EQUIPMENT OPTIMIZATION IN REGIONAL AGRICULTURAL LOGISTICS CENTERS

ОПТИМИЗАЦИЯ ОБОРУДОВАНИЯ РЕГИОНАЛЬНЫХ АГРАРНЫХ ЛОГИСТИЧЕСКИХ ЦЕНТРОВ

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Abstract : *A regional agricultural center is a key link in the system of supplying Georgian standard citrus cultures to the goods markets of European countries. The elements of such logistics centers are united into three groups which comprise three large logistics divisions – supply, production and distribution.*

Optimization of the production subdivisions and technical equipment is carried out on the basis of optimizing the whole center by developing a simulation model based on statistical modeling of random streams. At first, a structural-parametrical (qualitative) model of agricultural center was developed. For optimizing the center's technical equipment and operating standards, the combined optimization parameters have been developed. Based on the objective function formalization, there has been developed a system model of planning and optimizing of agricultural center by developing the system constraints. Optimization and algorithmization of subdivisions and the whole system are carried out by decomposition of model on separate blocks, which correspond to separate subsystems of the center.

KEY WORDS: REGIONAL LOGISTICS CENTER, LOGISTICAL SYSTEM, SIMULATION MODEL, STRUCHTURAL-PARAMETRICAL MODEL, DECOMPOSITION, ALGORITHMIZATION.

1. Introduction Export delivery chain of citrus cultures is a complex macro-logistical international transport-logistical system, whose central core is a regional agricultural logistics center. In the center, there are carried out production and processing of products. It has the possible sustainable communications with suppliers and customers.

On the basis of the management principles of delivery chains, in the conditions of unlimted impact of environmental factors, there has been selected the type of a model of system optimization.

2. Preconditions and means for resolving the problem

For modeling of logistics processes that take place in agricultural center we introduce the following designations: *KK* – index of the citrus production farming enterprise $(k \in K)$; *i* – index of peripheral pick-up and production sections, $(i \in m)$; *j*- index of a regional logistics agricultural center, $(j \in n)$; $j_1 -$index of citrus pick-up and processing technological shop, $(j_1 \in G_1)$; $j_2 -$ index of temporary storage of sorted citrus cultures in refrigerating store, $(j_2 \in G_2)$; j_3 – index of package and material resources store, $(j_3 \in G_3)$; $j_4 -$ index of preservation technological shop, $(j_4 \in G_4)$; j_5 - index of packing and consolidation store, $(j_5 \in G_5)$; $j_6 -$ index of temporary storage of finished products, $(j_7 \in G_7)$; $j_8 -$ index of products delivery section, $(j_8 \in G_8)$; $\mu -$index of motor transport motive power types, $(\mu \in \xi)$; $\mu_1 -$index of rolling equipment types, $(\mu_1 \in \xi)$; $i_1 -$ index of picked citrus types, $(i_1 \in \theta_1)$; $i_2 -$ index of sorted citrus types, $(i_2 \in I_2)$; $i_3 -$ index of preserved citrus finished product types; $i_4 -$index of cintrus fruits transportation mode, $(i_4 \in I_4)$; $i_5 -$ index of citrus temporary storage mode in refrigerating store, $(i_5 \in I_5)$; *P* – index of the equipment for roots and packaging means $(p \in P)$; $\delta -$index of the used transport package types $(\delta \in \Delta)$.

When implementing various projects in the field transport and logistics, there is envisaged the combined optimality criterion. It represents: determininf the effects by comparing the obtained integral results P_t and costs $З_t$; doscounting the requsted rates on capital and results at the initial stage, and taking into account the inflation bonus τ of discount rate *i*. These indicators are as follows: net present value maximum *maxSDS* and profitability index (*SI*), internal rate of return *MSN*. For the optimal version, the following conditions should be satisfied $SDS \geq 0$; $SI \geq 1$; $MSN \geq I^{\text{in}}$. The formulas for calculating the combined criteria are as follows

(1)

$$\max SDS = \sum_{t=t_0}^{T} (P_t - З_t) \frac{1}{[(1+i)(1+\tau)]^t} = \sum_{t=0}^{T} K_t \frac{1}{[(1+i)(1+\tau)]^t}$$

.

The profitability index is the ratio of the sum of the reduced effects to the value of capital investments

$$(2)\quad SI = \frac{1}{K} \sum_{t=t_1}^{t} (P_t - З_t^{+}) \frac{1}{[(1+i)(1+\tau)]^t} \ .$$

If $SDS \geq 0$ and *SI>1* – the project is effective and it can be implemented.

An internal rate of return MN is that rate of discount, with which the value of the reduced effects equals the amount of the reduced capital investments

(3)

$$MSN = \sum_{t=0}^{t} \frac{P_t - З_t}{[(1+i)(1+\tau)]^t} = \sum_{t=0}^{t} \frac{P}{[(1+i)(1+\tau)]^t} \geq E_{\text{Sn}}^{\text{in}}.$$

When determining effectiveness and modelling of the logistics objects, there should be examined the system "input-process-output".

The designing and management model of agricultural center is developed on the basis of its structural-parametrical model. Each group in the structural-parametrical model is represented by vector. The model is presented in the following form: $\overline{X}_t$ – is a vector of the input control (uncontrolled) parameters; $\vec{\varphi}(t) -$ a vector of the intermediate parameters; $\vec{\xi}(t) -$ a vector of the perturbation parameters; $\vec{Z}(t) -$ a vector of the technological parameters; $\vec{Y}(t) -$ a vector of the output controllable (state) parameters; $\vec{g}(t) -$a constraint vector.

The output parameters of mathematical model of the center, which represent its functioning are divided into: 1. General parameters of functioning of the center: $\vec{Q}_{ji1}$; P_{ji1}; K_{ji1}; C_{ji1}; R_{ji1}; SDS_{ji1}; MSN_j; SI_{ji1}; 2. Economic indicators of operation of each sub-system of the center: $K_{\mu ji1}$; $C_{\mu ji_1}$; $Q_{j_1i_1}$; $Q_{j_2i_1}$; $Q_{j_3i_1}$; $K_{j_3i_1}$; $Q_{j_5i_1}$; 3. Design parameters: $L_{\mu j}$; S_{ji_1}; P_{ji_1}; $N_{\text{damx}.j}$; P_{ji_1}; $r^{\text{d}}_{ji_1}$; S_{jpmn}; r^{pmn}_j; r^{xad}_j; r^{gk}_j; $t_{\text{cv..}}$; N_{ji_1}; 4. Labor resources and specific indicators assessing parameters: $P_{\text{opt .}}$; P_{meq}; P_{ump}; $C_{\text{xf .}}$; $З_{\text{mtv.}}$; 5. Specific indicators.

Comparison of different versions of the investment projects of the agricultural center and selecting the best one from them is recommended to be carried out on the basis of: net present value maximum (maxSDS_i); profitability index (SI_j); internal rate of return (MSN_j), and recoupment period (GV). This problem can be presented in the vectorial form as follows:

(4)

$$\vec{\Pi}_{ALC} = Y\left(\max \vec{Q}^{\text{br}}_{AC}; \max \vec{P}_{AC};\ \min \vec{З}^{\text{i}}_{AC}; \max \vec{R}_{AC}; \max \overline{SDS}^{\text{mf}}_{AC} \right)$$

.

The methodology for different ways of solving multi-criterion problems is described in the professional literature [3,4].

In order to construct a mathematical model of the center it is necessary to formulate the set of all constraints of the system and general intersubsystem constraints, select the objective function for each of them and for the system as a whole. The objective function, in the general form and with account for auxiliary criteria, is represented in the form of the equations (1-4).

For developing a mathematical model there are used the following designations [1].

In general, the optimal equiomeent of the regional agricultural center and the problem of defining its operation can be formulated as follows: it is necessary to find such plan (structure) and parameters of operating the regional agricultural center

(5)

$$\Pi = \{X_{k_j\mu i_1t}; X_{jj_1i_1t}; X_{j_1j_4i_4i_1t}; X_{jj_3\eta t}; X_{j_4i'_1i_3t}; X_{j_1j_2i_2i_5t}; X^0_{j_2i_2i_5t}; X_{j_2i_2i_5t};$$

$$X_{j_5\,pi_2t}; X_{j_5j_6pi_2t}; X_{j_6pi_5i_2t} \}.$$

that the objective function of macro-logistical effectiveness would reach its maximum value under the following conditions and constraints:

1. The condition of a balnce between production of citrus cultures and demand for them

$$(6)\ \sum_{k\in K}\ \sum_{i_1\in I_2}\sum_{\mu\in\xi}\sum_{i\in T} X_{k\mu i_2t} = \sum_{j=n}\sum_{i_1=\theta}\sum_{t\in T} A_{ji_1t}\cdot\beta'_1 .$$

2. The condition of meeting the demanf for finished products

$$(7)\ \sum_{j_1\in G_1}\sum_{j\in J_4}\sum_{i'_1}\sum_{t\in T}\sum_{i_3\in I_3} X_{jj_4i'_1t} = \sum_{j=G_1}\sum_{j_1\in I_1}\sum_{i_2\in I_2}\sum_{t\in T} X_{jj_1t_1t} =$$

$$= \sum_{j_4\in G_4}\sum_{i'_1\in I'_1}\sum_{i_3\in I_3}\sum_{t\in Y} D_{j_4i'_1i_3t} + \sum_{j_2\in G_2}\sum_{j_6}\sum_{i_5\in I_5}\sum_{p\in P}\sum_{i_2\in I_2} D_{j_2j_6i_5i_2t}\,.$$

3. The condition of using of roots and packaging

(8)

$$\sum_{p\in P}\left[(1+K_{\text{rez}}+K_{\text{rem}})\sum_{t\in T}\sum_{i_3\in I_3}\left(\frac{X_{jj_1pi_3t}\cdot t^{\text{br}}_{pjj_1}}{[G]_{i_3t}\cdot T}\right)+\sum_{p\in P}\sum_{i_2}\sum_{t\in T}\frac{X_{jj_ipi_2t}\cdot t^{\text{br}}_{jj_1}}{[G]_{i_2t}\cdot T}\right]\le$$

$$\le N_{jpi_2t} + N_{jpi_3t}\,.$$

4. The condition of using of labor resources

$$(9)\ \sum_{t\in T}\sum_{j\in n}\ \sum_{j_1\in n_1}\sum_{r\in R}\sum_{m\in M} Q_{jjrm}\cdot Ц_{jj_1rm} \le SR_{j_2j_1rm}\,,$$

where, $r-$ labor resources multiplicity index;

$Ц_{jj_1rm}-$ labor resources norms when performing the operations;

$SR_{jj_1rm}-$ the condition of the existence of labor resources multiplicity during the time of market sub-systems ϑ;

5. The condition of variables integrality and positivity property:

$$(10)\ X_{kj\mu i_1t}\ge 0;\ X_{jj_1i_1t}\ge 0;\ X_{j_1j_4i_4i_1t}\ge 0;\ X_{j_1i'_1i_3t};$$

$$X_{j_1j_2i_5i_5t}\ge 0;\ X^0_{j_2i_2i_5t}\ge 0;$$

$$X_{j_2i_5i_2t}\ge 0;\ X_{j_5pi_2t}\ge 0;\ X_{j_5j_6pi_2t}\ge 0;$$

$$X_{j_5pi_5i_2t}\ge 0.$$

$$p\in P;\ \mu\in\xi;\ t\le T;\ \delta\in\Delta;\ i_1\in\theta.$$

A mathematical model (5-10) is solved through its decomposition on the separate blocks, which correspond to the sub-systems and components of agricultural center.

3. Conclusion

1. A regional agricultural center is a multi-purpose complex, production logistical system. It pertains to the category of integrated production-distributing logistical systems, which operates under conditions of ambient probability-infinity factors;

2. Studies of optimizing technical equipment and operation of agricultural center should be carried out on the basis of methodology for analysis and synthesis of the complex systems, which envisages its structural-imitating modeling based on statistical simulation. The use of these models allows taking account for real working conditions in designing that increases efficiency of designing.

3. With the purpose of extension of operation life of agricultural center, we belive that it is expedient to raise the issue of icreasing operation durability of such-type objects by changing their specialization that will ensure its operation throughout the year.

4. Literature

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