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MICROECONOMIC ANALYSIS OF EQUILIBRIUM IN NETWORK INDUSTRIES

Abstract
The existence of pure monopoly in network industries increases the role of regulation mechanisms in connection with objectification and increase in their social effectiveness. The objective of regulation mechanisms is to find an appropriate proportion between price and product supply of network industry under assumption of the existence competitive market. With regard to analysis of equilibrium in network industries models it is important to point out that except for competition policy protection the state fulfils another specific task – regulation of network industries. The state influences proportional relations between price and supply of network industry production.
The aim of the paper is to examine the equilibrium conditions in the market of network industries. With regard to analysis of equilibrium in network industries models it is important to point out that except for competition policy protection the state fulfils another specific task – regulation of network industries. The state influences proportional relations between price and supply of network industry production.
The conditions for equilibrium of network industries and methods of their regulations will be examined in the paper. The stress will be laid on the regulation on the base of returns – Rate of Return Regulation (ROR). Attention will be paid to the ways of calculation reasonable profit in regulated industries.

Keywords
Network industries, regulated prices, reasonable profit in regulated industries, rate of return regulation, Averch-Johnson model.

ACM classification
J.4 SOCIAL AND BEHAVIORAL SCIENCES, *Economics*

JEL classification
L1 – Market Structure, Firm Strategy, and Market Performance, L12 – Monopoly; Monopolization Strategies

1 INTRODUCTION

In connection with the transition of the Slovak economy to a market system much attention has been drawn in the Slovak economic theory to the study and analysis of general principles of functioning of market economy structures. In more analytically oriented studies the attention was paid to the observation of general economic equilibrium models of market environment. With regard to the above-mentioned trends a significant place has been (and still is) assigned to the microeconomic equilibrium models of market structures.

Microeconomic market equilibrium models are not a general cure for all, often objectively very sensitive issues of this transition. A branch with its production potential of limited number of producers on the supply side accounts for an ideal object for application of branch equilibrium models. By analysis of branch structures of national economics network industries should bear a special care, because they represent, in many cases, key production and service branches.

The existence of pure monopoly in network industries increases the role of regulation mechanisms in connection with objectification and increase in their social effectiveness. The objective of regulation mechanisms is to find an reasonable proportion between price and product supply of network industry under assumption of the existence of a competitive market.

Each condition of disequilibrium could have a negative impact on the existing conditions as well as on the potential development of the economic system. A perfect competition as a theoretical concept of market structure is only an ideal hypothesis of a "fair" market environment in current developed economics, when all producers and customers have approximately similar hope for a successful performance of their economic activities. One of the most important attributes of a harmonically developing economic system is a state-guaranteed protection of competition policy principles. It is obvious that the existence of market structures of imperfect competition evokes negative effects for competition policy.

It is inevitable to say that theories about positive social and economic effects of concentration, like:

- reduction of production cost;
- support of innovative processes and technical development;
- increasing of employment;
- growth of living standard condition and social benefits of employees;
- boost of state budget revenues
- have its reasoning only in short-term period. In long-term course their concrete effect is usually indemonstrable.

With regard to analysis of equilibrium in network industries models it is important to point out that except for competition policy protection the state fulfils another specific task – regulation of network industries. The state influences proportional relations between price and supply of network industry production.

From a social viewpoint the problem lies in a fact, that monopolies realise a maximum profit at higher prices and lower level of output than companies operating in competition environment. The main aim of regulation of monopolies is to bring a proportion between price and supply closer to a situation that would occur in a competition market.

Under regulation we more and more understand a regulation in a wider term, it means, determining of market structure, including ownership, regulation of natural monopolies behaviour.

Regulation of pure monopolies with regard to the May 2004 entry of Slovak Republic into the European Union has become a discussed issue.

Creation of new regulatory framework in Slovak Republic was the important part of restructuring market with electricity, gas and other goods of network industries. In August 2001 the Regulatory Office for Network Industries (hereinafter referred as to "RONI") was established which task was an issue of licenses and regulation of prices and quality standards for goods of network industries. RONI started issuing licenses and creating quality standards in year 2001, but it started executing the price regulation from 1.1.2003. The primary aim of RONI was to prepare new regime of price regulation for goods of network industries.

RONI already defined regime of new price regulation for electricity distribution and worked out the system of new regulation rules for price making of goods of network industries. Models for determination of maximum prices and tariffs of goods of network industries were created over the years 2001-2002 and on their basis RONI proceeded in creation of regulatory and legal framework within the area of price regulation, which determined the method of calculation of maximum prices and tariffs for an item of goods or of a services, which delivery and provision is considered as a performing of activities subject to regulation.

A traditional methodological tool for price regulation, which is applied by price regulators at determining the price of products of network industries is the regulation on the basis of the rate of return, through which the production prices in the most developed economies are regulated, i.e. of electricity, gas and other companies.

The aim is to ensure the regulated subject to determine the price of production or services for his customer so that he can cover from its revenue all its *reasonable and providently arisen costs* as well as the regulated recoverability of its *provident* investment.

2 METHODOLOGICAL ASPECTS OF NETWORK INDUSTRIES MARKET REGULATION

In Slovak Republic, the company National Economic Research Associates is dealing

with preparation of methodological apparatus of tariffs regulation for electricity distribution. Project's results are documented in extensive and analytically detailed reports and also related models for calculation of price regulation are part of project's solutions and they are prepared in environment of software Microsoft Excel.

Methodologies, which were presented among realized solutions to these projects, served as significant support by creating series of RONI's decisions over the years 2001-2002 and price regulation of goods of network industries in Slovak Republic were managed according to them. Finally, 30.7.2003 RONI issued 4 regulations which defined concrete methods for price regulation in network industries (e.g. in energetic, gas industry, thermal economy and water management) and determined the scope of economically justified costs and adequate profit of regulated subjects. It is possible to consider this phase of regulatory methodology creation to be completed and in the next period it will be necessary to assess its efficiency and in case of need to specify, modify or supplement it.

The company National Economic Research Associates proposed for price regulation of electricity in Slovakia the method, which combines method of Rate of Return Regulation with a method of Performance Based Regulation.

The basic relations of model for price regulation of electricity in Slovak Republic were suggested by company National Economic Research Associates in compliance with theoretically reasoned methods of natural monopoly regulation and after certain elaboration were published in „ Regulation of Regulatory Office for Network Industries from 30.7.2003 No. 1/2003, which lays down further information about methods for electricity price regulation.

It is appropriate to remind that the standard method of Rate of Return Regulation (RoR) is aimed to ensure that regulated subject set the price of goods or services for its customers in such a way to cover from its revenues all adequate and cautiously arisen costs as well as regulated return of its investment. At the same time, it is necessary to realize that based on H. Averch and L. Johnson model, the company is regulated according to principal of Rate of Return on capital Regulation. Therefore in effort to increase its permitted "adequate" profit, companies tend to inadequately and uselessly raise their investments.

In the conditions of electricity price regulation is this methodology applicable by quantification of adequate revenues of energy company according to relation which is derived on the basis of modification of formula (content as well as methodical) for Rate of Return Regulation (ROR).

Within this general methodology, burden of argumentation about justifiability of costs to satisfaction of regulatory authority is the task and responsibility on the side of regulated subjects. Regulated subject must univocally demonstrates that each element of cost item arose cautiously and it is also an adequate cost needed for fulfilling energetically needs of economy.

Investments into fixed assets must be expended circumspectly, „used and useful" by provision of energy in such a way to become a component of a charge basis of company. Analogically, elements of operating costs must be classified as a cautious and needed for provision of service.

The main advantage of the price regulation method on the basis of the method RoR is that prices, based on tested year, are steady and so they are fixed till the next tariff's procedure. On the other hand, there are also disadvantages, from which the most substantial is that fact that this methodology supports by regulated energy company tendency to build up new power plants and equipment, which perhaps are not necessary but they pretend investments in to fixed assets. Of course, it is an extreme situation.

The certain modification of Rate on Return Regulation (RoR) is method of Performance Based Regulation (PBR). Method of PBR eliminates some „not motivating" features of method RoR and creates the system of stimulus for increasing performance of regulated subject. The method of Performance Based Regulation in initial phase on the basis of RoR defines initial, perhaps starting, requirements for revenues as well as basic tariffs for goods and services.

The initial year for setting starting parameters of system for energy market in Slovak Republic was year 2002. These

requirements for revenues and basic tariffs are regularly updated by using RoR methodology. Interval of tariffs revision is usually 3-10 years. Prices are regulated between revisions according to special formulas, which take into account character of industry and economic priorities of the whole managed system.

Resulted from the made analysis aimed on regulation of used methodology we can state that consulting company National Economic Research Associates chose regulation methods theoretically reasoned, by professional literature documented and in practise tried methods of price regulation, which motivate regulated subjects to increase of their production efficiency.

3 RATE OF RETURN REGULATION

A traditional methodological tool for price regulation, which is applied by price regulators at determining the price of products of network industries is the regulation on the basis of the rate of return, through which the production prices in the most developed economies are regulated, i.e. of electricity, gas and other companies.

The aim is to ensure the regulated subject to determine the price of production or services for his customer so that he can cover from its revenue all its *reasonable and providently arisen costs* as well as the regulated recoverability of its *provident* investment.

Let us now derive the allowable rate of cost return for investments *RoR* of the regulated firm analytically. Let us suppose that the firm produces a homogenous product in production volume q, which it realizes at a relevant market for the price p. Let us further suppose that the firm uses two production factors, namely labour force with consumption level L by the labour price w and the capital with consumption level K by the capital price r.

The profit of the firm is generally defined as the difference between yields and costs in form

$$\pi(q) = t(q) - n(q)$$

where

$t(q) = p \times q$ – function of proceeds of the firm, $t: R \to R$

$n(q) = n_v(q) + n_F$ – function of the total costs of the firm, $n: R \to R$

$n_v(q)$ – function of variable costs of the firm, $n_v: R \to R$

n_F – *fixed costs of the firm*, $n_F \in R$

If we substitute the general cost function by a cost function on the basis of consumption of production factors, we get a profit function in the following form

$$\pi(q) = p \times q - w \times L - r \times K$$

If we further express the production volume q on the basis of the production function in the form

$$q = f(K, L)$$

and the production price p on the basis of the price-demand function in the form

$$p = p(q)$$

so we can express the profit function in the form

$$\pi(q) = p(q) \times q - w \times L - r \times K$$

and after further modification in the form

$$\pi(q) = p(f(K, L)) \times f(K, L) - w \times L - r \times K$$

A non-regulated firm can set its endogenous decision parameters in any way. So it chooses an optimum output volume q^*, an acceptable optimum price p^* and corresponding consumptions of the production factors labour L and capital K in order to reach the maximum profit. It calculates the optimum output and optimum price by solving the following task of mathematical programming

$$\pi(q) = p(f(K,L)) \times f(K,L) - w \times L - r \times K \to \max$$

$$K, L \in R_{\geq 0}$$

So in this case the non-regulated firm has no formal obstacles for setting the parameters guaranteeing its maximum profit. On the other hand the regulated form must respect the boundaries defined by the regulator. The mode of price regulation on the basis of the rate of return consists in the fact that through the exogenously defined control variable *RoR* the allowable level of the quotient of the proceeds of the firm $p \times q$ **reduced by its non-capital expenditures** $L \times w$ and of the volume of consumed capital K is regulated.

The firm can optimise, respectively freely determine the consumption levels of labour L, capital K by the market prices of production factors w, r on one side and on the other side the level of its production q and the production price p. But the firm must respect

the rate of return defined by the regulator, i.e. the validity of the relation

$$RoR \geq \frac{p \times q - w \times L}{K} \quad (1)$$

Let us now explore more in detail the relation between the rate of return of the capital expenditure and the profit of the regulated subject. The profit can be analytically expressed as the difference between the proceeds and the costs of the firm in the form

$$\pi(q) = p \times q - w \times L - r \times K \quad (2)$$

Let us deduct from both sides of the relation (1) the price of the capital r. We get the relation

$$RoR - r \geq \frac{p \times q - w \times L}{K} - r$$

After another modification we get

$$RoR - r \geq \frac{p \times q - w \times L}{K} - \frac{r \times K}{K}$$

$$RoR - r \geq \frac{p \times q - w \times L - r \times K}{K} \quad (3)$$

From the comparison of the relations (2) and (3) we get the relation

$$RoR - r \geq \frac{\pi(q)}{K}$$

$$(RoR - r) \times K \geq \pi(q) \quad (4)$$

We can see from the relation (4), that the regulated subject can set its system parameters only so, that its reached profit does not exceed the value of the capital evaluated by the difference between the rate of return defined by the regulator *RoR* and the price of capital r.

The regulated firm can set its controlled, respectively endogenous decision parameters only in a way in which it respects the condition determined by the regulator. It determines the regulated volume of output q_R, the acceptable regulated price p_R and the corresponding consumptions of production factors labour L and capital K so that it reaches the maximum profit and at the same time it respects the condition of the regulator (4) about not-exceeding the reasonable profit level. The regulated output and the regulated price are calculated by the solution of the following task of mathematical programming

$$\pi(q) = p(f(K,L)) \times f(K,L) - w \times L - r \times K \rightarrow \max \quad (5)$$

by the boundaries

$$p(f(K,L)) \times f(K,L) - w \times L - r \times K - (RoR - r) \times K \leq 0 \quad (6)$$

$$K, L \in R_{\geq 0} \quad (7)$$

The solution of this optimisation task is the optimum level of consumption of the production factors labour L^* and capital K^*, on the basis of which subsequently the regulated optimum level of output q_R^* is quantified using the production function based on the relation $q_R^* = f(K^*, L^*)$ and the regulated optimum price p_R^* with the use of the price-demand and production function based on the relation

$$p_R^* = p(q_R^*) = p(f(K^*, L^*))$$

whereby the rate of return of the capital of the firm defined by the parameter *RoR*, i.e. the exogenous control parameter determined by the regulator is respected.

We show the geometrical interpretation of determining the optimum regulated price and the supply of the firm in the conditions of respecting the determined rate of return of the capital in Figure 1.

In the situation when the firm would not be regulated and it would have an exclusive position at a relevant market, it would choose such an optimum volume of consumption of the variable input *labour* L^* and *capital* K^*, that would ensure a maximum profit $\pi(q) = p(f(K^*, L^*)) \times f(K^*, L^*)$. On the basis of the optimum consumption of variable inputs it would determine its optimum supply $q^* = f(K^*, L^*)$ and the optimum price of production $p^* = p(q^*) = p(f(K^*, L^*))$. The function of profit would reach in this case its global maximum, to which in Figure 4 corresponds the point $\boldsymbol{Max_{Glob}}$.

In case the firm is regulated, it can choose only such a combination of production factors, so that the corresponding volume of supply and price of production generates the so-called *reasonable profit*, i.e. this relation is valid

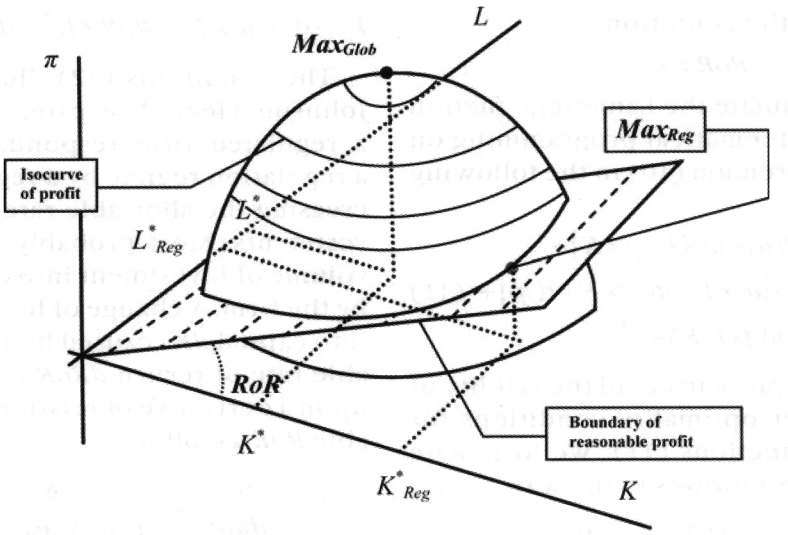
$$(RoR - r) \times K \geq p(f(K,L)) \times f(K,L) - w \times L - r \times K$$

$$(RoR - r) \times K \geq \pi(q)$$

So in the end result the regulated form can produce in such a way that its *reasonable profit* does not exceed $RoR - r$ multiple of the level of the variable input capital. This condition is called the *boundary of reasonable profit of a regulated firm* in professional literature.

On Figure 1 the *boundary of reasonable profit* is represented as a plane passing the

Figure 1



coordinate axis of the production factor labour L ($K=0$) and $RoR - r > 0$ represents the *tangent* of the angle, which the plane of boundary forms with the positive half-axis K. The bounding plane intersects the elipsoid of the values of the profit of the firm, whereby the points below this plane and on this plane represent the profit allowable under the regulation and the points above this plane the non-allowable profit of the firm.

The regulated form maximizes its profit by the solution of the optimisation task (5), (6), (7). On Figure 1 the point of maximum allowable profit of the regulated firm is the point $\boldsymbol{Max_{Reg}}$, whereby this maximum allowable profit is reached by the regulated firm for the optimum regulated value of the production factor, from which it produces the optimum regulated volume of output $q^*_R = f(L^*_{Reg}, K^*_{Reg})$, which it realizes on the market for the price $p^*_R = p(q^*_R)$.

However, this form of price regulation contains one serious risk, that it often motivates the firm to use a greater volume of the variable input capital than in a non-regulated firm.

4 AVERCH – JOHNSON MODEL OF REGULATION EFFECTS

A non-regulated monopolistic firm can set its optimal profit upon a solution of the following task on uncontrained extremum:

$$\pi(q) = t(q) - w \times L - r \times K \rightarrow \max \qquad (8)$$
$$q,\ K, L \in R_{\geq 0}$$

A solution of optimisation task is an optimal monopoly supply $q^*$and optimal consumption levels of production factors L^*, K^*. In case of exercise of regulation based on yields corresponding the rate of cost return for investment RoR *a* monopoly must respect the condition in the form

$$RoR \geq \frac{t(q) - w \times L}{K} \Leftrightarrow t(q) - w \times L \leq RoR \times K \qquad (9)$$

or after modification

$$t(q) - w \times L - r \times K \leq RoR \times K - r \times K$$
$$\underbrace{t(q) - w \times L - r \times K}_{\pi(q)} \leq RoR \times K - r \times K$$
$$\pi(q) \leq (RoR - r) \times K$$

It is evident that if a regulator determines for a regulated subject his rate of return RoR being higher than the price of capitak r, and is valid at the same time

$$RoR > r \Rightarrow RoR - r > 0$$

so then the firm has a guaranteed positive profit $\pi(q) > 0$ for each positive unit of invested capital K.

This conclusion really indicates a possibility, how the firm can increase its allowable "reasonable" profit by a non-reasonable and useless (inefficacious) accumulation of capital investments. Let us now explore this assumption in more detail. A regulated firm calculates its optimal parameters of behaviour by solving the following optimisation task of mathematical programming

$$\pi(q) = t(q) - w \times L - r \times K \rightarrow \max_{q,L,K}$$
subject to $\qquad (10)$
$$w \times L + RoR \times K - t(q) \geq 0$$
$$f(K, L) - q = 0$$

and also under the condition

$$RoR > r$$

Now we formulate the Langrange fuction for a task of mathematical programming on constrained extremum (10) in the following way

$$L(q,K,L,\lambda,\mu) = [t(q) - w\times L - r\times K] + \\ +\lambda[w\times L + RoR\times K - t(q)] + \\ +\mu[f(L,K) - q] \quad (11)$$

Let us now explore in detail the validity of the Kuhn-Tucker optimality conditions for the Lagrange functions (11). We formulate the optimality conditions in the way

(a) $\frac{\partial L}{\partial q} = 0$ (b) $\frac{\partial L}{\partial L} = 0$

(c) $\frac{\partial L}{\partial K} = 0$ (d) $\lambda \times \frac{\partial L}{\partial \lambda} = 0$

(e) $\mu \times \frac{\partial L}{\partial \mu} = 0$ (f) $\lambda, \mu \geq 0$

After a further modification of relations in Kuhn - Tucker conditions for optimal values of decision variables like volume of output q^*, consumption of production factors L^*, K^* and optimal values of Langrange multipliers l^*, m^*, we get the following

$$\left(1-\lambda^*\right)\frac{dt^*(q)}{dq} = \mu^* \quad (a1)$$

$$\mu^* \frac{\partial f^*(L,K)}{\partial L} = \left(1-\lambda^*\right)w \quad (b1)$$

$$\mu^* \frac{\partial f^*(L,K)}{\partial K} = r - \lambda^* \times RoR \quad (c1)$$

$$\lambda^*\left(w\times L^* + RoR\times K^* - t(q^*)\right) = 0 \quad (d1)$$

$$\mu^*\left(f(L^*,K^*) - q^*\right) = 0 \quad (e1)$$

$$\lambda^* \geq 0, \mu^* \geq 0 \quad (f1)$$

Let us now analyse the features of optimal solution of task (11), possibly the features of vector (q^*, K^*, L^*, l^*, m^*), that suits the optimality conditions (a1), ..., (f1). In case, the firm want to reach the level of profit on a boundary defined by a regulator, he must set its optimal solution so that the condition on the upper level of allowable rate of return for investments $w\times L + RoR\times K - t(q) \geq 0$ was fulfilled as equality. However, it is definitely fulfilled only under the condition, if optimal value of Langrange multiplier l^* is positive. Then, it is valid based on the relation (d1)

$$\lambda^* > 0 \Rightarrow w\times L^* + RoR\times K^* - t(q^*) = 0 \quad (12)$$

The conditions (12) illustrates Averch - Johnson efect. The primary issue is, how a regulated firm responds to toughening a regulation regime by a regulator, i.e. to decreasing the allowable rate of rerurn for investments. Most probably, it results in the volume of investment into capital K realised by the firm. A change of level of investments into capital dK^* caused by a change of allowable rate of rerurn $dRoR$ can be formulated upon a derivative of relation (12) by the variable RoR as follows:

$$\frac{dK^*}{dRoR} = \frac{K^*}{\frac{dt(q^*)}{dq}\frac{\partial f(K^*,L^*)}{\partial K}} < 0 \quad (13)$$

what implies that, if the regulator cuts the allowable rate of return for invested capital, then the regulated firm will apparently tend to redundant and inefficious increase of capital investments.

5 CONCLUSION

Based on the analysis of the behaviour of the firm in the conditions of regulation on the basis of the return of the used capital we have shown that in this regulation scheme the firm has the tendency to react to the tightening of the regulation conditions by the increase of the volume of used capital. However, the increase of the volume of the used capital is far from the aim of the system of regulation. The objective of regulation is rather to influence the values of other indicators important for the firm and for the economy, such as the volume of production, the level of product sale, respectively the cost level.

There are of course also other forms of price regulation, which influence the reasonable profit of the firm directly on the basis of the volume of its production, the level of product sale of the regulated firm, respectively on the basis of the amount of its total costs. The aim is to support the effective development of the regulated subject by help of regulation mechanisms.

Based on the results of analysis of Averch-Johnson model we can formulate the following important conclusions relating to behaviour of the firm being regulated upon

the principle of regulation of rate of return for used capital.:

- The firm being regulated upon the principle of regulation of rate of return for used capital is, in its natural effort to increase its "reasonable" profit, strongly motivated for redundant and inefficious growth of capital investments.
- By reduction of rate of return for capital expenditures and under the condition it is still valid $RoR > r$, the firm responds by increasing capital expenditures in order to retain the volume of its profit (natural effort).

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