# Applying the Dufournaud econometric model to the determination of the prices dynamics impact over the national economy and over its main vulnerable sectors in connection with the Romanian national economy specificity

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## ABSTRACT

In economics, a model represents an abstract, formal image of a phenomenon, process or economic system. It is built by symbolically reproducing the economic theory and by getting new information regarding the behavior of the objective being investigated. In economic theory there are several integrated econometric models meant to underline the interdependency between the branches of a national economy by the public utilities services, especially those connected to energy. The present article presents the first results of our efforts of building an econometric model adapted to the specificity of the Romanian economy, that would underline the impact of the prices modification for public utilities on the Romanian economy as a hole, on the competitiveness of Romanian companies and on the inflation.

## KEY WORDS:
*econometric model, prices, utilities, economic sectors, competitiveness*

The rise of the prices for utilities is motivated by the need of profitability of the public utilities sector. The research has followed the effect of this measure on some of the Romanian economic sectors, on the other prices in the economy, on the competitiveness of the Romanian companies, respectively on the inflation rate. In this purpose, two different methodological approaches have been used, in order to get answers to each one of the problems, respectively:

- the input-output analysis, the input-output data, the technical coefficients and the prices equations for the national economy, approached on 7 branches aggregations and, wider, on 34 branches, in order to determine the impact over the competitiveness of Romanian companies;

- the calculation, on the basis of the prices index published by INSSE, of the impact on the products and services prices of the consumption basket others than utilities, in order to determine this way the impact over the inflation rate.

## 1. Calculation premises for the econometric model

The Adhesion to the European Union placed the Romanian companies in front of a special challenge. The present context is full of opportunities but also a very risky one. Among these risks we can mention: the appreciation tendency of the national currency, which affects exporters; the limitation of the state aids only for exceptional and unrepeated situations, and only with the agreement of the European Commission; the rise of utilities prices; the free competition on the single European market. Among the opportunities we can quote: the interest reduction in the same time with the deflationist process, implying the easier access to credits; the reduction of the corporate income taxes; the diversification of the investment portfolio by the liberalization of the capital account; the participation to European trade organizations, that would defend better the Romanian trade organizations interests; the opportunity of accessing increasing communitarian funds.

The model aims to analyze the utilities prices increase from their impact on the Romanian companies' competitiveness. The utilities prices increase is a process that takes places for several years now, with certain regularity. In the model construction only the prices increase announced in February 2005 have been taken into account, respectively those who were to take place starting with the 1st of April 2005 and during the following period. Thus, the prices increases taken into account, agreed at that moment by the International Monetary Fund, were:

- 35% for natural gas;
- 5% for electric energy;
- 20% for thermal energy.

The utilities prices were among the regulated prices at that time. It was nevertheless considered that, with the liberalization of the specific utilities markets, the rates of these services could also raise in a first stage. The fundamental ratio in the approach of this subject was:

*Utilities prices*
=
*Production cost for utilities + Cost of adaptation to the new environmental conditions*

The cost of production for utilities was and still is very high from several reasons, among which: the old, physically and morally worn; the defective management; the salary expenses that had an increase rhythm that usually surpassed that of the work productivity. To all these we must add the environmental expenses, that Romania adopted during the EU negotiations, which started to be included in the prices, in the same time with the investment process for pollution reduction. The utilities prices increases must cover all the above-mentioned costs. Romania was forced to cease the distribution of financial aids for the utilities sector, being thus forced to let these prices free, determining, from the above-mentioned reasons, but also given the international conditions of the energy market, an unprecedented increase.

The model tended to offer the frame for an impact analysis on the utilities prices increase, in an economy where the ex-ante impact analysis is rare and where the legislative, administrative or fiscal measures are often taken under the momentary pressure, without any analysis of the effects they could have on the economy as a hole and on the companies in particular.

## 2. Presentation of the methodology used in building the new econometric model

The general balance models (CGE) are *general* measurable relationships models that help us describe the ensemble of the economy, at a high conceptualization and aggregation degree, aiming to different markets that interact with each other. The model we realized allows a *static* analysis of the different macroeconomic policies influence on a large number of indicators such as production and internal consumption, imports and exports, workforce occupancy, level of salaries, budgetary revenues and expenses, operational cash flow, polluting emissions reductions etc.

In order to accomplish the objectives of the study the model was run in the Generalized Algebraic Modeling System (GAMS), using the available statistic data from the Romanian National Accounts.

The basis of the statistical information used in the modeling process is made of the Input-Output table, the conception of which belongs to Wassily Leontief.

For the analysis of the environmental policy on the industrial competitiveness by running the CGE model, the elaboration of the Social Accounting Matrix was necessary, which, actually, is an extinguished form of the Input-Output table (U.N., 1999). The statistical information presented under the aspect of a matrix will constitute the input data indispensable for obtaining the results of the modeling process.

The Social Accounting Matrix (SAM), built upon the data existing in the National Accounts 1997 – 1999 and published in 2002 by the National Statistics Institute, is divided into three large blocks. The first represents the internal production of the different activity sectors. The 34 activities that are present in the National Accounts have been aggregated on seven domains: *agriculture; mining; processing industry; energy, gas, water; constructions; transportation; services.* In consequence, the first block of the SAM includes seven columns. The first section of this block, a square matrix made of seven lines and seven columns, reflects the Input-Output classical table. Completing this block, there are some additional lines, such as "Households"[1] and "Operational cash flow"[2]. The utility of these additional lines is that they allow the visualization of the fact that revenues, weather they come from "Salaries", from the profits of the "Non-financial societies and quasi-societies - SQS"[3] or from the "Public administration"[4] transfers are allocated to the population, economic agents abroad ("Rest of the world"[5]) or again to "Public administration". In SAM, as in the Input-Output table, the lines describe outputs, and the columns – inputs.

The second block of SAM is made of the following seven columns. The values presented in the diagonal matrix reflect the internal production (resulting from the first block) out of which we have subtracted the exports. These values represent, in fact, the internal production of the different sectors of activity, allocated to the internal consumption. At this we add the imports for which rates of duty are being paid reflected in the line "Public administration". The sum of the values from the columns of the second block represent internal consumption, at sector level, which include the intermediary consumptions, the final demand of the households, public administration and the gross formation of the fixed capital[6].

The third block of SAM includes, among others, "The row formation of the fixed capital" and the "Salaries". The values presented in the column named "Rest of the world" reflect exportation. The fidelity of the elaboration approach of SAM can be verified using the balance condition. So, the values presented in the line containing the total values, must be equal with those existing in the column corresponding to the total values.

In order to accomplish the objectives of the modeling, we have inscribed, also as input data, the values of the emission of $CO_2$, CO, $CH_4$, $N_2O$, $NO_x$, $SO_2$ and of volatile organic compounds (VOC) generated by the seven activity sectors.

We have noticed that, in the case of the "agriculture" sector, which also includes forestry resources, statistic data have reflected the carbon sequestration effect (over 50 millions tons per year) that the energy sector generated.

As these were, mainly, the input data necessary to our cognitive process, we continued by briefly describing the structure of the Computable General Equilibrium model.

We started by assigning indexes for the seven sectors of the national economy:

i = (AGR, MIN, MAN, EGW, CON, TRA, SER)

The j index was assigned to those sectors with goods or services that could make the object of international trade (in our case all the sectors; if, for instance, the water resources sector was

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1 Households represent the sector which includes the residential institutional units which main function is consumption or, eventually, production, if this is realized by individual entrepreneurs or family associations. The main resources of these units come from salaries, property revenues, transfers from other sectors or from sales of goods and services (INS, 2002).

2 Operational cash flow is the balance of the cash flow account and it shows what remains from the newly created value during the production process after paying the salaries and the production taxes (CNS, BNR, 1998, p.166)

3 Non-financial societies and quasi-societies include the non-financial institutional units that must produce non-financial goods and services for the market the resources of which come from selling their production. In this sector we also include the activity of the public corporations and of the non-financial commercial societies (INS, 2002).

4 Public administration includes the institutional units with the main function of producing services that are not meant for the collectivity and to undertake operations of redistribution of the state's revenues. The financing source of the units included in this sector is the public budget, extra budgetary funds, proper funds (INS, 2002).

5 The rest of the world is an ensemble of accounts that reflect operations that take place among resident and non-resident units (INS, 2002).

6 The gross formation of the fixed capital represent the value of the lasting goods (created for purposes other than military) acquired by the resident production units in order to be used for at least one year in the production process, ans the value of the services integrated in the fixed capital goods (INS, 2002)

independent in the statistic data, it made the object of a separate category, the one of non-merchantable goods).

j = (AGR, MIN, MAN, EGW, CON, TRA, SER)

***Equations used within the Dufournaud CGE model [Dufournaud Ch. M., 1997, 2000]***

CIF prices, used on the internal market, of the important products are defined this way: $DP_j = \overline{WP}_j \cdot ER \cdot (1 + t_j)$

The net prices are given by the equation: $NP_i = P_i - \sum_j a_{j,i} \cdot CP_j - \sum_l a_{l,i} \cdot P_l$

We can notice the distinction between $CP_j$ and $P_l$, in order to underline the difference between intermediary goods within the category of the merchantable goods, respectively of the non-merchantable goods on international markets.

The Armington first degree condition for the merchantable products on international markets is the following:

$$\frac{IM_j}{D_j} = \left(\frac{DP_j}{P_j}\right)^{\sigma_j} \cdot \left(\frac{\delta_j}{1-\delta_j}\right)^{\sigma_j}$$

Giving up the indexes, for simplification, the Armington condition results from the minimization of the following conditioned Lagrange function:

$$£ = DP \cdot IM + P \cdot D + \lambda \cdot \left[ X - \left(\delta \cdot IM^{-\rho} + (1-\delta) \cdot D^{-\rho}\right)^{-\frac{1}{\rho}} \right]$$

By the difference of the Lagrange function depending on IM, respectively D, we obtain:

$$\frac{\partial £}{\partial IM} = DP - \lambda \cdot \left(-\frac{1}{\rho}\right) \cdot \left(\delta \cdot IM^{-\rho} + (1-\delta) \cdot D^{-\rho}\right)^{-\frac{1}{\rho}-1} (-\rho) \cdot \delta \cdot IM^{-\rho-1} = 0$$

$$\frac{\partial £}{\partial D} = P - \lambda \cdot \left(-\frac{1}{\rho}\right) \cdot \left(\delta \cdot IM^{-\rho} + (1-\delta) \cdot D^{-\rho}\right)^{-\frac{1}{\rho}-1} (-\rho) \cdot (1-\delta) \cdot D^{-\rho-1} = 0$$

Making the report and simplifying, we obtain:

$$\frac{IM_j}{D_j} = \left(\frac{DP_j}{P_j}\right)^{\sigma_j} \cdot \left(\frac{\delta_j}{1-\delta_j}\right)^{\sigma_j}$$

The Armington function needs an equation of the compound price:

$$CP_j \cdot (IM_j + D_j) = DP_j \cdot IM_j + P_j \cdot D_j$$

The internal consumption is given by: $D_k = X_k - E_k$

The production function is the following: $X_i = \left(\alpha_i \cdot L_i^{-\rho_i} + (1-\alpha_i) \cdot \overline{K}_i^{-\rho_i}\right)^{-\frac{1}{\rho_i}}$

The capital being fixed, CGE is a short term model.

The labor demand is: $L_i = \left( \dfrac{NP_i}{W} \right)^{\theta_i} \cdot \alpha_i^{\theta_i} \cdot X_i$

Giving up again indexes, for simplification, the previous equation is deducted from the maximization of the conditioned Lagrange function, as it follows:

$$£ = NP \cdot X - W \cdot L + \lambda \cdot \left[ X - \left( \alpha \cdot L^{-\rho} + (1-\alpha) \cdot \overline{K}^{-\rho} \right)^{-\frac{1}{\rho}} \right]$$

By differentiating the Lagrange function by L, respectively X, we obtain:

$$\frac{\partial £}{\partial L} = -W - \lambda \cdot \left( -\frac{1}{\rho} \right) \cdot \left( \alpha \cdot L^{-\rho} + (1-\alpha) \cdot \overline{K}^{-\rho} \right)^{-\frac{1}{\rho}-1} (-\rho) \cdot \alpha \cdot L^{-\rho-1} = 0$$

$$\frac{\partial £}{\partial \mathrm{X}} = NP + \lambda = 0$$

Finally we obtain:

$$L = \left( \frac{NP}{W} \right)^{\sigma} \cdot \alpha^{\sigma} \cdot X \text{, unde } \sigma = 1/(1+\rho)$$

The profits obtained by the different sectors (operational cash flow) are defined as it follows:

$$\Pi_i = NP_i \cdot X_i - W \cdot L_i$$

The exportation demand is given by the following equation: $\dfrac{E_k}{D_k} = \left( \dfrac{WP_k}{P_k} \right)^{\varepsilon_k} \cdot \left( \dfrac{1-\gamma_k}{\gamma_k} \right)^{\varepsilon_k}$

Giving up indexes, the condition of the constant elasticity coefficient is obtained from the following maximization problem of the conditioned Lagrange type function:

$$£ = \mathrm{WP} \cdot \mathrm{E} + \mathrm{P} \cdot \mathrm{E} + \lambda \cdot \left[ \mathrm{Q} - \left( \gamma \cdot \mathrm{E}^{\rho} + (1-\gamma) \cdot D^{\rho} \right)^{\frac{1}{\rho}} \right]$$

By the differentiation of the Lagrange function we obtain:

$$\frac{\partial £}{\partial \mathrm{E}} = WP - \lambda \cdot \left( \frac{1}{\rho} \right) \cdot \left( \gamma \cdot \mathrm{E}^{\rho} + (1-\gamma) \cdot D^{\rho} \right)^{\frac{1}{\rho}-1} (\rho) \cdot \gamma \cdot E^{\rho-1} = 0$$

$$\frac{\partial £}{\partial \mathrm{D}} = P - \lambda \cdot \left( \frac{1}{\rho} \right) \cdot \left( \gamma \cdot \mathrm{E}^{\rho} + (1-\gamma) \cdot D^{\rho} \right)^{\frac{1}{\rho}-1} \cdot D^{\rho-1} = 0$$

By reporting the two equations and simplification, we obtain:

$$\frac{E_k}{D_k} = \left( \frac{WP_k}{P_k} \right)^{\varepsilon_k} \cdot \left( \frac{1-\gamma_k}{\gamma_k} \right)^{\varepsilon_k}$$

The row revenues of the household sector are defined as follows: :

$$Y = W \cdot \sum_i L_i + (1-c) \cdot \sum_i \Pi_i + \overline{TRANS}$$

The net revenues of the households are described by the following equation:

$$NY = (1 - sav) \cdot (1 - inc) \cdot Y$$

The households' consumption of merchantable goods on international market is defined as: $CP_j \cdot C_j = \imath_j \cdot NY$

The households' consumption of non-merchantable goods is given by:

$$P_l \cdot C_l = \imath_l \cdot NY$$

The previous equations are deducted by the maximization of the Cobb-Douglas utility function submitted to a budgetary restriction: $£ = \prod_i Q_i^{s_i} + \lambda \cdot \left( NY - \sum_i P_i \cdot Q_i \right)$

where $Q_i$ represents the households' consumption of "*i*" goods, *NY* the revenues of the households and $P_i$ the price of the good *i*. We mention that $\sum_i s_i = 1$. By differentiating the Lagrange type function by $Q_I$ and $\lambda$ and the simultaneous resolution of the system of equations obtained, it results a demand function for every good or service "i" : $Q_i = \frac{s_i \cdot NY}{P_i}$

The equations describing the row formation of fixed capital follow the same way. For the sectors that commercialize goods and services on the international market the equations are: $CP_j \cdot K_k = \varpi_j \cdot TOTSAV$, and for the rest of the sectors: $P_l \cdot K_l = \varpi_l \cdot TOTSAV$

The sum of the parameters $\varpi$ equals the unit.

The savings, at national level, are given by:

$$TOTSAV = sav \cdot Y \cdot (1 - inc) + GSAV + DEF$$

The state budget revenues, which come from indirect taxes, profit taxes and custom taxes, taxes applied to companies (non-financial societies and quasi-societies) result from the equation:

$$GOVREV = \sum_i ind_i \cdot P_i \cdot X_i + inc \cdot Y + \sum_j t_j \cdot DP_j \cdot IM_j + TAXCOR$$

The budgetary expenses, which represent the sum of the expenses made for the acquisition of goods and services by the state and for the governmental transfers to the "rest of the world", are given by the relation: $GOVEX = CP_{SER} \cdot \overline{G}_{SER} + \overline{GWORL}$

The revenues resulted from the taxation of the companies result from the application of the tax rate on the operational cash flow: $TAXCOR = c \cdot \sum_i \prod_i$

Obviously, the budgetary savings (or the deficit) are equal with the difference between revenues and expenses made from the state budget: $GSAV = GOVREV - GOVEX$

The trade balance is reflected by the difference between the values of export and import: $BAL = \overline{WP}_k \cdot E_k - DP_k \cdot IM_k$

The balance condition on the labor market is given by the relation: $\overline{L} = \sum_i L_i$

The balance condition on the merchantable goods and services markets is synthesized by: $D_j + IM_j = \sum_i a_{j,i} \cdot X_j + C_j + E_j + K_j + G_j$

For the rest of the goods and services, the balance condition is:

$$X_l = \sum_i a_{l,j} \cdot X_i + C_1 + E_l + K_l + G_l$$

Finally, the general prices index is given in the shape of a Cobb-Douglas type relation, as it follows: $NUM = \prod_j \left( \frac{CP_j}{\eta_j} \right)^{\eta_j} \cdot \prod_k \left( \frac{P_k}{\eta_k} \right)^{\eta_k}$

**3. The results of the research**

Four case studies have been made, as it follows:

The Base Case – the application of different environmental taxes: 2 $/tCO$_2$, 3 $/tCO$_2$, 5 $/tCO$_2$, 10 $/tCO$_2$, 20 $/tCO$_2$;

Sensitivity Analysis – model sensitivity analysis ;

Efficiency gain in the energy sector: improving the efficiency in the energy sector by the modification of the Input-Output coefficients;

Agriculture Support – reinforcement of the agricultural sector by directing the revenues resulted from the carbon tax to this sector.

As we have previously mentioned, the model we used allows, among others, the analysis of the carbon taxes influence, in the four cases, on the leu/dollar exchange rate (figure 1). The increase of the energy prices, without any compensatory measures, will lead to the depreciation of the national currency. If, on the contrary, this measure will be accompanied by efficiency increases in the energy sector, weather by supporting the agricultural sector, an appreciation of the national currency will register. We should remember that if the efficiency increase measures are, starting with a value 5$/t CO$_2$, annihilated by the taxes burden, the currency starting to depreciate, the flux of revenues to the agriculture will lead to the national currency reinforcement.

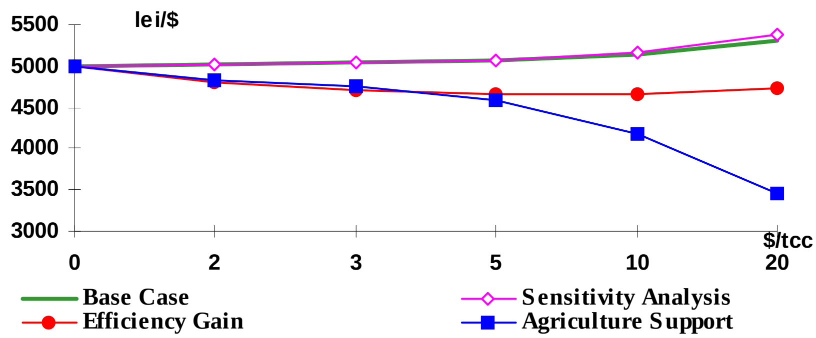


Fig. 1 Influences of the energy prices on the leu/dollar exchange rate, in the four case studies

We have also considered interesting the presentation of the implications of the energy prices increase on the population revenues (figure 2). We notice that only an increase of the efficiency of energy industry can annihilate (but only up to a value of maximum 5$/t CO$_2$) the burden of some carbon taxes. In this scenario, we initially register an increase of the population's revenues.

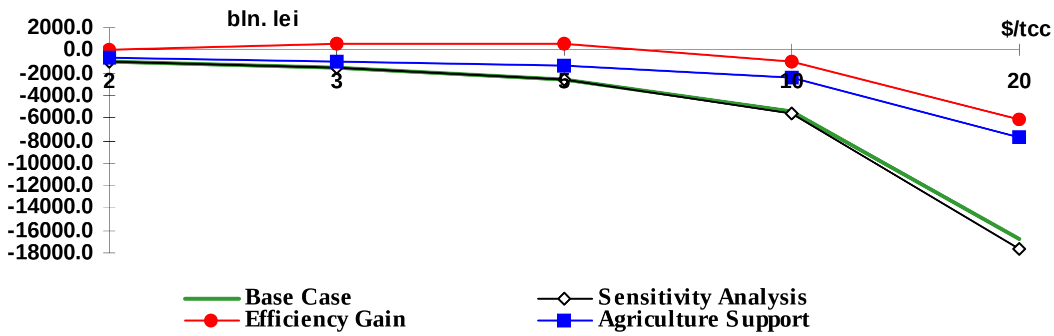


Fig.2. Influences of the energy prices on the population's revenues, in the four case studies

The results of the research allow the analysis of the reaction of the different economy sectors to different levels of taxes on pollution (appendix). For instance, in the case of the application of an environmental tax, if the energy sector seems to be the most affected (as it was expected, being the biggest pollution producer), there are sectors that will register significant increases of the operational cash flow, such as constructions (figure 3). We can thus anticipate the structural modifications of the economy caused by a certain energy prices policy.

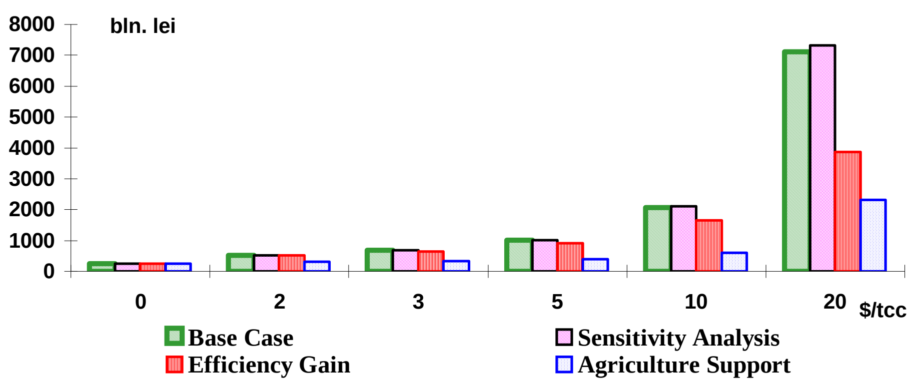


Fig.3. Influences of the energy prices on the operational cash flow in the Constructions sector, in the 4 case studies

The CGE model also allows the quantification of the level of reduction of polluting emissions corresponding to each level of the taxes (figure 4). We can identify, also, the energy policies mix that must accompany the fiscal decision in order to realize the environment protection objectives, as well as those of increase of the population's welfare.

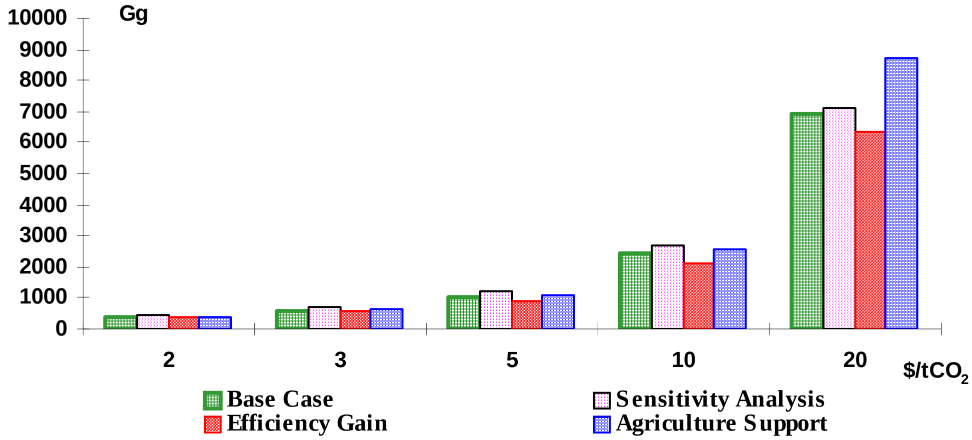


Fig. 4. Reductions of the $CO_2$ emissions corresponding to the different tax levels, in the 4 case studies

Considering the carbon dioxide emissions generated by the National Electro-energetic System (of about 50 millions tons every year), at a level of the tax of 2 $/ton of $CO_2$ will result a total amount of 100 million dollars that should be found in the prices auctioned by the thermal-electric plants at the electricity stock market, with all the implied consequences on their competitiveness.
Also, if the annual specific $CO_2$ emission in the thermal plants using fossil fuels rises to about 1ton/MWh (for instance, in 1998, the specific carbon dioxide emission reported at the production of electrical energy obtained from the thermal plants on fossil fuels was of 1112 g/kWh), it results an increase of the electric energy price by 2$/MWh, which is the equivalent of an increase of about 4%.
**In conclusion**, we state that, by extending the number of variables and of interdependency relations used an econometric model can be built that would evaluate the impact and the influences that the row material end energy prices have on the Romanian industrial products competitiveness, approach that will constitute an essential coordinate of our future research and publishing activity.

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