Mathematical Model for the Study the Romanian Industry Evolution

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Abstract

This paper presents a mathematical model intended to investigate the evolution of the Romanian industry in the last twenty-seven years. Also it includes the calculation of the performance indices for the optimal evolution of the Romanian industry. The data used to build the model were taken from Eurostat and the Statistical Yearbooks of the Romanian National Institute of Statistics.

Key words: mathematical model, optimization, industry, macroeconomic correlations
J.E.L. classification: C10, C50, C61, L10

1. Introduction

The Romanian industry is still an important sector of the Romanian Economy although it has undergone profound changes in the last twenty-seven years. It has the largest contribution to the gross value added in the economy, namely 25,7% in 2016, according to Eurostat. In 1990 the contribution of the industry to GDP was 40%, between 2008 and 2009 it contributed 23-24% to GDP, in 2011 it increased to 22% and then it decreased to 22% in 2016, according to Eurostat.

The period after 1990 is characterized by the appearance and increase of foreign investments, these being positively influenced by restructuring the industry and the economy, by the development of the service sector and by increasing the attractiveness of the legislative framework (Decree Law no.96/1990 provides the measures to attract the investments. The Law no.35/1991 about the regime of foreign investments provides the granting of fiscal facilities. The Government Emergency Ordinance no. 31/1997 provides for the exemptions from the custom duties for all foreign investors and other facilities. The Law no 332/2001 promotes the direct investments with significant impact on the economy. The Government Emergency Ordinance no. 85/2008 encourages the investments located in the economically underdeveloped areas.

Romania's investment strategy obtained better results than those from other states with stronger business environments (Dobrescu E., 2013, pp.5-31).

The present paper tries to make a short study on the evolution of the Romanian industry in the last twenty-seven years, highlighting both the various correlations and the mathematical models as well as the determination of the optimal performance indices: the Gross Added Value, the Labor Productivity and the Gross Domestic Product (GDP).

The database contains the indicators characterizing the Romanian industry between 1990 and 2016. The used indicators are as follows: average net monthly wages, average number of employees, production, intermediate consumption, gross added value, net investment, foreign direct investment, exports, imports, tangible assets, research and development expenditures, change in leu-euro exchange rate, changes in consumer prices. The values of these indicators were taken from Eurostat and the Statistical Yearbooks of the Romanian National Institute of Statistics.

The indicators derived from the above mentioned indicators computed for the same time interval are as follows: degree of labour endowment as the ratio of the tangible assets to the number of employees; efficiency degree of material resources as the ratio of GDP to the tangible assets; industrial access degree as the ratio of import and export to GDP.

The used indicators were converted into the indices reported to the previous year.

All indicator values in lei were converted into dollars and then into euro according to the euro exchange rate given by the Bank of England's Foreign Exchange Desk from London.

The analysis of the macroeconomic indicators was carried out for the total industry and for the manufacturing industry (food, beverages and tobacco; textiles, clothing, leather goods, footwear, means of transport (road transport, trailers, semi-trailer and other means of transport), metallurgy, crude oil processing, chemicals, pharmaceuticals, plastics and rubber, woodworking, furniture, cellulose and paper, non-metallic minerals, electric machines and appliances).

2. Literature review

The relationship between the economic growth and various macroeconomic variables has always been of real interest to researchers.

The book *Macroeconometric Models* by Wladyslaw Welfe presents the summary of the macroeconometric models built by several researchers in various countries from different parts of the world (Wladyslaw Welfe, 2013).

Ulku H. (Ulku H, 2004, pp. 2-35) analyzed the relationship between research and development expenditures and economic growth for 30 countries, by applying a model proposed by Romer in 1986 (Romer P.M., 1986, pp. 71-102).

Pesssoa (Pessoa A., 2007, pp. 1-17) investigates the influence of the research and development expenditures on the economic growth for Sweden and Ireland. For the conclusive results he found it necessary to take into account other indicators too.

Büthe and Milner (Büthe T., Milner H., 2008, pp.741-762) conducted a study on the foreign direct investments in developing countries.

Marina Tkalec and Maruška Vizek (Tkalec M., Vizek M., 2009, pp. 61-92) analyzed the influence of personal consumption, investments, interest rate, government consumption, fiscal deficit on the production for 22 manufacturing sectors.

The researchers Czarnitzki and Toivanen (Czarnitzki D., Toivanen O., 2013, pp. 2-40) studied the influence of the research and development expenditures on increasing the labor productivity and stimulating the investments.

Nistor (Nistor P., 20 14, pp.577-582) evaluated the influence of the foreign direct investments on the Romanian economic growth.

Other Romanian researchers Anghel M.G., Anghelache C, Dumitrescu D.V, Dumitrescu D. analyzed the effect of foreign direct investments and International Trade Balance on the GDP growth using regression models (Anghel M.G., Anghelache C., Dumitrescu D.V., Dumitrescu D., 2016, pp. 130-137).

3. The correlations between the indicators describe the industry evolution

The correlation is a measure for the degree of the statistical link between indicators characterizing the industry evolution. The Pearson coefficient is used to establish correlations between the indicators. Also for each indicator, the average annual growth rate is computed.

Considering the heterogeneity of the studied period, the paper focuses on identification of the structural breakages specific to the main sectors of the industry. So, by econometric testing (Bai-Perron Test) the following structural breakages resulted: food, beverages and tobacco industry in 2004, 2007 and 2013; crude oil processing industry in 2010 and 2013; furniture industry in 1996, 2004 and 2010; plastic and rubber industry in 2006; cellulose and paper industry in 2001, 2005 and 2008; electric machines and appliances industry in 2006.

To determine the macroeconomic correlations the structural breakages in the main industry sectors have been considered.

A fulfillment correlation between the labour productivity and the wages presents a great importance at micro and macroeconomic level. At microeconomic level, the effect is the balance between production, costs and wages. At macroeconomic level, the effect is maintaining the movement of the goods and the money, avoiding the inflationary phenomena.

For a positive economic development with positive influences on the living standards, it is necessary that the labour productivity dynamics outstrips both the wages dynamics as well as the endowment with tangible assets.

The computation shows that in Romanian industry there is no interdependence between the economic results and the wages. The growth rate of the wages is higher than that of the labour productivity. The dynamics of the labour productivity does not outstrip the dynamics of the endowment with tangible assets.

For an industry to be efficient, the labour productivity dynamics must be superior to the intermediate consumption dynamics. Both for total industry as well as for manufacturing industry, the labour productivity is higher than that of the intermediate consumption only in the period 1990-2010, the correlation between them being of the average intensity, with the growth rate of the labour productivity higher than that of the intermediate consumption.

Also the intermediate consumption can incorporate the labour productivity gains in the case of outsourcing an activity or a higher intermediate consumption covered by imports. There is a possibility that purchased items have a higher quality and therefore include productivity gains. This explain that from 2011 the intermediate consumption dynamics is higher than the labour productivity dynamics.

Outsourcing an activity can lead to substitution of the primary production factors, including the labour force with intermediate consumption items. In this case, the labour productivity increases as a direct consequence of outsourcing but it is not influenced by the changes in technical progress or innovation. This explains that for both the total industry as well as for the manufacturing industry, the labour productivity dynamics is higher than that of the research and development expenditures, not being a correlation between these two.

Both for the total industry as well as for the manufacturing industry, there is a higher dynamics of the prices than that of the wages. Prices and wages are in reverse and low intensity correlation, the growth rate of the wages being higher than the growth rate of the consumer prices. This situation leads to a decrease in the purchasing power of the real wages. Also, the correlation between the labour productivity and the leu-euro exchange rate is in reverse and low intensity, the growth rate of the labour productivity being higher the growth rate of the leu-euro exchange.

Gross added value represents the surplus value obtained in the production process highlighting the efficient use of the labour and the equipment. The complexity of the products is higher and the processing rate of the raw materials is higher than the gross added value is higher and the intermediate consumption is lower. In Romanian industry, there is a strong correlation between the gross added value and the production, the growth rate of the gross added value being higher than that of the production. This correlation reflects the decrease in the intermediate consumption and thus the increase of their efficiency. The statistical data shows that in the manufacturing industry, the added value created by the Romanian companies decreases in the period 2008-2016 with an annual rate of 0,47%, and the added value created by the foreign companies increases with an annual rate of 0,96%.

GDP and labour force are in low intensity correlation in the period 1990-2008, the growth rate of GDP being higher than that of the labour force, this situation leads to an increase of the labour productivity. Since 2009, the correlation between the two dynamics is strong but the growth rate of GDP is lower than that of the labour force, so, the labour productivity decreases in real terms.

Between GDP and the tangible assets there is a low intensity correlation with the growth rate of GDP being higher than that of the tangible assets. Also the tangible assets dynamics is higher than that of GDP, this results in a decrease in the efficient use of the tangible assets.

In the Romanian industry, the correlation between the production and the wages is very low, almost non-existent, the growth rate of the wages being higher than that of the production. Due to the lack of optimal correlation, a tendency to increase the wages can be noted, with a pronounced inflationary character.

In conclusion, is necessary to balance the correlations: production – wages, labour productivity – wages and wages – prices.

To balance the above correlations it is necessary a gradual decrease in the material costs, their share being predominant in the production cost for most products.

If the GDP increases faster than the consumption then a decrease in the consumption costs and an increase in profitability of the production is resulted.

After 1990, the correlation between the intermediate consumption and GDP is of average intensity for the total industry, and for the manufacturing industry the correlation is strong. For the Romanian industry the growth rate of GDP is higher than that of the intermediate consumption. Until 2009, GDP dynamics tracks the intermediate consumption dynamics with few exceptions, namely in the years 1996 and 2000. After 2009, the intermediate consumption dynamics is higher than that of GDP and then the consumption increase and thus the production costs.

For the total industry, the correlation between the net investments dynamics and that of exports is low, and for the manufacturing industry there is no correlation between these indicators. The growth rate of the exports is higher than that of the net investments.

Romania's public investment sources are limited by the different priorities such as: payment of the wages and the pensions, keeping the budget deficit under control, etc. Without the investments the economy is losing and then the private funding should be encouraged.

Foreign direct investment is not only a flow of the capital but also technology, knowledge, organizational practices that stimulate and generate the economic growth. There are situations in which the presence of foreign companies can lead to the deterioration of the local companies, to unfair competition, but also to the failure of the local producers. Thus, a strategy is needed to guide the foreign direct investment flows to those sectors and regions where the positive effects to be optimally exploited and the negative effects are reduced as much as possible.

As a general trend, the foreign direct investment dynamics is higher than that of GDP. The correlation between these two dynamics is of medium intensity. For total industry the growth rate of the foreign direct investment is lower than that of GDP, but for the manufacturing industry the growth rate of the foreign direct investment is higher than that of GDP. The situation is due to the fact that in the profitable sectors, the foreign investors convert some of the profit into dividends, these being distributed to the shareholders. Although the remaining volume of the profit is reinvested, it fails to offset losses and distribution of the dividends.

4. Mathematical model

In the present paper, the indicators characterize the evolution of the industry falls into two categories: independent and dependent. Independent indicators are input variables of the models, namely: production, intermediate consumption, net investments, foreign direct investments, industrial access degree, research and development expenditures, degree of labour endowment. Dependent indicators are output variables of the models, namely: gross added value, labour productivity and GDP. To determine the mathematical equations of the models, linear regression and nonlinear regression are used.

For the gross added value, two models were built, both for the total industry and for the manufacturing industry. The models equations are of the following form (1):

$$VAB_i = a_{0i} + a_{1i} \cdot PM + a_{2i} \cdot INV\_nete + a_{3i} \cdot Prod + a_{4i} \cdot inz\_muncii + a_{5i} \cdot G\_d\_i \quad \textbf{(1)}$$

$i = 1,2$; a_{ji}, $j = \overline{1,5}$ are models coefficients; VAB - gross added value;

PM - labour productivity; INV_nete - net investments; $Prod$- production;

inz_muncii - degree of labour endowment; G_d_i - industrial acces degree.

Regression results for the gross added value are presented in the table 1:

Table no. 1: Regression results for the gross added value

Industry	PM	INV-nete	Prod	Inz_muncii	G_d_i	Free term	Accuracy of the model
Total	0,29	0,023	0,53	0,01	-0,007	12,63	0,93
Manufacturing	0,089	0,027	0,96	0,018	-0,014	-3,17	0,97

Source: Processing data modelling

For the labour productivity, two models were built, both for the total industry and for the manufacturing industry. The models equations are of the following form (2):

$PM_i = a_{0i} + a_{1i} \cdot CI + a_{2i} \cdot INV\_nete + a_{3i} \cdot Chelt\_CD + a_{4i} \cdot Prod + a_{5i} \cdot inz\_muncii +$
$+a_{6i} \cdot G\_d\_i \quad i = 1,2$ **(2)**

a_{ji}, $j = \overline{1,6}$ are models coefficients; PM - labour productivity; CI - intermediate consumption INV_nete - net investments; $Prod$- production; inz_muncii - degree of labour endowment; G_d_i - industrial acces degree; $Chelt\_CD$ - research and development expenditures.

Regression results for the gross added value are presented in the table 2:

Table no. 2: Regression results for the labour productivity

Industry	CI	INV_ nete	Chelt_ CD	Prod	inz_ muncii	G_d_i	Free term	Accuracy of the model
Total	-0,9	-0,24	0,0007	2,18	-0,007	0,019	-1,15	0,88
Manufacturing	-1,61	-0,02	-0,002	2,26	0,19	0,009	19,2	0,82

Source: Processing data modelling

For GDP, two models were built, both for the total industry and for the manufacturing industry. The models equations are of the following form (3):

$PIB_i = a_{0i} + a_{1i} \cdot \frac{1}{ISD} + a_{2i} \cdot \sin(G\_d\_i), \quad i = 1,2$ **(3)**

a_{ji}, $j = 1,2$ are models coefficients; PIB – Gross Domestic Product (GDP);

ISD – foreign direct investment; G_d_i - industrial acces degree;

Regression results for the gross added value are presented in the table 3:

Table no. 3: Regression results for the GDP

Industry	ISD	G_d_i	Free term	Accuracy of the model
Total	-3018,33	-3,1	129,55	0,81
Manufacturing	-3927,28	-3,37	138	0,83

Source: Processing data modelling

The accuracy of each model is given by R^2 - the adequacy degree of the model. The model will be adjusted until its value has reached a value closer to 1. To show in the presented models some coefficients were significant, the T-test (Student) was performed for each coefficient of the model.

5. Determining the performance indices for an optimal evolution in industry

Optimization of the performance indices max(GDP), max(labour productivity), max(gross added value)) is performed using an optimization software module based on the direct evolutive search method BOX. The method is used to optimize the nonlinear/linear multivariable functions with explicit and implicit constraints. This method uses a spatial geometric figure called COMPLEX with k – number of peaks, k>n+1, where n- number of variables. COMPLEX changes its shape moving towards the solution of the problem (optimum).

Optimization involves the optimal decision-making and allows the definition of the best policy and strategies in the light of a performance criterion.

It should be underlined that the current use of the model is for a limited time, due to the changes in structure of the studied system, being necessary to readjust the model.

Optimization is obtained only for the total industry.

To maximize the labour productivity, the objective function is the following:

PM = -1,15 – 0,9 * CI – 0,24* INV_nete + 0,0007 * Chelt_CD +2,18 *Prod – 0,007* inz_muncii +0,019 * G-d_i with constraints:

$89 \leq PM \leq 250$; $90 \leq INV\_nete \leq 150$; $11 \leq Chelt\_CD \leq 1258$; $83 \leq Prod \leq 200$

$95 \leq inz\_muncii \leq 200$; $153 \leq G - d\_i \leq 285$

After optimization, the following result is obtained. For an intermediate consumption index of 90% compared to previous year correlated with: net investment index of 100% compared to previous year; research and development expenditures index of 110% compared to previous year; production index of 150% over previous year; degree of labour endowment of 160% compared to

previous year; industrial access index of 200% compared to previous year, labour productivity index will be 223,6% compared to previous year.

To maximize the gross added value, the objective function is the following:

VAB = 12,63 +0,29* PM + 0,023* INV_nete + 0,53 * Prod – 0,007* inz_muncii -0,007 * G-d_i

with constraints: $89 \leq PM \leq 250;\ 90 \leq INV\_nete \leq 250;\ 83 \leq Prod \leq 200$

$95 \leq inz\_muncii \leq 300;\ \ 153 \leq G - d\_i \leq 300$

After optimization, the following result is obtained. For a labour productivity index of 127,99% compared to previous year correlated with: net investment index of 127,4% compared to previous year; degree of labour endowment of 250,8% compared to previous year; industrial access index of 297,68% compared to previous year, gross added value index will be 297,68% compared to previous year.

To maximize GDP, the objective function is the following:

PIB = 129,55 –3018,33* 1/ISD – 3,1* sin (G_d_i) with constraints:

$87 \leq PIB \leq 120;\ \ 89 \leq ISD \leq 250;\ \ 153 \leq G - d\_i \leq 285$

After optimization, the following result is obtained. For a foreign direct investment index of 228,71% compared to previous year correlated with industrial access index of 295% compared to previous year, GDP will be 117,16% compared to previous year.

6. Conclusions

In conclusion, for the profitability of the industry, it is necessary:

- a balancing of correlations: production – wages, labour productivity – wages, wages – prices;
- a strategy for the foreign direct investment flows to reduce the negative effects;
- a reduction in consumption and thus the production costs and an efficient use of the tangible assets
- promotion of the technical progress because often, outsourcing of the activities in companies hides the lack of the technical progress.

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