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Total Factor Productivity Approach in Competitive and Regulated World

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Abstract

Total factor productivity (TFP) is a method of measuring performance of businesses. TFP is used both in competitive and regulated industries, such as electricity distribution companies. The aim of this paper is to consider what are the fundamentals of TFP approach in competitive and regulated business, what are the differences and their causes and what are the possible weaknesses and misinterpretation of results. In the first part, we deal with the contradictory relationship between competition and regulation and the principles of tariff regulation. Consequently, we introduce TFP and methods of its measurement. Then we describe the purposes of using TFP in competitive and tariff-regulated industries. Finally, we deal with the differences in productivity of competitive and regulated business. Competitive firms are concerned to increase productivity above the industry average in order to survive on the market. Often, they deal only with labor productivity at the organizational level. Regulated businesses don't face competitive pressures, but regulatory constraints. Often, TFP of regulated firms is measured by regulatory agencies and therefore, the firms may manipulate with data. Regulatory agencies usually possess much more information than regulated firms but their data are not so accurate. The second set of differences is caused by efficiency gap between regulated and non-regulated firms. The positive impact of competition on productivity is confirmed by most studies, but sometimes, competition may cause a TFP decline, especially during transition from planned to market economy or privatization of firms. This has to be taken in consideration when analyzing and comparing TFP growth, as well as the overall level of regulation.

Keywords: Total factor productivity; regulation; competition; benchmarking

1. Introduction

Productivity is a basic and intuitive measure of performance. We can speak of a firm's productivity, but we can also measure the productivity of workers, machines, multiple firms, industrial sectors, national economies or even global economy. Total factor productivity (TFP) is a method of measuring productivity and its growth.

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The regulation of energy tariffs has recently become a popular topic among academic and popular community. Although the general aim of government regulation is to protect consumers and promote general welfare and justice, it is also often mentioned in connection with a reduction of economic efficiency and productivity. TFP approach then consequently differs in regulated and non-regulated businesses. The difference is even greater if TFP is used as a method of tariff regulation. In this case, the main differences are in the purposes of the use of TFP and the obtained results.

The aim of this article is to consider the following questions: what are the fundamentals of TFP approach in competitive and regulated business? What are the differences and their causes? And what are the possible weaknesses and misinterpretation of results?

In the first part, we will discuss the relationship between regulation and competition and explain the principles of tariff regulation of public utilities. Then we will introduce productivity, TFP and its measurement. Consequently, we will deal with the objectives and use of TFP in regulated and non-regulated business and next, we will discuss the differences between TFP measurement results obtained in regulated and non-regulated world and their causes and discuss the weaknesses and possible misinterpretations of TFP measurement and comparison of results.

2. Regulation vs. Competition

Competition and regulation are often considered to be in contradiction rather than being complementary. Regulation usually takes place in the case when society takes the view that competition does not bring satisfactory benefits (natural monopoly, buyer's ignorance, destructive competition, cream-skimming and other possible negative phenomena of competition are described largely by Kahn [1], Bonbright [2] or Phillips [3].

Usually, perfect competition is considered not entirely desirable because [1]

- consumers desire differentiation of products and services;
- returns to scale which reduce overall costs suppose rather a smaller number of large firms;
- monopoly profits can be a good stimulus to innovate;
- if serious market imperfections prevail, perfect competition cannot be efficient.

We can state that recently, there has been a shift in emphasis from the competitive model of industrial organizations to not perfectly competitive models. Economists mostly agree that perfect competition is not applicable to large industrial enterprises. In US, most firms balance between monopolistic competition and oligopoly structures [1]. Probably the most promoted concept nowadays is the workable competition, which is a more realistic concept. Workable competition [4] is an economic model of a market in which competition is not perfect, but sufficient to give buyers alternatives and protects them from the abuse of monopoly power. Another well-known model is the contestable market theory [5], which holds that a real threat of competition is sufficient to make a monopoly firm to behave efficiently and reach competitive equilibrium.

Competition is often considered unfeasible in certain sectors such as natural gas or electricity distribution which are considered to be natural monopolies. These industries are often referred to as public utilities. Following Kahn [1], we can divide state's regulation into setting market entry and exit conditions, regulation of tariffs, regulation of quality-of-service and the duty of universal service. Every method of economic regulation is a compromise between perfect competition and pure regulation and is based, to some extent, on the principles of competition.

2.1. Tariff Regulation Based on TFP

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. The 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 the regulated service) and *RoR* is the rate of return (usually approximated using weighted average cost of capital, WACC). A classical **cost-of-service regulation** is based on simply summing eligible expenses and calculating a required rate of return. This approach has several disadvantages – information asymmetries between regulator and regulated companies, incentive to overinvest (A-J-W effect, see [6]) or to invest imprudently (gold

plating) and last but not least, the tariff level has to be reviewed frequently, typically every year.

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 profit. In general, we distinguish two basic alternatives of incentive regulation: price-cap and revenue-cap.

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

$$P(t) = (1 + RPI - X).\ P(t-1) \tag{2}$$

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 in this case, total revenues are capped. The formula is

$$R(t) = (1 + RPI - X).\ R(t-1) \tag{3}$$

where $R(t)$ are the revenues in time t and $R(t-1)$denotes revenues in time $t-1$.Since the tariffs or revenues are capped according to the inflation rate (RPI-factor) and efficiency (X-factor), the incentive regulation is also often called 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** [7]. In general, benchmarking means comparing performance of a firm against a relative performance measurement. If properly applied, it 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 in the industry. When the firm succeeds to improve its productivity more than other firms, it is rewarded by greater allowed revenues. In order to apply incentive regulation, it is necessary to determine the X-factor of efficiency; it can be calculated using total factor productivity change. Following Makholm [8], we can derive that

$$\Delta p = \Delta p_N - (\Delta TFP - \Delta TFP_N + \Delta w_N - \Delta w) = \Delta p_N - X \tag{4}$$

where Δp_N is the price growth of economy (industry) outputs, Δw_N is the price growth of economy (industry) inputs and ΔTFP_N is the change of productivity of the whole economy (industry). [38]

3. Total Factor Productivity and it's Measurement

Productivity is defined as the ratio of output to input. 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 same issue applies to measuring productivity changes. Inter-firm differences in productivity can be caused by factors which may or may not be influenced by the firms, such as inaccurate measurement, differences in production technology, in the scale of production etc.

In economic theory, TFP 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 is measured by productivity indexes or productivity indicators. Indexes have a multiplicative form, whereas indicators have additive form.

Among measures based on distance function, we can cite Malmquist productivity index [9], Hicks-Moorsteen productivity index [10] and Luenberger productivity indicator [11]. These measures require optimization problem solving (data envelopment analysis) or regression methods which measure the distance from a real, but unknown frontier.

Other TFP measures are based on price aggregation, such as Törnqvist productivity index [12], Fisher productivity index [13] or Bennet-Bowley productivity indicator [14].These measures require data about input and output prices, but can be derived directly from empirical data. We will shortly present two perhaps most commonly used TFP measures: Malmquist and Törnqvist index.

3.1. Malmquist index of productivity

A produced can be defined as an entity transforming a set of inputs $\mathbf{x} = (x_1, x_2, \ldots, x_n)$ into a set of outputs $\mathbf{y} = (y_1, y_2, \ldots, y_m)$. In order to define Malmquist index, we have first to introduce the notion of

efficiency. **Efficiency** of a firm can be defined as a ratio of observed values of inputs and outputs and their optimal values. The analysis of efficiency can be oriented either on minimizing inputs with given outputs or maximizing outputs with given inputs. The production technology can be represented using a set of couples (input-output vectors)

$T = \{(\mathbf{x},\mathbf{y})\}$, where **x** is input to produce **y**. *(5)*

Another possible representation of production technology is the output requirement set *P(x)*, e.g.

$$P(x) = \{\mathbf{y} : (\mathbf{x},\mathbf{y}) \in T\} \quad (6)$$

As a measure of efficiency, we can use the Debreu-Farrell approach ([15] and [16]). Using the above-described notation, we can define the Debreu-Farrell measure of technical efficiency as the maximum possible equiproportional increase of given output so that it still belongs to the output requirement set.

$$TE(\mathbf{x},\mathbf{y}) = \max\{\Phi : \Phi\mathbf{y} \in P(\mathbf{x})\} \quad (7)$$

The inverse value of technical efficiency is called distance function.

$$D(\mathbf{x},\mathbf{y}) = \min\{\lambda : \mathbf{y}/\lambda \in P(\mathbf{x})\} \quad (8)$$

When applying the output-maximizing approach, the lesser the distance from a production frontier, the better is the efficiency score. In the real world, the production frontier is unknown and has to be estimated using econometric methods (e.g. corrected ordinary least squares, COLS) or mathematical programming (e.g. data envelopment analysis, DEA). Using the above described definitions, we can define the Malmquist index of productivity. Consider a period during which the production has changed from $(\mathbf{x_t},\mathbf{y_t})$ to $(\mathbf{x_{t+1}},\mathbf{y_{t+1}})$. The **Malmquist index of productivity** can be defined as

$$M(\mathbf{x}_t,\mathbf{y}_t,\mathbf{x}_{t+1},\mathbf{y}_{t+1}) = \sqrt{\frac{D_t(\mathbf{x}_{t+1},\mathbf{y}_{t+1})}{D_t(\mathbf{x}_t,\mathbf{y}_t)} \times \frac{D_{t+1}(\mathbf{x}_{t+1},\mathbf{y}_{t+1})}{D_{t+1}(\mathbf{x}_t,\mathbf{y}_t)}} \quad (9)$$

Malmquist index is of great theoretical importance. However, it is necessary to estimate the real but unknown production frontier using econometric or mathematical programming methods.

3.2. Törnqvist index of productivity

Törnqvist index is an example of indexes which can be calculated from observed empirical data without having to estimate the unknown production frontier. These indexes are often called superlative indexes. Under certain conditions, they approach Malmquist index [17]. The calculation is based on observed prices (weights) of input and output factors. Let $\mathbf{w} = (w_1,w_2,\ldots,w_n)$ denote the prices of inputs and $\mathbf{p} = (p_1,p_2,\ldots,p_m)$ denote the prices of outputs. Törnqvist index of productivity is defined as a ratio of output quantity index Y_T and input quantity index X_T. Usually, the two quantity indexes are specified in their logarithmic form as

$$\ln Y_T = \frac{1}{2}\left(\sum_m \left[\frac{p_{m,t}y_{m,t}}{\sum_m p_{m,t}y_{m,t}} + \frac{p_{m,t+1}y_{m,t+1}}{\sum_m p_{m,t++}y_{m,t+1}}\right] \ln\frac{y_{m,t+1}}{y_{m,t}}\right)$$
$$\ln X_T = \frac{1}{2}\left(\sum_n \left[\frac{w_{n,t}x_{n,t}}{\sum_n w_{n,t}x_{n,t}} + \frac{w_{n,t+1}x_{n,t+1}}{\sum_n w_{n,t++}x_{n,t+1}}\right] \ln\frac{x_{n,t+1}}{x_{n,t}}\right) \quad (10)$$

And finally, the **Törnqvist index of productivity** can be specified as

$$\Pi_T = \frac{Y_T}{X_T} = e^{\ln Y_T - \ln X_T} \quad (11)$$

However, it is not within the scope of this article to describe all measures of productivity. The reader is encouraged to see [17] or [18] for more detailed description. For the purpose of this article, however, it is important to note that „real“ TFP measures such as Törnqvist index approximate „theoretical“ measures (Malmquist index) only when factor prices reflect their marginal productivities, i.e. the observed factor prices are competitive. Otherwise, the productivity change can be biased [17].

This is, however, not an assumption on the analyzed object, but rather on its environment and concerns both regulated and competitive firms. Another remarkable aspect is that there is no assumption of perfect competition of businesses when deriving Törnqvist index from Malmquist index [19].

Results determined by various methods and persons should not be mixed; consider a comparison of TFP growth of gas distribution industry calculated by regulatory agency using Malmquist index and TFP growth calculated by a firm using Törnqvist index. Misinterpretation could arise not only from differences between methods, but also from different data quality (the firm would dispose by more accurate data than the regulatory agency would) and different choice of output and input variables (for example, the capital input can be calculated by many ways).

4. The Use of TFP in Competitive Business

In the competitive world, productivity is one of the key success factors. Among methods aimed at increasing productivity, we can cite lean management techniques (kanban, kaizen, 5S), quantitative methods such as operations research, the just-in-time concept, total productive maintenance (TPM) and much more.

Outputs have to be defined in relation with their real success on the market and inputs have to be carefully considered and no input shall be negliged. However, in practice, mostly only the labor productivity is assessed. According to a survey conducted in Czech Republic, 94% of businesses assessed their own productivity, but 74% of them have evaluated only labor productivity [20]. This is due to historical reasons, when human labor was the dominant resource. However, nowadays, labor costs represent only a small proportion of total costs.

Another survey reveals that most firms use either employee headcount or employee full labor costs as a primary resource measure and over half of organizations measure productivity at more than one organizational level, with the company being the most frequent level chosen [21]. This means that firms mostly do not deal with the productivity of whole sectors or even economy.

The main difference from the use of TFP in regulated business is that businesses assess their own productivity in order to improve their success on the market. Usually, they are not able to assess other firm's productivity due to information asymmetries. In addition, they generally do not employ experts or scientists capable to carry out complex studies of productivity. Conversely, concerning own productivity evaluation, their data is very accurate. The level does usually not exceed the organizational level. The aim is to produce accurate results on the firm's productivity.

5. The Use of TFP in Tariff-Regulated Business

Firms whose tariffs are regulated do not face real competition and therefore do not benchmark their productivity with other firms; instead, they face regulatory constraints which should mimic competition.

As previously mentioned, competitive pressures are simulated using performance-based regulation and benchmarking methods. In a competitive environment, a firm's earnings are related to the industry average and to the firm's relative market position. A firm has to reduce its costs below its competitors in order to survive. The main idea of regulatory benchmarking is to set the price cap with respect to the performance of other companies. Two main approaches prevail: benchmarking efficiency (using methods such as data envelopment analysis, stochastic frontier analysis) and productivity (TFP approach). If the firm manages to have better productivity growth than the rest of the industry, it is rewarded by higher allowed revenues and profits.

The use of incentive regulation in public utilities regulation also raises the question whether its introduction has a positive effect on regulated firms' productivity. Coelli and Supawat [23] suggest that the introduction of incentive regulation does not have positive effect on the productivity of regulated firms.

Because the choice of regulatory method and its parameters is crucial, regulatory agencies often realize settlement processes (negotiated settlement, see e.g. [24]) whose aim is to find a general consensus upon the regulatory method. This is the moment when regulated firms can assess their own productivity under different models and try to promote the method which is the most favorable for them.

However, productivity is measured by regulatory bodies, not by the regulated firms on their own. If so, the aim is to maximize profits under the regulatory constraints, which means firms deal with the question how to improve the results obtained by the regulatory agency. Regulatory agencies usually possess much more information than regulated firms do; they have the right to request data for

regulatory purposes. This provides some space for manipulating with the data by regulated firms, because their goal is not to provide accurate data, but to provide data which maximize their allowed revenues. In economic literature, this is referred to as gaming, i.e. behavior that aims to increase profits without achieving real efficiency gains. This phenomenon is well described in [25].

We can summarize the differences in using TFP in Table 1.

Table 1. The Use of TFP in Competitive and Tariff-Regulated Business	Competitive	Tariff-regulated
Evaluating subject	Firm	Regulatory agency
Staff	No experts in TFP	Experts in TFP
Data on firm	Accurate	Possible deliberate distortions (gaming)
Data on market	Lack of access to data	Regulator has access to market data
Level	Organization	Industry
Aim	Evaluate and improve own productivity	Maximize revenue requirements

6. Differences in Productivity of Competitive and Regulated Business

Neoclassical theory postulates that competition leads to three sources of efficiency: production efficiency, allocative efficiency and dynamic efficiency. The generally accepted hypothesis that increased competition leads to a higher efficiency and productivity. The reasons are purely economic: X-inefficiency, i.e. the difference between efficient behavior of firms and their real behavior in practice [26] occurs when technical-efficiency is not being achieved because of a lack of competitive pressures, and rationalization of industries, when resources are reallocated because the firms have to compete against each other.

Djankov and Murrell [27] summarized 23 studies which investigated the impact of increased competition on performance. The results are mixed. Various methods, measures of competition and explanatory variables (Herfindahl index, number of competitors etc.), their endogeneity and various TFP measures could have been sources of possible errors.

Arnold, Nicoletti and Scarpetta [28] found that regulations that limit competitive pressures tend to reduce the productivity of firms. In accordance with this conclusion is the conclusion of Orazem and Vodopivec [29] who found out that increased market competition raises TFP across all firms in an industry and suggest that most past studies which brought mixed results concentrated on short time frame and only large firms and balanced panels. Another study [36] revealed that the positive impact of competition on productivity is weakened have a dominant shareholder. However, energy distribution utilities often originate from unbundling of activities (production, distribution and sales) and have a 100% shareholder. A similar empirical study [37] revealed an analogous complementarity between competition and corporate governance.

In contrast with studies confirming the positive impact of competition on TFP are some special cases. For instance, increased competition in the countries of the former Eastern Bloc may have contributed to TFP decline because it disrupted the Warsaw Pact economic connections [30]. This could be a source of misinterpretation; it seems that competition leads to a better productivity but under certain conditions, it is necessary to take into consideration the transition from planned to market economy, because the transition may cause a temporary productivity decline until new structures are created. Similarly, privatization of state-owned firms may cause a TFP decline, because the technology gap may discourage enterprises restructuring [31]. A transitional decline of TFP in an oligopoly market being exposed to competition has also been documented [27].

The effect is strengthened by entry barriers of the market; for instance, starting business in Russia takes two times longer than in Central Europe, which had negative impact on TFP changes after opening markets to competition [32]. This is in accordance with economic theory: entry costs reduce competition and incentives to adopt more advanced technologies. This hypothesis is supported by Poschke [33] who suggests that entry barriers are the reason why US economy has a higher TFP than

European economies and Crafts [34] who found that government regulation has a negative impact on the incentive to invest and to innovate which causes TFP growth in OECD countries to vary. This could represent another source of misinterpretation when comparing TFP across firms; their productivity is affected by external factors such as economic environment and the extent of government regulation. A great number of factors are influencing each firm's performance (see e.g. [35]), such as size, ownership structure, capital structure, age and quality of assets, inflation rate, interest groups, unemployment, purchase power, customer density etc. However, it would not be in the scope and intentions of this paper to describe and analyze all these factors.

7. Conclusion

The contradictory relationship between competition and regulation raises some questions about the differences in total factor productivity approach. The intention of this article was to analyze the differences in using TFP methods in these two paradigms and their causes and possible weaknesses and misinterpretation of results.

Fortunately, TFP measures do not rely on the assumption of perfect competition. The differences between the TFP approach in regulated and non-regulated business arise from two reasons: the purposes of its use and the obtained results.

The first set of differences arises from the purposes of measuring TFP. Competitive firms are concerned to increase their productivity above the industry average in order to survive. Often, they deal only with the labor productivity and evaluate productivity at organizational level. Although regulated businesses can also evaluate their own productivity, they do not face these competitive pressures, but regulatory constraints which should mimic competition. Often, TFP of regulated firms is measured by regulatory agencies and therefore, the firms try to improve the results obtained by the regulatory agency and may manipulate with the data. Regulatory agencies usually possess much more information than regulated firms but their data are not so accurate.

The second set of differences we may consider is caused by economic efficiency gap between regulated and non-regulated firms. The positive impact of competition on productivity is confirmed by most studies, but in certain cases competition can cause a decline in TFP, especially during the transition from planned to market economy or during the privatization of state-owned firms. Moreover, the existence of majority shareholders, which is a common case in energy distribution, tends to reduce the positive impacts of competition to productivity. This has to be taken in consideration when analyzing and comparing TFP growth, as well as the overall level of regulation and other constraints, because in sectors or countries will low degree of government regulation the productivity is likely to be higher.

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References

[1] Kahn A. *The Economics of Regulation: Principles and Institutions*. Cambridge: MIT Press; 1988.
[2] Bonbright J. *Principles of Public Utility Rates*. New York: Columbia University Press; 1961.
[3] Phillips C. *The Regulation of Public Utilities: Theory and Practice*. Vienna : Public Utilities Reports; 1993.
[4] Clark JM. Toward a Concept of Workable Competition. The American Economic Review 1940; 30(2): 241–56.
[5] Baumol WJ, Panzar JC, Willig RD. *Contestable Markets and the Theory of Industry Structure*. New York : Harcourt Brace Jovanovich; 1982.
[6] Averch H, Johnson LL. Behavior of the Firm Under Regulatory Constraint. American Economic Review 1962; 52 (5): 1052–69.
[7] Schleifer A. A theory of yardstick competition. Rand Journal of Economics 1985; 16(3): 319–28.
[8] Makholm J. Elusive Efficiency and the X-Factor in Incentive Regulation: the Törnqvist v. DEA/Malmquist Dispute. NERA Publications; 2007.
[9] Caves DW, Christensen LR, Diewert WE. Multilateral Comparisons of Output, Input, and Productivity Using Superlative Index Numbers. Economic Journal 1982; 92(365): 73–86.

[10] Diewert WE. Fisher ideal output, input, and productivity indexes revisited. Journal of Productivity Analysis 1992; 3:211–48.
[11] Chambers, Robert. A New Look at Exact Input, Output, Productivity and Technical Change Measurement, mimeo, Department of Agricultural and Resource Economics, University of Maryland, College Park; 1996.
[12] Törnqvist L. The Bank of Finland's Consumption Price Index. Bank of Finland Monthly Bulletin 1936; 10:1–8.
[13] Fisher I. *The Making of Index Numbers.* Boston: Houghton-Mifflin; 1922.
[14] Bennet TL. The Theory of Measurement of Changes in Cost of Living. Journal of the Royal Statistical Society 1920; 83: 455–62.
[15] Debreu G. The Coefficient of Resource Utilization. Econometrica 1951; 19(3): 273–92.
[16] Farrell M. The Measurement of Productive Efficiency. Journal of the Royal Statistical Society 1957; 120(3): 253–82.
[17] Färe R, Grosskopf S, Margaritis D. Efficiency and Productivity: Malmquist and More. In: Fried HO, Lovell CAK, Schmidt SS, editors. *The Measurement of Productive Efficiency and Productivity Growth*. New York: Oxford University Press; 2008, p. 522–622.
[18] Coelli T, Prasada RDS, Battese GE. *An Introduction to Efficiency and Productivity Analysis*. Boston: Kluwer Academic Publishers; 1998.
[19] Diewert E, Fox KJ. Malmquist and Tornqvist Productivity Indexes: Returns to scale and technical progress with imperfect competition. Journal of Economics 2010; 101(1): 73–95.
[20] Kislingerova E et al. *Evaluation of the survey in the Czech business sphere – results from the 1st stage*. Prague : VSE; 2007.
[21] Best Practices LLC. 2005. Achieving Process Excellence: Benchmarking Productivity Measurement, http://www.best-in-class.com/bestp/domrep.nsf/products/achieving-process-excellence-benchmarking-productivity-measurement; 2005.
[22] Beesley M, Littlechild S. The regulation of privatized monpolies in the United Kingdom. Rand Journal of Economics 1989; 20(3):454–72.
[23] Coelli T, Rungsuriyawiboon S. Regulatory Reform and Economic Performance in US Electricity Generation. In: Coelli T, Lawrence D, editors. *Performance Measurement and Regulation of Network Utilities* .Northampton: Edward Elgar; 2006, p. 267–96.
[24] Doucet J, Littlechild S.Negotiated settlements: The development of legal and economic thinking. Utilities Policy 2006; 14(4): 266–77.
[25] Jamasb T, Nillesen P, Pollitt MG. Strategic Behaviour Under Regulation Benchmarking. DAE Working Paper 312. Cambridge: University of Cambridge; 2003.
[26] Leibenstein H. Allocative Efficiency vs. X-Efficiency. American Economic Review 1966; 56 (3): 392–415.
[27] Djankov S, Murell P. Enterprise restructuring in transition: A quantitative survey. Journal of Economic Literature 2002; 40:739–92.
[28] Arnold JM, Nicoletti G, Scarpetta S. Does Anti-Competitive Regulation Matter for Productivity? Evidence from European Firms. IZA dscussion paper No. 5511, IZA, Bonn; 2011.
[29] Orazem PF, Vodopivec M. Do Market Pressures Induce Economic Efficiency? The Case of Slovenian Manufacturing, 1994–2001. Southern Economic Journal 2007; 76(2):553–576.
[30] Blanchard O, Kremer M. Disorganization. Quarterly Journal of Economics 1997; 112:1091–126.
[31] Angelucci M, Estrin S, Konings J, Zolkiewsk Z. The Effect of Ownership and Competitive Pressure on Firm Performance in Transition Countries: Micro Evidence from Bulgaria, Romania and Poland. CEPR Discussion Papers 2985; 2001.
[32] Djankov S, La Porta R, Lopez-de-Silanes F, Shleifer A. The Regulation of Entry. Quarterly Journal of Economics 2002, 117:1–37.
[33] Poschke M. The Regulation of Entry and Aggregate Productivity. Economic Journal 2010; 120(549): 1175–200.
[34] Crafts N. Regulation and Productivity Performance. Oxford Review of Economic Policy 2006; 22(2): 186–202.
[35] Pedell B. *Regulatory Risk and the Cost of Capital: Determinants and Implications for Rate Regulation*. New York: Springer; 2006.
[36] Nickel S, Nicolitsas D. Wages, restrictive practices and productivity. Labour Economics 1997; 4: 201–21.
[37] Groosfeld I, Tressel T. Competition and corporate governance: substitutes or compliments? Evidence from the Warsaw Stock Exchange. Davidson Institute Working Paper Series, No.369, The University of Michigan Business School; 2001.
[38] Tseng M.L., Lan, L.W., Wang, R., Chiu, A.S.F.; Cheng, H.P. (2011). Using hybrid model to evaluate the green performance in uncertainty. *Environmental Monitoring and Assessment,* 175(1), 367-385.