulation: Principles and institutions*. MIT Press, Cambridge, 1988.

[2] P. Baláž, F. Margan, V. Ružeková, S. Zábojník, *Energy Security during Globalisation and Its Impact on Competitiveness of EU*. Ekonóm, Bratislava, 2011.

[3] M. Helísek, How Far Along is Euro Adoption in the Czech Republic? Benefits for Businesses Still Remain. *Central European Business Review*, vol. 2, no. 1, pp. 21-27, 2013.

[4] A. Lesser, L. Giacchino, *Fundamentals of energy regulation*. Public Utilities Reports, Vienna, 2007.

[5] H. Averch, L. L. Johnson, "Behavior of the firm under regulatory constraint,", *American Economic Review*, vol. 52, no. 5, pp. 1052-1069, 1962.

[6] J. D. Makholm, *Elusive efficiency and the X-factor in incentive regulation: The Törnqvist v. DEA/Malmquist dispute*. Nera Publications, Benin City, 2007.

[7] T. J. Coelli, D. S. Prasada Rao, C. J. O'Donnell, G. E. Battese, *An introduction to efficiency and productivity analysis*. Springer, New York, 2005.

[8] D. W. Caves, L. R. Christensen, W. E. Diewert, "Multilateral comparisons of output, input, and productivity using superlative index numbers," *Economic Journal*, vol. 92, no. 365, pp. 73-86, 1982.

[9] L. Törnqvist, "The Bank of Finland's Consumption Price Index," *Bank of Finland Monthly Bulletin*, vol. 10, pp. 1-8, 1936.

[10] I. Fisher, *The making of index numbers*. Houghton-Mifflin, Boston, 1922.

[11] O. Machek, J. Špička, "Measuring Performance Growth of Agricultural Sector: A Total Factor Productivity Approach," *International Journal of Economics and Statistics*, vol. 1, no. 4, pp. 200-208, 2013.

[12] D. Lawrence, E. Diewert, "Regulating electricity networks: The ABC of setting X in New Zealand," in *Performance measurement and regulation of network utilities*, T. J. Coelli, D. Lawrence, Ed. Northampton: Edward Elgar, 2006, pp. 207–241.

[13] PEG, *Second-generation incentive regulation for Ontario power distributors*. Pacific Economics Group, Madison, 2006.

[14] CEPA, *Productivity improvements in distribution network operators. Final report*. Cambdridge: Cambridge Economic Policy Associates Ltd., 2003.

[15] OFGEM, *RIIO-T1/GD1: Initial proposals – Real price effects and ongoing efficiency appendix*. Office of Gas and Electricity Markets. OFGEM, London, 2012.

[16] E. Van Damme, "Liberalizing the Dutch electricity market: 1998–2004. *Energy Journal*," vol. 26, pp. 155–180, 2005.

[17] AEMC, *Total factor productivity for distribution network regulation*. Australian Energy Market Commission, Sydney, 2011.

[18] O. Machek, J. Hnilica, "International experience with productivity benchmarking in the regulation of public utilities," 9th International Scientific Conferene Financial Management of Firms and Financial Institutions, Ostrava, Sep. 9-10, pp: 451-461, 2013.

[19] Lawrence, D., *Regulation of electricity lines businesses, analysis of lines business performance 1996–2003. Report prepared for Commerce Commission, Wellington, New Zealand, 2003*. Meyrick and Associates, Hawker, 2003.

[20] O. Machek, Data issues in total factor productivity benchmarking: A Central European perspective. The Annals of the University of Oradea. Economic Sciences, vol. 21, no. 2, pp. 224-230, 2012.

[21] O. Machek, O. Nowak, J. Hnilica, "Prediction of the Price Cap under RPI-X Incentive Regulation of Network Industries Based on Productivity Benchmarking," *International Journal of Mathematics and Computers in Simulation*, vol. 7, no. 1.

[22] O. Nowak, O. Machek, "Forecasting Price Changes Under TFP Based Incentive Regulation," Proceedings of the WSEAS Advances in Economics, Risk Management, Policital and Law Science. Zlín, Sep. 20-22, 2012, pp: 347–352.

[23] O. Machek, J. Hnilica, "Total Factor Productivity Approach in Competitive and Regulated World," *Procedia – Social and Behavioral Sciences*, vol. 57, pp. 223-230, 2012.

[24] C. Bonaci, J. Strouhal, L. Müllerová, J. Roubíčková, "Corporate Governance Debate on Professional Ethics in Accounting Profession," Central European Business Review, vol. 2, no. 3, pp. 30-35, 2013.