ASSISTED DECISIONS IN FARMING MANAGEMENT BASED ON METHODS OF OPERATIONS RESEARCH – LINEAR MULTIOBJECT PROGRAMMING

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Abstract.
Linear programming, as a part of applied mathematics, more definitely – the branch of Operations Research, is seen as a solving method of problems linked to optimization. Each economical problem having as a purpose its optimization, especially concerning the distribution of resources, has in wiew the obtaining of an optimal value of a goal, for example a maximum of the profit, or a minimum of the costs.

Each economical problem depends of a lot factors submitted to some restrictions (constraints). The goal is dependent of these factors, reason for which the goal is found in a mathematical dependence (function) of these factors, named decisional factors. One has in wiew the optimization of an economic goal represented by a mathematical function of more variables. The optimization function represents a goal from the practice of a large variety of areas: technical, pedagogical, medical, agricultural, personnel organization, etc.The discussed function may be called "purpose function", or "goal (objective) function", or "efficiency function". We prefer the name of "objective function". If the dependence of the function of the decisional factors is a mathematical linear one (used in the areas mentioned above), then the problem is a linear progamming one. A linear programming problem can be: a "classical linear programming problem", a "a multiobject problem", or a "transport problem".

In the paper is presented only the "multiobject problem". Is presented the mathematical pattern, the coresponding terminology and also some practical issued solved on the computer in the summaries submitted to the work. Supplementary, we have to mentioned that the authors are the holders of the implementations on computer of the pattern mentioned above, in both known programming environment Fortran 77, C++ and desk computer one.

Key words: multiobject programming, goal function, decisional factors, decisional variables, deviated variables, objective function, restrictions

INTRODUCTION

The paper falls within a context of the wider concerns of the authors, context that we could initial: "Optimal decisions in management and economics based of the methods of operations research". The operations research is the modern scientific approach to complex problems facing the management - in industry, agriculture, animal hasbandry, business, resources use, defense, etc., with a view to producing the best decisions.

Basic concepts of operations research, such as the methods and models of the classical linear programming based on “simplex” algorithms, or “linear multiobject programming” (the last being the goal of this work), or the problems of “transport” and the “repartition”, are pleading for information and training managers in objectives in the areas of essential economical objectives, such as the optimal allocation of resources, drawing optimum production plans, development the human potential (efficient allocation of staff during the course of production requirements), obtaining the maximum benefits from the investment, optimal coverage of the lots in agriculture, obtaining the best biological rations in animal hasbandry, the best strategies of the defense in military, etc.

Depending on the nature of the economical problem or problem into the management subject of the optimization, is considering achieving of a single objective or several objectives simultaneously submitted to the optimizing (some objectives submitted of the minimizing, another objective submitted to maximizing, depending on the nature of each objective). In the second case it is about of a linear multiobject programming. It is the paper's purpose, which presents an of reference enunciation, the mathematical model and the adequate terminology.

Unlike classical linear programming where there is a single objective, in practice management may have regard to the situations involving the achievement of several targets simultaneously. For example, the manager of a company is entitled to pursue simultaneously objectives such as the maximizing of a profit, the investment limited by an fund default that he are available, the increasing of the sales, the maintaining of the employment, etc… Some of the objectives can be achieved, others can not be achieved. In addition, it is possible that some of the objectives would be even conflicting. The manager is the one, that, depending on the importance and priority of the objectives, in order to achieve them, dropping a part of restrictive factors that we have previously called decision makers. The mathematical model that includes coverage of several targets simultaneously is linear “multiobject programming”. In addition, this model can be successfully used as a particular case and for shaping economic issues on which classical linear programming offers no solution.

MATERIAL AND METHOD

Wording of the problem

In the case of linear programming “multiobject” model, frequently is possible we have simultaneous non achievement all the objectives envisaged. Our new model, however, highlights “deviations” from achieving|non achieving these objectives. So is that the model is aimed at minimizing **“**deviations from achieving all the desired objectives”. As a consequence, the model confers of the manager a certain flexibility in choosing the solution. The objectives can have different priorities and shares (importances). By introducing these new elements we obtain various other solutions, solutions that may agree or not by the manager.

Mathematical model.

In contrast to the classical linear programming, in case of “multiobject programming”, to the wording of mathematical model we make a distinguishing between the economical objectives that the manager proposes to him, and the objective function which is alwais submitted to minimizing here. The mathematical expression of the objective function, submitted to the minimizing consists only of deviations (non-negative deviational variables, as the compensation variables) from the achieving economical goals. The objective function will have target destination, clear and simple expression – <it minimizes the amount of the deviates from the economical views taken into the considerations of the manager>.

Restrictions:

Is posible to be present restrictions of the kind of classical linear programming. In addition to these restrictions, we impose the non-negativity of the deviational variables which may appear in the objective function (the expression (2.3) below). It’s about of restrictions:

$$d_1^+, d_1^- \ ; \ d_2^+, d_2^- \ ; \cdots ; \ d_k^+, d_k^- \geq 0$$

(1)

(the non-negativity of the deviational variables conditions).

Objectives:

Let us we have **k** economical objectives, translated into the **k** following mathematical relationships (equalities or | and inequalities):

$$f_i = f_i(x_1, x_2, \cdots, x_n) = \sum_{j=1}^{n} o_{ij} x_j \ :: \ O_i \ , \ i = \overline{1,k}$$

(2).

The matematics operators appointed by the indicator of comparison**:** in the **(2)** can be any of the set**:** $= \ < \ \leq \ > \ \geq$**.**

By introducing the deviational variables d_i^+, d_i^- , $i = \overline{1,k}$, the objectives **(2)** can be simple transformed into equalities, as follows:

$$f_i = f_i(x_1, x_2, \cdots, x_n) = \sum_{j=1}^{n} o_{ij} x_j \ - \ O_i = d_i \ , \ i = \overline{1,k}$$

(2)’

where: $d_i = d_i^+ - d_i^- \ , \ i = \overline{1,k} \ \ (d_i^+, d_i^- \geq 0)$.

Any of relations **(2)** or **(2)'** may appoint “restrictions expressed objectives”.

Objective function

It is the following amount of deviational variables d_i^+, d_i^- subject to minimizing:

$$g_{\min} = d_1^+ + d_1^- + d_2^+ + d_2^- + \cdots + d_k^+ + d_k^- = \sum_{i=1}^{k} d_i^+ + d_i^-$$

(3).

RESULTS AND DISCUSSIONS

In the case that the desired objectives have equal importance (equal share) and equal priority, the expression of the objective function is **(3)** above.

In the case that the objectives are differentiated by the importance (weights), but equal priorities, then the expression of the objective function will contain suplimentary some weights with values stipulated by the manager – "objectives's weights", traditionally noted p_i^+ and p_i^-. In this case, the expression objective function becomes:

$$g_{\min} = \sum_{i=1}^{k} (p_i^+ d_i^+ + p_i^- d_i^-)$$

(3)'.

Instead of the weights, the manager may take in the consideration some penalizing factors p_i^+ and p_i^- which describes the non-achieving purpose degree.

In case that the objectives are differentiated by the priorities, but equal importance (weights), then the expression of the objective function will contain suplimentary some priorities with values stipulated by the manager – "objectives's priorities", noted traditionally P_i^+ and P_i^-. In this case, the expression objective function becomes:

$$g_{\min} = \sum_{i=1}^{k} (P_i^+ d_i^+ + P_i^- d_i^-)$$

(3)''.

In the most general case, that the objectives are both differentiated by the importance (weights) and the priorities, then the expression of the objective function will contain suplimentary the weights p_i^+, p_i^- and the priorities P_i^+, P_i^-. These entities have the values stipulated by the manager – "objectives's weights and priorities". The expression of the objective function is:

$$g_{\min} = \sum_{i=1}^{k} (P_i^+ p_i^+ d_i^+ + P_i^- p_i^- d_i^-)$$

(3)’’’.

Explanatory note:

- The variables $x_1, x_2, \cdots, x_n$ that occur along all the restrictions, inclusively in the **(2)** expressions of restrictions expressed objectives retain the name of *decision variables* and are with non-negative values.
- The coefficients $o_1, o_2, \cdots, o_n$ appearing in the **(2)**, the *coefficients of objectives*, are know constants and they can have any sign.
- The free items $O_1, O_2, \cdots, O_k$ from the **(2)** expression, appointed *values of objectives* are know constants.
- The non-negativities conditions from restrictions, so those on the deviations in the **(1)** are required in order to either return to the algorithm "Simplex", or to use the special program "Goal Programming" recommended for the multi-criteria programming.
- The deviational variables d_i^+ and d_i^-, $(i = \overline{1,k})$ from **(2)'** and **(3)** have the following meanings:
  - d_i^+ shows the amount by which the ***i*** objective was not achieved by the addition;
  - d_i^- shows the amount by which the ***i*** objective was not achieved by default.

(i) If d_i^- deviation is accepted by the manager, then it makes no sense to be present in the objective function; it’s the case of objective ***i****’s* expression with the inegality $\leq$. It will present d_i^+.

(ii) If d_i^+ deviation is accepted by the manager, then it makes no sense to be present in the objective function; it’s the case of objective ***i****’s* expression with the inegality $\geq$. It will present d_i^-.

(iii) If however, are not accepted any of deviations d_i^+ and d_i^-, then both this deviations will be present in the objective function; it’s the case of objective ***i****’s* expression with the egality $=$.

In other words, related to the (i), (ii) and (iii), which is accepted by the manager, has no meaning to be present in the expression of the objective function.

CONCLUSIONS

With the treatment above we are entitled to aspire some results – the solution of an economical concrete problem, treated through the "multiobject" programming.

- We name the ***"solution"*** of a problem treats through the multiobject programming
  (also, that is offered by an execution on the computer of a concrete problem) the following:

(i) the **"optimal context"**, that is the values of the decisional variables: $x_1, x_2, \cdots, x_n$
which concur to achievement of the objectives;

(ii) the **"deviaţional context"**, that is the values of the deviational variables: d_i^+, d_i^- which reflects the degree of achievement | non-achievement of the objectives.

The solution may be analyzed by the manager and he will take a decision in accordance purpose. The manager may introduce new data, new weights and priorities, add. restrictions or gives up to a part of them, until the results indicated by the optimal solution are accepted.

- The authors are the holders of the implementations on computer of the all linear
  programming concept, inclusively linear multiobject programming model described above. The authors's implementations are in both known programming environment: Fortran 77, C++.
- In the end of this paper is presented a model problem based on the linear multiobject programming. The problem is one from the farming management. Here, it comprises an enunciation (wording), the suitable mathematical model and a running on the computer. In accordance with this reference model problem is present a problem (application) during of two summaries. In the first summary is present the running on computer of the problem, and in the other summary a lot of the results interpretations on the solution offered by the runing on the computer are present.

MODEL APPLICATION based on linear multiobject programming
(agricultural area – optimal covering of lots)

Enunciation

"On the three agricultural lots **L1,L2,L3** on intends to grow the cultures **C1,C2,C3**.

(i) As for the doses of growing to one hectare, for these three cultures, the doses are:

- for the culture **C1** is: **200** kg/ha, **150** kg/ha, **100** kg/he respectively on the lots **L1,L2,L3**;
- for the culture **C2** is: **150** kg/ha, **200** kg/ha, **100** kg/he respectively on the lots **L1,L2,L3**;
- for the culture **C3** is: **150** kg/ha, **150** kg/ha, **150** kg/he respectively on the lots **L1,L2,L3**.

(ii) As for the unit costs of cultivation (growing) for one hectare, they are: **500** RON/ha on the lot **L1**, **400** RON/ha on the lot **L2** and **300** RON/ha on the lot **L3**.

(iii) Then, on has expected a growing income from one hectare of **800** RON/ha from the lot **L1**, **700** RON/ha from the lot **L2** and **600** RON/ha from the lot **L3**.

Under the conditions listed above the following objectives are pursued:

Goal 1: To obtain a total income of growing on the three lots of at least **50000** RON;
Goal 2: To cultivate (grow) at least **12000** kg with the culture **C1**;
Goal 3: To cultivate (grow) at least **9000** kg with the culture **C2**;
Goal 4: To cultivate (grow) at least **10000** kg with the culture **C3**;
Goal 5: Do not spend with the entire cultivation more than **30000** RON.

They asked to draw up an optimal coverage of the lots, that is to faithfully fulfill the objectives <===> number of hectares x_1, x_2, x_3 on the two lots **L1,L2,L3** to be recommended to cultivate for the performance 1-5 objectives, including obtaining a total income ***maximum*”**

Settlement data values and values for the objectives

Table 1

The data values of the problem and the values for the objectives

	Lot L1	Lot L2	Lot L3		Restrictions of the objectives
Cultures:				Objective 1:	≥ 50000
C1	200	150	100	Objective 2:	≥ 12000
C2	150	200	100	Objective 3:	≥ 9000
C3	150	150	150	Objective 4:	≥ 10000
Prices per hectare (RON/ha)	500	400	300	Objective 5:	≤ 30000
Income per hectare (RON/ha)	800	700	600		

Mathematical model:

The restrictions that express objectives:

$$\begin{cases} 1) \quad 800x_1 + 700x_2 + 600x_3 + (d_1^- - d_1^+) = 50000 \\ 2) \quad 200x_1 + 150x_2 + 100x_3 + (d_2^- - d_2^+) = 12000 \\ 3) \quad 150x_1 + 200x_2 + 100x_3 + (d_3^- - d_3^+) = 9000 \\ 4) \quad 150x_1 + 150x_2 + 150x_3 + (d_4^- - d_4^+) = 10000 \\ 5) \quad 500x_1 + 400x_2 + 300x_3 + (d_5^- - d_5^+) = 30000 \end{cases} .$$

The restrictions upon the deviational variables's non-negativity:

$$d_1^+, d_1^- \; ; \; d_2^+, d_2^- \; ; \; d_3^+, d_3^- \; ; \; d_4^+, d_4^- \; ; \; d_5^+, d_5^- \geq 0 .$$

Objective function: $g = d_1^- + d_2^- + d_3^- + d_4^- + d_5^+$ subject to the *minimizing*.

Deviational variables that really lack in the objective function expression are superfluous, according to the observations (i), (ii) and (iii) from the explanatory note above.

Running on the computer is done of the scenario present in the Table 2:

Table 2

Scenario: the results offered of running on the computer

Model Application				*(Optimal coverage of the lots)*					
	Lot **L1**	Lot **L2**	Lot **L3**	Income and cultivation (grow)		**d-**	**d+**	**X**	Restrictions for the objectives
Cultures:				50000	(Goal 1)	0	0	55	50000
C1	200	150	100	12000	(Goal 2)	0	250	0	12000
C2	150	200	100	9000	(Goal 3)	250	0	10	9000
C3	150	150	150	10000	(Goal 4)	0	500		10000
Price/ha (RON/ha)	500	400	300	30000	(Goal 5)	0	0		30000
Income/ha (RON/ha)	800	700	600						
Objective function:	250								

Results interpretations:

$x_1 = 55$, which means that are growing **55** ha on the lot **L1**,

$x_2 = 0$, nothing on the lot **L2**,

$x_3 = 10$. **10** ha on the lot **L3**.

$d_1^- = 0$, $d_1^+ = 0$ which means that on obtain a total income exactly **50000** RON;

$d_2^- = 0,\ d_2^+ = 250$ which means that are growing with **250** kg of culture **C1** in addition.
In total: ***12250*** kg;

$d_3^- = 250,\ d_3^+ = 0$ which means that are growing less with **250** kg of culture **C2**
That is: ***8750*** kg;

$d_4^- = 0,\ d_4^+ = 500$ which means that are growing with **500** kg of culture **C3** in addition.
In total: ***10500*** kg;

$d_5^- = 0,\ d_5^+ = 0$ which means that on spends for entire cultivation a total sum of exactly
30000 RON (the estimated sum).

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