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# Contributions to Achieving a Mathematical Model for Sustainable Development of an Industrial Organization Manufacturing Welded Parts

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## Abstract

*The paper presents a mathematical modeling approach needed to turn an industrial organization in an ecotechnological organization. The determination of the objective function, of the economical component indicators, of the social component indicators and of the environmental indicators is performed in a particular case for an enterprise manufacturing welded parts, S.C. CONSUD S.A.*
*Based on the specific functions, design graphics, for the determination of the conditions for the transformation of an industrial organization in an ecotechnological organization, were obtained.*

**Key words:** *industrial, organization, mathematical, modeling environmental*

## General

To optimize the development of a special industrial organization manufacturing welded parts (OIFCS) it is needed to find the modeling objective functions for the whole process that can be optimized.

The components of such a model are:

- Objective function, purpose function DDOCS (sustainable development function of an organization manufacturing welded parts);
- Variables (indicators, parameters) and their influence factors;
- Restrictions on variables.

The function for sustainable development of OIFCS can relate to the following aspects [3]:

- It is a global indicator of sustainable development, which partially depends on the indicators (parameters);
- It provides a method for assessing sustainable development, for assessing changes over time and its implementation in an optimal way;
- Based on the analysis of its values, we can make various predictions, expectations, sustainable development;

- We can make the assessment against sustainable development of the functions of several organizations with lessons on not only their growth, but an increase in conditions of "common sense" (ethics, morality) sustainable development;
- Mathematical problems can be solved to optimize functions aimed at the economic, social, environmental, that occur in the expression DDOCS function using the methods of operational research;
- The analysis of the objective function can address and through the numerical methods that relate to the calculation of some functions through the development of discrete values tables.

  Knowing the values of a function *f*, for only a few points in the interval of definition, called interpolation nodes, any function *f*, with *f* having the same values in these nodes will be a function of interpolation for *f*. For example, for the linear interpolation, the graph of *F* is a polygonal line with vertices $[x_i, f(x_i)]$. Other interpolation functions are: Lagrange polynomials, Legendre, Hermite, Cebîşev etc.[1].
- The mathematical model is minimum-maximum, the maximum is the production function and the minimum is the side effects of technological activities;
- The mathematical model is suitable to the optimization criteria (criteria for maximizing profit, maximizing the use of renewable resources, minimize production costs, energy consumption) or can be addressed through the multifactorial optimization (also called Pareto optimization). The general form of the model (problem) is linear programming:

$$\begin{gathered} min(max) \sum_{j=1}^{n} c_j x_j \\ \sum_{j=1}^{n} a_{ij} x_j \leq (\geq) b_i, i = \overline{1,m}, \\ x_j \geq 0, j = \overline{1,m}, \end{gathered} \quad (1)$$

- DDOCS function is a function of time. In turn, this is because economic resource savings are made possible by increased production and profits. So, time has to be part of DDOCS function;
- Computing and considering that its value should be close to the mean, i.e.:

$$f_m = \frac{\min\{f_a^{\prime}, f_o^{\prime}\} + \max\{f_a^{\prime}, f_o^{\prime}\}}{2} \quad (2)$$

  and shape an equilibrium situation.
- It is an indicator values against which we can obtain a hierarchy of industrial organizations and countries around the world that can be delineated based on different areas of human development.

## Objectives

The objectives to be considered for modeling are [2], [4]:

- Establishment of sustainable development office at a general level of industrial organizations. It can be customized by country, region, sector;
- Determination of purpose function at the level of economic, social, ecotehnology, the allocation of mineral resources, environmental, energy and capital, the study of ecosphere integration of newly created socio-economic structures;

- Establishing and calculating indicators (parameters) that occur in the expression of the functions and relations between them;
- Decomposition by orders of magnitude of the indicators components;
- Determination of coefficients (influence factors) for subcomponents and their calculation for the three components of *f* DDOCS;
- Achieving marginal calculation;
- Calculating the ratio indicators (normalized or not) DDOCS, after the formulas:

$$f_m^{\text{DDOCS}}, f_1, f_2, f_3$$

$$p\% = \frac{x_i}{f_m} \text{ or } \frac{x_i}{f_1} \text{ or } \frac{x_i}{f_2} \text{ or } \frac{x_i}{f_3} \mid (\cdot\ 10^{-i_k}), \tag{3}$$

- Hierarchy of industrial organizations:
- In terms of sustainable development branch, county and levels;
- Relative values of certain indicators or

$$f_m^{\text{DDOCS}}, f_1,\ f_2,\ f_3.$$

- Proposal of open issues.

*Note*: This model is designed without the existence of conditions of force majeure (disasters, earthquakes, fires, pandemics etc.) when indicators values approach zero. Also the model can adapt to the economic crisis, when some indicators are null but should also involve the use of chaos theory [3].

## Sustainable Development Function of Industrial Organizations

DDOI function, , *f* (*t*), through which sustainable development can be judged (sustainable industrial organizations), is defined in the following format:

$$f(t) = (f_1(x_1(t), \dots, x_n(t)), f_2\left(x_{n+1}(t), \dots, x_{n+m}(t)\right), f_3\left(x_{n+m+1}(t), \dots, x_{n+m+p}(t)\right) =$$

$$\left(\frac{\sum_{k=s}^{n}\left[\pm p_k(t)x_k(t)\right]10^{i_k}}{n}, \frac{\sum_{k=s}^{m}\left[\pm r_k(t)x_{n+k}(t)\right]10^{j_k}}{m}, \frac{\sum_{k=s}^{p}\left[\pm q_k(t)x_{n+m+k}(t)\right]10^{l_k}}{p}\right) \tag{4}$$

$$f: N_{2010} \to [0,\infty) \times [0,\infty) \times [0,\infty)$$

$$N_{2010} = \{2010, 2011, 2012, \dots\} \tag{5}$$

$$m \qquad f': N_{2010} \to [0,\infty)$$

where: *t* is time expressed in years.

Means since 2010, initially as non-renewable resource reserves are estimated at the time of the year.

In this expression vector functions include the following components:

- function aimed at the economic level:

$$f_1: \Omega_1 \times \Omega_2 \times \dots \times \Omega_n \to [0,\infty) \tag{6}$$

- function aimed at social level:

$$f_2: \Omega_{n+1} \times \Omega_{n+2} \times \ldots \times \Omega_{n+m} \rightarrow [0,\infty)' \quad (7)$$

- function aimed at environmental level:

$$f_3: \Omega_{n+m+1} \times \Omega_{n+m+2} \times \ldots \times \Omega_{n+m+p} \rightarrow [0,\infty) \quad (8)$$

Knowing the definition of their laws, DDOCS function will be known also taking into account the indicators below [10].

## Indicators of the economic component

The choice of indicators used in literature to define:

$$f_1(t) = (f_1(x_1(t), x_2(t) \ldots, x_n(t)) = \frac{\sum_{k=1}^{n} [\pm p_k(t) x_k(t)] 10^{i_k}}{n} \quad (9)$$

where: $x_1$ is the global liquidity indicator, computed as follows:

$$x_1: N_{2010} \rightarrow \Omega_1 \subseteq [0,\infty)$$

$$x_1(t) = \frac{\text{active circular}}{\text{current liabilities}} \quad | \, t \quad (10)$$

$x_2$ – indicator of immediate liquidity, of the form:

$$x_2: N_{2010} \rightarrow \Omega_2 \subseteq [0,\infty)$$

$$x_2(t) = \frac{\text{current active stocks}}{\text{current liabilities}} \quad | \, t \quad (11)$$

$x_{33}$ – discounted net revenue, of the form:

$$x_{33}: N_{2010} \rightarrow \Omega_{33} \subseteq [0,\infty)$$

$$x_{33}(t) = VNA_t = \sum_{h=1}^{DE+DFP} Vh \frac{1}{(1+a)^h} - (Ih + Ch) \frac{1}{(1+a)^h} \quad | \, t \quad (12)$$

$x_{34}$ – rough indicator of the rate of return depending on the action production of the form:

$$x_{34}: N_{2010} \rightarrow \Omega_{34} \subseteq [0,\infty)$$

$$x_{34}(t) = \frac{Q_m \left( \frac{\sum sk_1 \times pk_0}{100} - \frac{\sum sk_0 \times pk_0}{100} \right)}{Q_m c} 100, \quad | \, (t) \quad (13)$$

because the gross level of a product that sells quality classes

$$PB = Q_m (p - c)$$

Average unit selling price (excluding VAT) for the product, i.e. [9]:

$$p = \frac{\sum sk \times pk}{100}$$

$$PB = Q_m \left( \frac{\sum sk \times pk}{100} - c \right) \quad (14)$$

where: $Q_m$ is the production of actual physical commodity, *pk* - unit sales prices (excluding VAT) per class production quality, *sk* - structure of graded physical production, *C* - cost.

$x_{35}$ – indicator computed as labor productivity, of the form:

$$x_{35}: N_{2010} \to \Omega_{35} \subseteq [0,\infty)$$
$$x_{35}(t) = \frac{CA}{N}(\text{direct expression}) \quad |\,(t) \tag{15}$$

where: *CA* is the turnover, *N* - number of employees

$$CA = C\,DB \quad , \tag{16}$$

in which *C* is the cost of turnover; *DB* - gross profit.
or:

$$CA = CA_t = \Sigma\, q\, p \tag{17}$$

in which *q* is the quantity sold, *p* - the selling price.
or

$$CA_t = CA = N\,Z\,h\,Wh, \tag{18}$$

where: *N* is the number of employees, *Z* - number of working days, *h* - number of hours worked per day, *Wh* - hourly productivity.

$$x_{35}(t) = \frac{T}{NA}(\text{direct expression}) \quad |(\text{t}), \tag{19}$$

where: *T* - earnings per share, in the form:

$$x_{36}(t) = \frac{\text{net profit}}{\text{number of shares}} \quad |\,(\text{t}) \tag{20}$$

## Indicators of social component

The choice of indicators was used literature have defined the main indicators of function, like:

$$f_2 : N_{n+1} \times N_{n+2} \times \ldots \times N_{n+p} \to [0,\infty)$$
$$f_2(t) = f_2\left(x_{n+1}(t), x_{n+2}(t), \ldots, x_{n+m}(t)\right) = \frac{\sum_{k=1}^{m}\left[\pm r_k(t)\, x_{n+k}\right]10^{i_k}}{m} \tag{21}$$

where: indicators (parameters) $x_i, \overline{n+1, n+m}$ have the following meanings:

- indicator reflecting the average number of staff of the form:

$$x_{n+1}: N_{2010} \to \Omega_{n+1} \subseteq [0,\infty)$$
$$x_{n+1}(t) = \overline{NS}_t = \frac{\Sigma NZ}{\Sigma z} \quad |\,(t) \tag{22}$$

where: *N* is the number of staff daily scripting, *Z* - number of days the number of staff remained concerned scripting;

- cost of insurance and social protection (CAS, Unemployment, CASS, occupational diseases)

$$x_{n+2}: N_{2010} \to \Omega_{n+2} \subseteq [0,\infty)$$

- expenses for equipment and protective materials

$$x_{n+3}: N_{2010} \rightarrow \Omega_{n+3} \subseteq [0, \infty)$$

- gross average wage / gross average wage in the economy (industry), including [9]:

$$x_{n+s}(t) = \frac{\text{total salary costs}}{\text{turnover}} \mid (t) \tag{23}$$

- an indicator that reflects the work factor remuneration, of the form:

$$x_{n+5}: N_{2010} \rightarrow \Omega_{n+5} \subseteq [0, \infty)$$

$$x_{n+s}(t) = \frac{\text{total salary costs}}{\text{turnover}} \mid (t) \tag{24}$$

## Optimization Problems

FDDOCS optimization objective function can be done by considering a specific question or when the dominant perspective, therefore, will still present some opportunities for optimization. You can set the place it occupies in the industrial organization of a branch (within a county), if it establishes a method for comparing and more industrial organizations, to establish the place it occupies in the organization concerned that organization [7].

To optimize the objective function, were analyzed the results of the calculation of economical, social and environment indicators during the years 2007, 2008 and 2009 (Tables 1, 2 and 3).

**Table 1**. The values of economical, social and environmental indicators for 2007 (extract)

| No | Economic indicators | | Social indicators | | Environment Indicators | |
|---|---|---|---|---|---|---|
| | **Notation** | **Value** | **Notation** | **Value** | **Notation** | **Value** |
| 1. | $x_1$ | 18.0 | $x_{n+1}$ | 15.6 | $x_{n+m+1}$ | 16.0 |
| 2. | $x_2$ | 86.0 | $x_{n+2}$ | 12.32 | $x_{n+m+1}$ | 10.0 |
| 3. | $x_3$ | 48.6 | $x_{n+3}$ | 11.51 | $x_{n+m+2}$ | 10.0 |
| 4. | $x_4$ | 33.3 | $x_{n+4}$ | 10.8 | $x_{n+m+2}$ | 70.0 |
| 5. | $x_5$ | 46.53 | $x_{n+5}$ | 17.10 | $x_{n+m+2}$ | 20.0 |
| 6. | $x_6$ | 76.50 | $x_{n+6}$ | 13.5 | $x_{n+m+2}$ | 0.0 |
| 7. | $x_7$ | 66.59 | $x_{n+7}$ | 95.2 | $x_{n+m+2}$ | 10.0 |
| 8. | $x_8$ | 89.0 | $x_{n+8}$ | 24.3 | $x_{n+m+2}$ | 90.0 |

Functions were determined [12],[13]:.

$$f_1\ [x_1(2007), x_2(2007), \dots, x_{36}(2007)\,] = 35{,}421 \tag{25}$$

$$f_2\ [x_{n+1}(2007), x_{n+2}(2007), \dots, x_{n+39}(2007)\,] = 19{,}45 \tag{26}$$

$$f_3\left[x_{n+m+1}(2007), x_{n+m+2}(2007), \ldots, x_{n+m+46}(2007)\right] = 6{,}54 \quad (27)$$

**Table 2.** The values of economical, social and environmental indicators for 2008 (extract)

| No. | Economic indicators | | Social indicators | | Environment Indicators | |
|---|---|---|---|---|---|---|
| | **Notation** | **Value** | **Notation** | **Value** | **Notation** | **Value** |
| 1. | $x_1$ | 15.2 | $x_{n+1}$ | 17.5 | $x_{n+m+18}$ | 15.0 |
| 2. | $x_2$ | 75.0 | $x_{n+2}$ | 12.6 | $x_{n+m+19}$ | 0.0 |
| 3. | $x_3$ | 45.6 | $x_{n+3}$ | 10.28 | $x_{n+m+20}$ | 16.0 |
| 4. | $x_4$ | 15.2 | $x_{n+4}$ | 96.0 | $x_{n+m+21}$ | 10.0 |
| 5. | $x_5$ | 50.54 | $x_{n+5}$ | 18.59 | $x_{n+m+22}$ | 70.0 |
| 6. | $x_6$ | 68.1 | $x_{n+6}$ | 21.9 | $x_{n+m+23}$ | 0.0 |
| 7. | $x_7$ | 64.2 | $x_{n+7}$ | 89.0 | $x_{n+m+24}$ | 0.0 |
| 8. | $x_8$ | 86.0 | $x_{n+8}$ | 89.2 | $x_{n+m+25}$ | 20.0 |
| 9. | $x_9$ | 70.0 | $x_{n+9}$ | 24.7 | $x_{n+m+26}$ | 30.0 |
| 10. | $x_{10}$ | 22.5 | $x_{n+10}$ | 48.5 | $x_{n+m+27}$ | 10.0 |

**Table 3.** The values of economical, social and environmental indicators for 2009 (extract)

| No. | Economic indicators | | Social indicators | | Environment Indicators | |
|---|---|---|---|---|---|---|
| | **Notation** | **Value** | **Notation** | **Value** | **Notation** | **Value** |
| 1. | $x_1$ | 15.8 | $x_{n+1}$ | 16.2 | $x_{n+m+18}$ | 15.0 |
| 2. | $x_2$ | 98.0 | $x_{n+2}$ | 45.4 | $x_{n+m+19}$ | 0.0 |
| 3. | $x_3$ | 45.6 | $x_{n+3}$ | 49.5 | $x_{n+m+20}$ | 16.0 |
| 4. | $x_4$ | 15.7 | $x_{n+4}$ | 11.2 | $x_{n+m+21}$ | 10.0 |
| 5. | $x_5$ | 71.5 | $x_{n+5}$ | 20.4 | $x_{n+m+22}$ | 70.0 |
| 6. | $x_6$ | 80.6 | $x_{n+6}$ | 13.6 | $x_{n+m+23}$ | 0.0 |
| 7. | $x_7$ | 79.8 | $x_{n+7}$ | 78.9 | $x_{n+m+24}$ | 0.0 |
| 8. | $x_8$ | 30.0 | $x_{n+8}$ | 91.0 | $x_{n+m+25}$ | 20.0 |
| 9. | $x_9$ | 23.0 | $x_{n+9}$ | 37.5 | $x_{n+m+26}$ | 30.0 |
| 10. | $x_{10}$ | 80.0 | $x_{n+10}$ | 20.0 | $x_{n+m+27}$ | 10.0 |

For a correct record of the results, the functions $f_1$, $f_2$, $f_3$ and $f_m$ are plotted for the years 2007, 2008 and 2009 in the graphs from Figures 1, 2, 3 and 4 [5],[6].

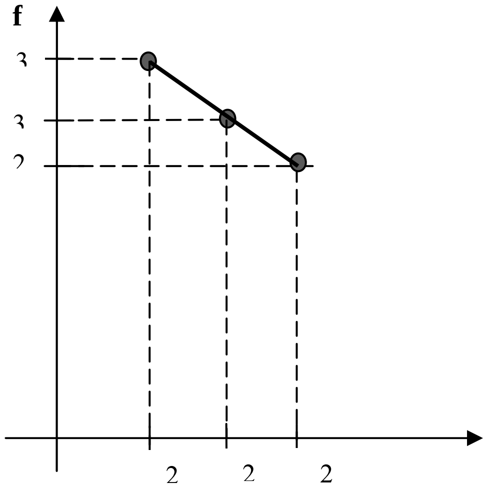

**Fig.** 1. Graph for function $f_1$

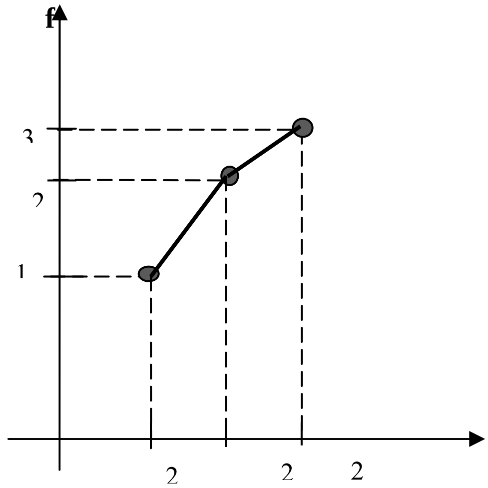

**Fig. 2**. Graph for function $f_2$

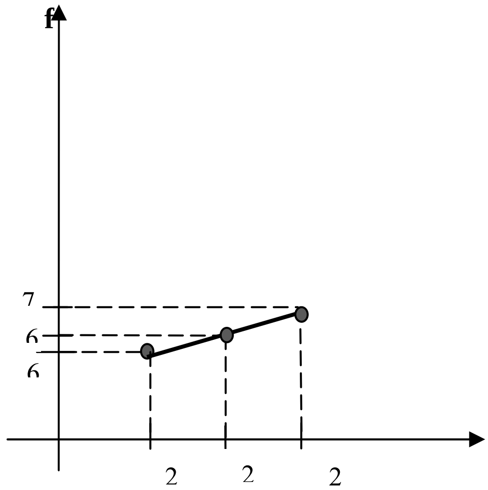

**Fig. 3**. Graph for function $f_3$

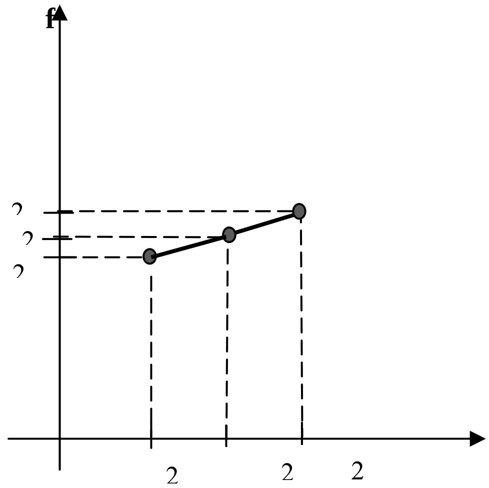

**Fig. 4**. Graph for function $f_4$

## Case Study Conclusions CONSUD S.C.

Studying the character of the graphs in Figures 1, 2, 3 and 4, it can be seen that the trend for the function $f_m$ is increasing, although not all component values $f_1$, $f_2$ or $f_3$ increased (values of function $f_1$are decreasing, the function $f_2$ is increasing, and the function $f_3$ is easily increasing). It can be considered that the organization CONSUD S.C. can not have a "problem" in this case. On the contrary, it is noted an interest in sustainable development [8].

Normally, the target of any industrial organization is making a profit every year that increases the economic component, $f_1$ which considers a development organization. It is true that the profit motive is a necessary condition for the welfare of industrial organization, but aiming for an indecent profit is incompatible with excessive growth and sustainable development, with the introduction of innovations, the creation of added value. In these circumstances, the issue of sustainable development of industrial organization passes in the background. Therefore, it is necessary for sustainable development $f_2$ component and another [11]. As seen from how the proposed optimization, $f_2$ the development of components and attention, $f_1$ even at the expense of, you can not find it affected the development of industrial organization, but more so, it is supported a sustainable development. Even though apparently short-term (three years), lower values $f_1$ of the organization, and ultimately society has an enormous gain, but no foreseeable time limit.

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# Contribuții privind realizarea unui model matematic pentru dezvoltare durabilă a unei organizații industriale de fabricare construcții sudate

## Rezumat


*In lucrare se prezintă o metoda de modelare matematica necesara transformării unei organizații industriale intr-o organizație ecotehnologică . Determinarea funcției obiectiv, a indicatorilor componentei economice, a indicatorilor componentei sociale si a indicatorilor componentei de mediu se face intr-un caz particular pentru o întreprindere de fabricare construcții sudate SC CONSUD SA.*
*Cu funcțiile determinate s-au ridicat grafice de proiectare si determinare a condițiilor de transformare a unei organizații industriale intr-o organizație ecotehnologică.*