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Input-Output Models for Energy Demand-Side Management

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Abstract

Using the ratios of the inter industry interregional input-output model, this study analyses the impact of the product value enhancement in the power generation industry upon the product value in other industry sectors of the regional industrial complex, as well as evaluates the industry specific consequences of the analyzed risk with regard to the initiating party of the increase.

Keywords: Input-Output Model, Demand-Side Management, Energy Policy.

Introduction

In the face of the growing pressure to improve the energy efficiency and resilience of the national economy, the effective implementation of the policy of active electrical energy demand management proves a promising direction in an effort to enhance the resilience and efficiency of power generation industry as well as contribute to the harmonization of interests of producers and consumers of energy.

Demand-side management (DSM) and thereto related system of integrated resource planning (IRP) [1-7] remain grossly underutilized so far. The essence of the demand-side management is purposeful and systematic control of the energy company with regard to the volume, pattern and mode of the energy demand in the region served. The following instruments are employed in these operational activities: temporary factor sensitive tariff systems, the quality of energy delivery, the financial solvency of the consumer; the use of alternative power consumption mode management applications; the support of investment projects (participation included) that aim to increase the level of electrification of the national economy at the regional level; the provision of assistance (stimulation) in the matter of energy efficiency to consumers at the regional level so as to save on cost of the construction of new power generating facilities

The analysis of tariff policies of energy companies

Let us analyze alternative tariff policies of energy companies in terms of potential economic repercussions for both energy generating company and energy consumer based on the assumption of a certain monopoly power over the latter (in case of an oligopolistic electric power market). [2,3,8] With this end in view, we can distinguish, in general terms, two fundamentally different types of the tariff policy of energy generating companies as far as the relationship with the consumer is concerned.

1) the policy of a short term maximization of the income of the energy generating company, aimed at securing maximum profits from the consumer ("more today");
2) the policy of a long term maximization of the income of the energy generating company, aimed at promoting an effective demand, i.e. aimed at support and advancing of the consumer as the sole source of income of the energy generating company ("more tomorrow"). Let us focus on pros and cons of each strategy.

The advantages of the short term income maximization policy of the energy company: high-speed short-term attainment of super-profits for the energy generating company and no need for expenditure on research and technological development. Disadvantages: lack of development of the energy generating company and shift of the cost burden through increasing rates to the consumer, which more often than not makes the consumer: a) go bankrupt; b) reduce the company's energy demand, among other things: switch to alternative sources of energy; transfer assets to alternative business segments or to other territories; buy energy from other energy generating companies (whenever practicable); c) suspend production/delay the payment for the energy received; d) resort to unauthorized connections to the energy system, which increases the commercial loss of the energy generating company.

Industrial consumers are often not cost-competitive with the import of similar commercial output because of high level energy costs due, among other thing, to the energy generating company's inactivity with regard to the reduction of the energy intensity of the production. The long term policy, though, exposed a paradox: "Increased energy intensity means decreased energy demand" (fig.1).

For the region this policy implies restriction of its economic potential, and for the locals-decline in real income. In the foreseeable future, the energy generating company will most definitely experience a continued deterioration in the financial health, caused by the constant decline in effective demand, the growth of the relative share of non-cash payments in the gross volume of output sold and the enhancement of price for goods and services purchased by the energy generating company itself.

The advantages of the long term profit maximization policy of the energy generating company: the increase of the company’s revenues, owing to the growth / stabilization of energy demand, as well as the social and economic benefits for the state, local authorities and society in general.

To implement this policy the top management of the energy generating company should refrain from the attainment of super-profits "today" at the expense of its consumers. Although this policy improves the investment climate in the region and increases the effective energy demand. In this case,

the statement "the interests of the consumer mean the interests of the energy generating company" becomes a reference point for the selection of the most efficient tariff and investment policy.
The motivation of the energy generating company to employ demand-side management, to implement the policy of a long term maximization of the company's income in addition to external factors (increasing cost of construction and operation of new power plants, uncertainty about prospective energy demand, a growing competition from independent sources of electricity and heat, the non-payments crisis) should be computed by the public authorities on the basis of subject-oriented legal, organizational and economic measures, which are prescriptive, restrictive, advisory and promotional in nature.

Interindustry Input-Output Model Based Analysis of Mutual Influence of Price Fluctuations

It is common knowledge [8-14] that interindustry input-output model data may serve as the basis for the formulation of a competitive output pricing system for various interrelated industries by application of a system of equations of the form

$$P_j = \sum_{i=1}^{n} a_{ij} P_i + Z_j \text{ , } j = 1,..., n, \qquad (1)$$

wherein $Z_j = (d_j + v_j + m_j)$;
herein P_j – price per *j* output unit (output of *j* industry sector);
a_{ij} – the ratio of material cost of *i* output to the manufacturing cost of a *j* output unit;
d_j – deprecation – per *j* output unit;
v_j and m_j– the values of direct labor costs and after-tax profit per output unit of *j* industry.

The last three values represent preset share limits (absolute shares) in the price structure of *j* output unit.
Interindustry input-output model based price calculation differs from standard pricing procedure (as is currently done, for example, in individual operating entities) in that for each output type (output of each industry) price values are combined into a jointly solvable system of equations. Thus, in a certain way it simulates the process of mutually dependent pricing for a set of industry sectors. [15-18] Therewith, the total amount of primary income is aligned with the total volume of the final output (although it does not guarantee the achievement of material and financial balance between the industry sectors – parties of the specified process, since the presented effective demand for the components of the final output remains outside the interindustry interregional input-output model).
Let us redraft the system (1) in a matrix form:

$$P = A^T \cdot P + Z,$$

Wherein A^T– a transposable to *A* productive in a single-point sense matrix.
Let us extract from A^T submatrix A_{Π}^T via its deletion from the former – without limiting the generality – for example, the first row and the first column. A_{Π}^T , consequently, will consist of coefficients of direct costs (constituent elements a_{ij}), consistent with industry sectors (output) $2 \le i, j \le n$. The submatrix A_{Π}^T is also productive (characteristic of the productive matrix).
Productivity A^T means that there exists a positive vector p^0, that must satisfy equality at given positive vector Z^0:

$$P^0 = A^T p^0 + Z^0. \qquad (2)$$

The vector P^0 is, herewith, defined as follows:

$$P^0 = (E - A^T)^{-1} Z^0,$$

wherein E – a unit matrix.
From the equation (2) we get:

$$P_j^0 = \sum_{i=2}^{n} a_{ij} P_i^0 + Z_j^0 + a_{1j} P_1^0 \text{ , } (2 \le j \le n).$$

The following statement is reasonable:

Statement.

Let the value $P_1' > p_1^0$ be fixed. Let us also assume, that $Z_j' \ge Z_j^0$ $(2 \le j \le n)$ and $a_{1j}>0$ for all $j = 1,..., n$[1].

Then $P_j' > P_j^0$ for all $j = 2,..., n$, wherein the vector $(P_2', P_3', ..., P_n')$ represents the pricing system satisfying the equations:

$$P_j' = \sum_{i=2}^{n} a_{ij} \cdot P_i' + (Z_j' + a_{1j} \cdot P_1') \text{ , } \quad (3)$$
$$(2 \le j \le n).$$

Proof.

The productivity A_{Π}^T implies the existence of P_j' $(2 \le j \le n)$ such that

$$P_j' = \sum_{i=2}^{n} a_{ij} \cdot P_i' + (Z_j' + a_{1j} \cdot P_1') \quad (2 \le j \le n).$$

But

$$P_j' = \sum_{i=2}^{n} b_{ij}^{\Pi} \; Z_i' + a_{1i} P_1' \; >$$

$$> \sum_{i=2}^{n} b_{ij}^{\Pi} \; Z_i^0 + a_{1i} P_1^0 \; = P_j^0 (2 \le j \le n), \qquad (4)$$

herein b_{ij}^{Π} – element of the matrix $(E - A_{\Pi}^T)^{-1}$, besides $b_{ij}^{\Pi} \ge a_{ij}$ and $b_{ii}^{\Pi} \ge 1 + a_{ii}$ $(2 \le i, j \le n)$ ■.

Discussion and Final Comments

A meaningful interpretation of the proven allegations could be as follows. Industry sector No 1 enhances the price of the

[1] The last inequality implies a growing demand for the output of industry sector No 1 in all industry sectors of the regional industrial complex. For the electrical power engineering, this assumption is in full conformity with the current state of affairs.

output $(P_1' > P_1^0)$. For other industry sectors, this increase appears to be a negative factor (disturbance effect), that affects business activities and requires counter-measures. Within the relatively short period (the length of the production cycle plus access cycle), when there is no time (and financial means) to develop and implement energy-and resource-saving programs (i.e., change in the ratio of material cost a_{ij}), the only plausible counter measure (it issues from the uniqueness of the solution of the system of equations (3)), as a minimum, to maintain the total value of deprecation, labor costs and after-tax income at the former absolute level ($Z_j' \geq Z_j^0$)in the output price structure (although this will be insufficient for the normal reproduction of capital assets under new circumstances) is the across-the-board price enhancement $(P_j' > P_j^0, j = 2,..., n)$.

The possibility of Z_1 increase appears to be a stimulating goal for industry sector No 1. Indeed,

$$Z_1^0 = p_1^0(1 - a_{11}) - \sum_{i=2}^{n} a_{i1}P_i^0 <$$

$$< P_1'(1 - a_{11}) - \sum_{i=2}^{n} a_{i1}P_i^0 = Z_1^{0'}$$

However, this ratio is true only with the output pricing in other industry sectors held constant. If, as a result of the output price enhancement, after a while industry sector No 1 faces the inequality of the type

$$Z_1^0 \geq Z_1', \quad (5)$$

the above mentioned action will lose its economic rationale.

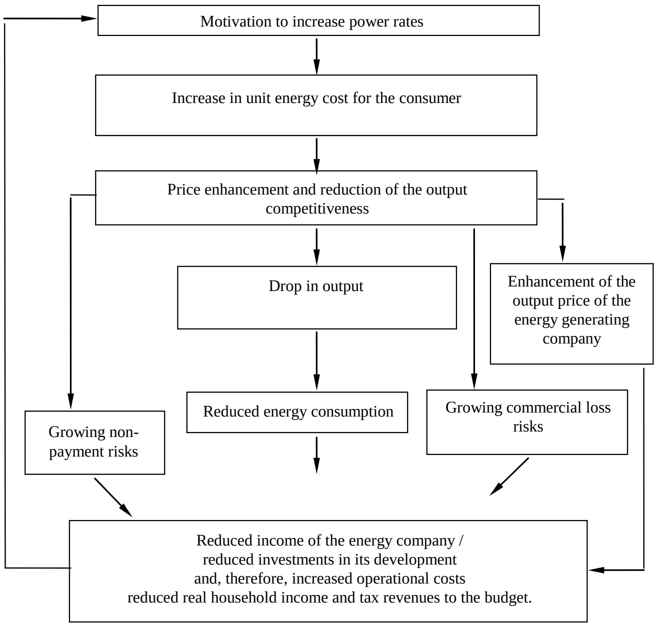

Fig.1 The aftereffect of the short term income maximization policy of the energy generating company

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