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policy and commitment of individual countries in the implementation of the objectives of White Paper.

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ON STOCHASTIC MODEL OF THE TRANSPORT PROCESS

We consider some stochastic models of the transport process. A demand is a random variable with known density function. We solve task of transportation assuming that the demand is a random variable with an uniform distribution, a linear distribution and an exponential distribution.

stochastic model, transport process, density function, demand, supply.

Introduction

Let us consider the transport task with random demand (see e.g. [1], [2]). Assume that we have the cost matrix $C = [c_{ij}]$, $c_{ij} > 0$, and $a_1, \dots, a_m$ are the numbers denoting of suppliers supply. The demand of customers is independent random variables with known density functions. Denote by β_j the demand of receipt point j. Let number $k_j\,(l_j)$ be the know loss which is related to the delivery of point j too little (too much) goods in relation to its current demand. By the demand we understand realization (which we do not know in advance) a random variable. The task is to put such a plan, that the sum of the total cost of transport and the expected value of both types of losses is the smallest.

A mathematical model of the problem is the following: we need to find the numbers of $x_{ij} \geq 0$ ($i = 1,\dots, k$; $j = 1,\dots, n$), where x_{ij} is the quantity of commodity to be supplied from the i-th provider to j-th customer, satisfy the condition:

$$\sum_{j=1}^{n} x_{ij} \leq a_i,\ i = 1,\dots, k, \tag{1}$$

for which the function

$$Z = Z_1 + E(Z_2), \tag{2}$$

where

$$Z_1 = \sum_{i=1}^{k}\sum_{j=1}^{n} c_{ij}x_{ij}, \tag{2a}$$

and

$$E(Z_2) = \sum_{j=1}^{n} \underset{\beta_j \geq x_j}{E}[k_j(\beta_j - x_j)] + \sum_{j=1}^{n} \underset{\beta_j \leq x_j}{E}[l_j(x_j - \beta_j)] \tag{2b}$$

the smallest value is achieved.

The symbol $\underset{\beta_j \geq x_j}{E}(\beta_j - x_j)$ indicates the expected value of a random variable $\beta_j - x_j$ in area $\beta_j \geq x_j$, where $x_j = \sum_{i=1}^{m} x_{ij}$ and the symbol $\underset{\beta_j \leq x_j}{E}(x_j - \beta_j)$ is determined similarly.

1 Method

Considered the transport task is the non-linear programming and although it can be reduced to linear models, their solution is considerable computational difficulties. Therefore, we will take into account the special cases of the problem.

The first component Z_1 in the equality (1) for further consideration will be omitted, as it presents the classic model of the transport task. We assume that the quantity of the demand is a random variable β_j with density function of the form

$$f(\beta_j)=\frac{1}{m},\ \text{for } 0\le\beta_j\le m, \tag{3a}$$

$$f(\beta_j)=\frac{2}{a^2}\beta_j,\ \text{for } 0\le\beta_j\le a, \tag{3b}$$

$$f(\beta_j)=\lambda e^{-\lambda\beta_j},\ \text{for } \beta_j\ge 0, \tag{3c}$$

i.e. with the uniform distribution, the linear distribution and the exponential distribution, respectively. Note that in the equality (2b) expression $k_j(\beta_j-x_j)$ is a waste (the product of the loss k_j by the quantity of the lack of goods (β_j-x_j)), which is a result providing a point j too little in relation to its current demand. Similarly $l_j(x_j-\beta_j)$ just is a waste of the product of the loss l_j by the quantity of the surplus of goods $(x_j-\beta_j)$, which is like providing a point j too much in relation to its current demand. The task will be finding such values x_j in order to minimize the function Z_2.

We calculate first the expected value of the expression

$$E(Z_3)=k_j \underset{\beta_j\ge x_j}{E}(\beta_j-x_j)+l_j \underset{\beta_j\le x_j}{E}(x_j-\beta_j), \tag{4}$$

for the density function random variable β_j of the form (3a).

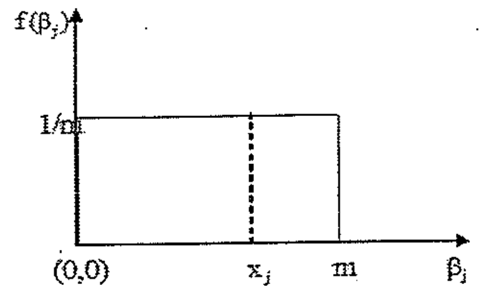

Fig. 1. The probability density function of the uniform random variable β_j

We have (see, e.g. [3])

$$E(Z_3)=l_j\int_0^{x_j}(x_j-\beta_j)\frac{1}{m}d\beta_j+k_j\int_{x_j}^{m}(\beta_j-x_j)\frac{1}{m}d\beta_j=\frac{k_j+l_j}{2m}x_j^2+\frac{1}{2}k_j(m-2x_j).$$

In order to calculate the optimal value x_j^*, we use the differential calculus.

We get

$$\frac{dE(Z_3)}{dx_j}=\frac{k_j+l_j}{m}x_j-k_j$$

and equating the derivative to zero it is easy to see that

$$x_j=\frac{m\,k_j}{k_j+l_j}.$$

The value $x_j=x_j^*=\frac{m\,k_j}{k_j+l_j}$ minimizes $E(Z_3)$, because $\frac{d^2E(Z_3)}{dx_j^2}=\frac{k_j+l_j}{m}>0$, for all x_j, since k_j, l_j and m are positive.

Because $E(Z_2)=\sum_{j=1}^{n}E(Z_3)$, so the total cost of transport of goods for the expected value of both types of losses would be the smallest for

$$x^{**}=\sum_{j=1}^{n}x_j^*=m\sum_{j=1}^{n}\frac{k_j}{k_j+l_j}. \tag{5}$$

In the second case where the density of the random variable β_j is linear we get

$$E(Z_3)=l_j\int_0^{x_j}(x_j-\beta_j)\frac{2}{a^2}\beta_j\,d\beta_j+k_j\int_{x_j}^{a}(\beta_j-x_j)\frac{2}{a^2}\beta_j\,d\beta_j=$$

$$=\frac{l_j}{3a^2}x_j^3+\frac{2k_j}{a^2}\left(\frac{1}{3}a^3-\frac{1}{2}a^2x_j+\frac{1}{6}x_j^3\right).$$

We find value $x_j^*=a\sqrt{\frac{k_j}{k_j+l_j}}$ which minimizes the $E(Z_3)$ because of

$$\frac{d^2E(Z_3)}{dx_j^2}=\frac{2}{a^2}(k_j+l_j)x_j>0.$$

Hence, the total cost of transport of goods for the expected value of both types of losses would be the smallest for

$$x^{**} = a\sum_{j=1}^{n} \sqrt{\frac{k_j}{k_j+l_j}}. \qquad (6)$$

In the third case with the density of the random variable β_j of exponential form, we get

$$E(Z_3) = l_j\lambda\int_0^{x_j}(x_j-\beta_j)e^{-\lambda\beta_j}d\beta_j + k_j\lambda\int_{x_j}^{\infty}(\beta_j-x_j)e^{-\lambda\beta_j}d\beta_j =$$

$$= -l_jx_je^{-\lambda\beta_j}|_0^{x_j} - \lambda l_j[-\frac{1}{\lambda}\beta_je^{-\lambda\beta_j} - \frac{1}{\lambda^2}e^{-\lambda\beta_j}]_0^{x_j} +$$

$$+\lambda k_j[-\frac{1}{\lambda}\beta_je^{-\lambda\beta_j} - \frac{1}{\lambda^2}e^{-\lambda\beta_j}]_{x_j}^{\infty} + k_jx_je^{-\lambda\beta_j}|_{x_j}^{\infty} =$$

$$= \frac{l_j}{\lambda}(\lambda x_j + e^{-\lambda x_j} - 1) + \frac{k_j}{\lambda}e^{-\lambda x_j}$$

and the total cost of transport of goods for the expected value of both types of losses will be the smallest ($\frac{d^2E(Z_3)}{dx_j^2} = \lambda(k_j+l_j)e^{-\lambda x_j} > 0$) since

$$x^{**} = \frac{1}{\lambda}\sum_{j=1}^{n}\ln\frac{k_j+l_j}{l_j}. \qquad (7)$$

2 Remarks

The special cases were applyed to the model in the situation when the demand is stochastic. However, this model could also be considered, when supply would be a random variable. In addition, we can consider models taking into account multiple criteria with solving transport problems (see [4]).

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USABILITY ANALYSIS OF GAME THEORY IN THE STRATEGIC LOGISTICS DECISIONS OF SUPPLY CHAIN – THEORETICAL APPROACH

Strategic decisions in the supply chain are made on the basis of analyzes of the environment including the expected behavior of entities operating in it. These decisions can be analyzed by using game theory. This article presents selected strategic areas in this context. These are the issues: decisions in negotiation, creation of purchase groups, information sharing, profit sharing and risk management in supply chains.

supply chain, game theory, strategies, logistics decisions.

Introduction

Game theory is the study of the choice of strategies by interacting rational agents, or in other words, interactive decision theory [1]. Aumann (1991) suggests that game theory belongs to a third category of theories which are analytic: game theorists analyze the formal implications of various levels of mutual rationality in strategic situations. The analysis tells players what they should do when certain assumptions are met – when others are rational, for instance. There is no guarantee that the assumptions are met; game theory just tells you what to do if they are. It is part of a package of sensible advice, but it is not the whole package [2]. The area of strategic decisions is certainly less dynamic than other areas of decision-making in the enterprise, so it is more susceptible to the application of game theory.

Supply chains strategies are derived from the type of interaction between participants in the chain: cooperation, competition and control [3]. This approach is in line with the theory of games, therefore provides another basis for the verification of the possibility of presentation and solutions of strategic decision problems in supply chains with use of tools elaborated on the basis of this theory.

The situation of decision-making problem of negotiation in supply chain is presented by a tree diagram (fig. 1).