IJDPP International Journal of Development and Public Policy
| e-ISSN: 2792-3991 | www.openaccessjournals.eu | Volume: 1 Issue: 5

Types of Nonlinear Programming Problems and Their Application

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Abstract: The article considers the most important issues in the field of production planning and resource management in the country, related to nonlinear programming, and provides for the benefit of the enterprise (firm) in a market economy.

Keywords: nonlinear, boundary functional, local optimal, mathematicalmethods, production, optimization model, firm, profit.

When it comes to mathematical programming, in general $g_i(x_1, x_2, ..., x_n)\{\leq, =\geq\}, b_i, i = 1 \div m$ (1)

satisfying relationships and $Z = f(x_1, x_2, ..., x_n)$ converting the function to maximum, minimum $(x_1, x_2, ..., x_n)$ the problem of finding the values of the unknown is implied.

The terms of this issue can be summarized as follows.

$g_i(x_1, x_2, ..., x_n)$ (1)

$Z = f(x_1, x_2, ..., x_n) \to \max(\min)$. (2)

Here $g_i(x_1, x_2, ..., x_n)$ and $f(x_1, x_2, ..., x_n)$ given features, $b_i, i = 1, m$ s are constant numbers. (1) conditions are the boundary conditions of the matter, $Z = f(x_1, x_2, ..., x_n)$ the function is called the objective function. (1) for each relationship in $\leq, =, \geq$ only one of the characters will be appropriate, and alternatively full characters may be appropriate for different relationships.

In some nonlinear programming problems, some or all of the variables will be conditioned not to be negative. In some cases, some (or all) of the unknowns are required to be whole. (1) - (2) all in question $g_i(x_1, x_2, ..., x_n)$ and $f(x_1, x_2, ..., x_n)$ if the functions are linear, and all variables are required to be nonnegative, the problem will be a linear programming problem. Conversely, if at least one of these functions is a nonlinear function, the problem is called a nonlinear programming problem.

(2) in question $(x_1, x_2, ..., x_n)$ that is, if the boundary conditions are not involved, it is called an unconditional optimization problem, and it is written as follows:

$$Z = f(x_1, x_2, ..., x_n) \to \max(\min); \quad (3)$$

$$(x_1, x_2, ..., x_n) \in E_n. \quad (4)$$

here $(x_1, x_2, ..., x_n)$ n-dimensional vector (point), $E_n - n$dimensional Euclidean space, that is, the addition of vectors, multiplication of numbers, and scalar multiplication of two vectors $x = (x_1, x_2, ..., x_n)$ set of vectors (points).

Suppose that (1) the system consists only of a system of equations, the unknowns are not conditioned to be nonnegative, and that m <n, $g_i(x_1, x_2, ..., x_n)$ the functions are continuous and have at least a second order special product. In this case, the nonlinear programming problem is written as follows:

$$g_i(x_1, x_2, ..., x_n)\{\leq, =\geq\}, b_i, i = 1 \div m \quad (5)$$

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$Z = f(x_1, x_2, ..., x_n) \to \max(\min).$ (6)

Such a problem is called a conditional maximum (minimum) problem, which consists of the equations of boundary conditions. Since the problems of the last (3) - (4) and (5), (3) views can be solved by traditional (classical) methods based on differential calculus, they are called classical problems of optimization.

If all the relations in the system (1) consist of inequalities and some of them correspond to the symbols ≤ and some to the symbols ≥, these inequalities can easily be made to look the same.

Also time $f(x_1, x_2, ..., x_n)$

condition $-f(x_1, x_2, ..., x_n) \to \min$

can be written in appearance. Therefore, without breaking the generality, the problem of nonlinear programming, in which the conditions are inequal, can be written as follows:

$g_i(x_1, x_2, ..., x_n) \le b_i, (i = \overline{1,m})$ (6)

$x_j \ge 0 (j = \overline{1,n});$ (7)

$Z = f(x_1, x_2, ..., x_n) \to \min$ (8)

In matters in which the non-negative condition of the unknown (7) is not involved, such a condition can easily be introduced.

In some cases, some of the relations in condition (1) of the problem may consist of equations and some of the inequalities. Such problems can be written in the form of a minimum problem with mixed terms:

$g_i(x_1, x_2, ..., x_n) \le b_i, (i = \overline{1,m})$ (9)

$g_i(x_1, x_2, ..., x_n) \le b_i, (i = \overline{m_1 + 1, m});$ (10)

$Z = f(x_1, x_2, ..., x_n) \to \min$ (11)

In this case, the relations (9) - (10) consist of boundary conditions, including the condition that the unknown is non-negative.

Now we see the problem given in the following view:

$g_i(x_1, x_2, ..., x_n) \le b_i, (i = \overline{1,m})$ (12)

$x = (x_1, x_2, ..., x_n) \in G \cap E_n,$ (13)

$Z = f(x_1, x_2, ..., x_n) \to \min$ (14)

This issue is a general overview of the finite-dimensional nonlinear programming problem, in which $f(x_1, x_2, ..., x_n)$ – target function, $g_i(x_1, x_2, ..., x_n)$ – boundary functional, G is the area of detection of the problem, and the points of the set G are called (12) - (14) the possible body (area) of the problem.

In nonlinear programming, there is the concept of local and global optimal body (field), which are described as follows.Suppose, x^* point*(12) – (14)*The possible diagnosis of the problem and its minor $\sum(x^*) \in G$ let.

If

$f(x^*) \le f(x^*) \left[f(x^*) \ge f(x^*) \right]$ (15)

inequality is optional $X \in \sum(x^*)$ if appropriate for, (x^*) and (15) the objective function that gives the local minimum (maximum) value to the target function is called the local optimal recognition or global optimal solution.

ISSN 2792-3991 (online), Published under Volume: 1 Issue: 5 in October -2021

If

$f(x^*) \le f(x^*)\left[f(x^*) \ge f(x^*)\right]$

inequality is optional $X \in G$ if appropriate for, X (15) the target function is called the global optimal body or global optimal solution, which gives a global (absolute) minimum (maximum) value.

A universal method similar to the simplex method in linear programming has not been invented to solve the problems (6) - (8), (9) - (11) above.

These are issues $g_i(x_1, x_2,..., x_n)$ ва $f(x_1, x_2,..., x_n)$ s have been little studied for cases with arbitrary nonlinear functions.

The best-studied nonlinear programming issues to date $g_i(x_1, x_2,..., x_n)$ and $f(x_1, x_2,..., x_n)$ functions are convex (concave) issues. Such issues are called convex programming problems.

The main feature of the convex programming problem is that any local optimal solution will be a global solution.

On many issues encountered in economic practice $g_i(x_1, x_2,..., x_n)$ features are linear, $f(x_1, x_2,..., x_n)$ the objective function is quadratic $f(x_1, x_2,..., x_n) = \sum_{j=1}^{n} g_j x_j + \sum_{i=1}^{n}\sum_{j=1}^{n} d_{ij} x_i x_j$

will be. Such problems are called quadratic programming problems. Boundary conditions or objective function, or both of them, are the sum of *n* functions, viz $g_i(x_1, x_2,..., x_n) = g_{i1}(x_1) + g_{i2}(x_2) + ... + g_{in}(x_n)$ (16)

and

$f(x_1, x_2,..., x_n) = f_1(x_1) + f_2(x_2) + ... + f_n(x_n)$ (17)

issues that are called separabel programming issues.

Approximate methods based on the simplex method have been developed to solve quadratic and separabel programming problems. One of the approximate solutions to nonlinear programming problems, including quadratic programming, is the gradient method.

The gradient method can be used to solve any nonlinear programming problem. However, given that this method finds locally optimal solutions to problems, it is advisable to apply it to the solution of convex programming problems.

One of the most important issues encountered in production planning and resource management related to nonlinear programming is the issue of stasis programming. Some of the parameters in these issues may be vague or random quantities.Any of the linear and nonlinear programming problems mentioned above, as well as problems whose parameters do not change with time, are called static problems. Problems whose parameters change over time and are treated as a function of time are called dynamic programming problems. The branch (network) of mathematical programming that includes methods for solving such problems is called dynamic programming. Dynamic programming methods can be used not only to solve dynamic programming problems, but also to solve arbitrary nonlinear programming problems.

CONCLUSION

In order to increase the efficiency of small business and private entrepreneurship, it is necessary to allocate the scarce resources, to choose the most optimal, ie the most optimal option from the multivariate solutions according to the given criteria. An enterprise that manufactures many different products in this field needs to formulate and solve the problem of linear programming. The goal of enterprises is to make a profit, and this requires the optimal allocation of resources and efficient management.

Economic-mathematical methods do not negate traditional methods. It helps to develop them further and to analyze the performance indicators in terms of other indicators in an objectively changing environment. The importance and advantages of mathematical methods and models are: they use material, labor and monetary resources rationally; serves as a leading tool in the development of economic and natural sciences; it will be possible to make some corrections during the compilation of predictions and their implementation; not only in-depth analysis of economic processes, but

ISSN 2792-3991 (online), Published under Volume: 1 Issue: 5 in October -2021

also the discovery of their new unexplored laws and trends; Facilitates mechanization and automation of computational work, mental labor.

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