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Interval Planning the Supplies of Scarce Product

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Abstract

The article describes the technology of planning the supplies of scarce product in numeric segments, taking into account the priorities of orders. Formulation of the problem is represented by the system of mandatory and orienting rules to reflect relationships between input and output variables. Input of the problem includes production capacity, orders and their priorities. Output is the supplies plan. The technology presented in the paper is implemented in the online service.

Keywords: interval planning the supplies, priorities of orders, mandatory and orienting rules

1 Introduction

The considered problem refers to the tasks of long-term planning the supplies of scarce products. Given the minimum and maximum production capacity of an enterprise, the minimum and maximum supposed orders from the product customers and priorities of the orders, the efficient supplies plan needs to be found. The informal criterion of efficiency is represented by a vector whose components are profit and market share. The efficiency is estimated by an expert who solves the problem using the Online Resource Planning Services [1, 3, 4]. An expert can change priorities of the orders (and probably, other data) at each iteration of search for appropriate solution. For example, changes in priorities can be based on consent or refusal of some customers to receive the proposed volume of the product.

The solution found by using the proposed algorithm, always satisfies the *mandatory rules* and satisfies *orienting rules* as much as the interval specificity of the problem allows [3]. If fulfillment of orienting rules is possible, the solution corresponding to them is treated as more efficient than any other.

In the known software products for supply planning (for example, SAP [5]), it is assumed that the data is known exactly and can be represented in the form of numeric values. However, given the stochastic nature of the data for this problem, it is advisable to present data in the form of numeric segments.
The technology considered in this article is studied in the framework of scientific research "Creating the methodology of informatization of normalized economic mechanism and software implementation of expert resource planning based on e-services" [4]. The research is executed in the Institute of Informatics Problems at the Federal Research Center "Computer Science and Control" of the Russian Academy of Sciences.

2 Statement of the problem

For a numeric segment $[a, A]$ ($a > 0, A > 0$), which specifies the minimum and maximum production capacity, segments $[b_i, B_i]$ ($b_i \geq 0, B_i > 0, i=1...n$, sum($b_i$, $i=1...n$) $\geq a$, sum(B_i, $i=1...n$) $\geq A$), which specify the orders for a scarce product, and economic priorities of the orders $p_i > 0$ ($i=1...n$), it is required to find the segments $[x_i, X_i]$: {$0 \leq x_i \leq b_i$, $X_i \leq B_i$, $i=1...n$, sum(x_i, $i=1...n$) $= a$, sum(X_i, $i=1...n$) $= A$}, representing the supply plan[1].

3 The technology of interval supply planning

To solve this problem we use the variant of interval method, implemented in the online service "Cost Planning" [1, 3]. The problem is solved iteratively. First, the left bounds of the segments are found, and then the right bounds.

Search for the left bounds
The mandatory rule of supply planning:
sum(x_i, $i=1...n$) $= a$.
For $b_i = 0$, obviously, $x_i = 0$. Let I be the set of indices i for x_i that are not yet calculated ($I = \{i \mid b_i > 0, 1 \leq i \leq n\}$).
The orienting rule is
$x_i / x_j = (b_i / b_j) * (p_i / p_j)$ for each i, j: elem I (notation "i: elem I" means "i is the element of the set I).
Let introduce the variable $\Delta a := a$ (hereinafter := is the assignment operator).
In each iteration for the left bounds which are still not found (j: elem I) we set
$x_j := b_j * p_j$ / sum($b_i * p_i$, i: elem I) $* \Delta a$.
Then we introduce the auxiliary set $I' = \{i$: elem $I \mid x_i \geq b_i\}$. For each i: elem I' x_i is treated as found: $x_i := b_i$.
Next, in case of empty I' we set $I' := I$. Then we change I and Δa:

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[1] Hereinafter formal statements are written in the *TSM* language, which is used for recording specifications of programmable tasks without use of mathematical formula editors [2].

$I := I \setminus I'$, $\Delta a := \Delta a - \text{sum}(x_i, i: \text{elem } I')$.
Now, if I is empty, the iterations are terminated.

Search for the right bounds
The mandatory rule is
$\text{sum}(X_i, i=1\ldots n) = A$.
Let introduce the set I of indices i, for which $B_i > b_i$, and the set K of indices i, for which $B_i = b_i$ ($I = \{1,\ldots,n\} \setminus K$).
The orienting rules are
$(X_i - x_i) / (X_j - x_j) = [(B_i - b_i) * p_i] / [(B_j - b_j) * p_j]$ for each i, j: elem I, and
$X_i / X_j = (B_i * p_i) / (B_j * p_j)$ for each i, j: elem K.
Let introduce the variable $\Delta A := A - \text{sum}(x_i, i=1\ldots n)$.
In each iteration for each j: elem I we set
$X_j := x_j + [(B_j - b_j) * p_j] / [\text{sum}(B_i - b_i) * p_i, i: \text{elem } I] * \Delta A$.
Then we introduce the auxiliary set $I' = \{i: \text{elem } I \mid X_i \geq B_i\}$. For each i: elem I' X_i is treated as found: $X_i = B_i$.
Next, in case of empty I' we set $I' := I$. Then we change I and ΔA as follows:
$\Delta A := \Delta A - \text{sum}(X_i - x_i, i: \text{elem } I')$, $I := I \setminus I'$.
Now, if I is empty, the iterations are terminated.
After the end of iterations it is possible that $\Delta A > 0$. This can happen only if for all i, where $B_i > b_i$, we have got $X_i = B_i$ (otherwise iterations would be continued, and ΔA would increase the bounds where $X_i < B_i$). In this case we distribute ΔA between orders, for which $b_i = B_i$. In each iteration for j: elem K we set
$X_j = x_j + (B_j * p_j / \text{sum}(B_i * p_i, i: \text{elem } K) * \Delta A$. Then we introduce the auxiliary set $K' := \{i: \text{elem } K \mid X_i \geq B_i\}$. For each i: elem K' X_i is treated as found: $X_i = B_i$.
Next, in case of empty K' we set $K' := K$. Then we change ΔA and K:
$\Delta A := \Delta A - \text{sum}(X_i - x_i, i: \text{elem } K')$, $K := K \setminus K'$.
Now, if K is empty, we stop iterations.

Conclusion

The proposed technology, implemented in the online service (http://www.res-plan.com), allows an expert to find efficient and flexible plan for the supplies of scarce product with taking into account different economic factors. The advantage of planning in numeric segments over standard planning is that supplier and customers have more economic freedom. They can define in a contract that volume of supplies has to be in the agreed segment. Possible prepayment may correspond to its left boundary.

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