

# A GENERALIZED MATHEMATICAL MODEL OF OPTIMIZING INTERMODAL SUPPLY SYSTEM OF EXPORT CITRUS FRUITS TO INTERNATIONAL MARKETS

## ОБОБЩЕННАЯ МАТЕМАТИЧЕСКАЯ МОДЕЛЬ ОПТИМИЗАЦИИ СИСТЕМЫ ИНТЕРМОДАЛЬНОЙ ДОСТАВКИ ЦИТРУСОВ НА МЕЖДУНАРОДНЫЕ РЫНКИ

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**Abstract:** *The citrus fruits export supply system is a complex micro-logistics international transport logistical system. It pertains to intermodal transport supply chain of exported products. The central link in the chain is a regional agricultural logistic center, where the products are processing and preparing for shipping. The agricultural center is distinguished by a multitude of possible ties with suppliers and buyers, and as far as possible it is located in their geographic center.*

*The goal of the logistic system as a complex structure, is to create an optimally functioning logistic system and develop a scientific-technical methodology of development on the basis of principles of intermodality, international marketing and supply chain management in the conditions of an indeterminate impact of external factors.. In accordance with the developed optimization procedures, there have been optimized the parameters and selected the values of studying parameters at a level of probability belief.*

**KEY WORDS:** INTERNATIONAL SYSTEM OF CITRUS FRUITS SUPPLY; AGRICULTURAL LOGISTIC CENTER; TRANSPORT SYSTEM OPTIMIZATION .

### 1.Introduction

The citrus fruits export supply system is a complex micro-logistics international transport logistical system. It pertains to intermodal transport supply chain of exported products. The central link in the chain is a regional agricultural logistic center (focusing company), where the products are processing and preparing for shipping. The agricultural center it is located in the center with a multitude of possible ties with suppliers and buyers.

In a supply system, the material flow is directed from the left (upstream: procurements – raw material zone – agrarian enterprises) to the right (downstream: supply sphere). An ultimate consumer (an international market) can order the products. Then the whole system is set in motion.

An organizational mechanism of intermodal supply system illustrates interaction of global supply chain of exported cargo (agrarian enterprises, motor vehicles, agricultural center, sender port, railway and maritime transport, ferry line, destination port, distribution center (terminal), destination station).

### 2. Preconditions and means for resolving the problem

The goal of the logistic system as a complex structure, is to create an optimally functioning logistic system and develop a scientific-technical methodology of development on the basis of principles of intermodality, international marketing and supply chain management in the conditions of an indeterminate impact of external factors. Based on that, there has been chosen the type of an optimization model of this system, which envisages planning of transport processes in addition to production and storage processes. As a general model, there have been chosen a combined model of supply chains strategic management. It comprises: the optimization models of raw material zone location and motor transportation (upstream on route “farming enterprises - agricultural logistics center»); the economic-mathematical optimization models (production areas) of refrigerated warehouses and technological sites of the agricultural center; an optimization mathematical model of classical intermodal railway-motor vehicle-maritime

transportations on route “the agricultural center – railway-maritime (ferry) transportations - destination station – an optimization mathematical model of motor vehicle transportation systems”; an optimization mathematical model of terminal-type transportation complexes (sender ports – destination ports and destination terminals) with a multistage transportation (downstream), in the way of global supply chains. The price setting processes in the logistical chains have been optimized with the use of international supply basic terms and conditions of «Incoterms 2010» - EXW, FOB, FCA, DDP, DAT and DAP [1].

For developing a mathematical model, we introduce the following designations: the citrus producer farming enterprise – ( $k \in K$ ) ; peripheral pick-up and production sections – ( $i \in m$ ) ; regional agricultural logistic center - ( $j \in n$ ) ; citrus pick-up and process area - ( $j_1 \in G_1$ ) ; sorted citrus temporary cooling warehouse - ( $j_2 \in G_2$ ) ; package and material store – ( $j_3 \in G_3$ ) ; conservation process area - ( $j_4 \in G_4$ ) ; packing and consolidation store ; ( $j_5 \in G_5$ ) ; finished products delivery and railway freight line ( $j_8 \in G_8$ ) ; motor vehicle transport stock - ( $\mu \in \xi$ ) ; railway rolling stock - ( $\mu_1 \in \xi_1$ ) ; finished products temporary store - ( $j_6 \in G_6$ ) ; collected citrus varieties - ( $i_1 \in \theta$ ) ; sorted citrus varieties - ( $i_2 \in I_2$ ) ; sorts of the off-test citrus raw materials – ( $i_3 \in I_3$ ) ; sorts of the conserved citrus raw materials - ( $i_4 \in I_4$ ) ; young planting and packaging devices - ( $p \in P$ ) ; types of the used cargo containers ( $\delta \in \Delta$ ) ; types of the high-tonnage (20' and 40') multipurpose containers - ( $\varepsilon \in \mathcal{E}$ ) .

For evaluating efficiency of processes occurring in supply logistical subsystems and selecting the optimal version from several alternative ones, there has been developed the system of the combined use of optimality criteria, which brings together the

maximum of the combination of purely discounted revenues, profitability index and internal rate of return ( $\max SDS^{ML} \geq 0$  ;  $SI \geq 1$  ;  $SSN^{ML} \geq E^{in}$  ).

Based on the selected optimization criteria and logic of material flow direction, there has been developed a generalized mathematical model of by taking into account the restrictions and conditions as follows : 1. The balance conditions between the citrus production and demand in the agricultural center ; 2. Conditions of meeting the demand for the finished products ; 3. Conditions for balancing of practical capacity of tying-up berths ; 4. Conditions of using transport rolling stock ; 5. Conditions of using young planting and packeting devices ; 6. Conditions of integrality and positivity of variables [2].

There have been developed the optimization logarithm of logistics chains schemes on the international commodity markets and service charge by using Incoterms-2010 terminology, which imply the interaction scheme of intermodal transportation supplies of export citrus fruits in the following form : dominant enterprise (EXW) – rail transportation (FCA) – port of transit ; an intermodal operator (FCA/FOB) – sea (ferry) transportation – port of destination - rail transportation (CFR/CIF) – rail delivery – destination terminal (DAT) – motor vehicle transport – consignee, destination station (DDP/DAP). There also have been carried out structural-functional studies of logistical, regional logistical and supply systems, and developed the methodological bases for mathematical modeling of intermodal supplies of export citrus fruits to international markets. By taking into account a functional volume of Eastern Europe commodity markets, basic supply conditions Incoterms-2010 and the functions of management intermodal operator, there have been developed the scheme for forming supply chains of Georgian export products to Eastern Europe commodity markets and export prices. Also, the functional scheme of the nodal complex for problems solving has been developed.

On the basis of export products supply intermodal system and optimization methods, there have been developed the methodological foundations for constructing a simulation model of this system management, and its logic and outline flowcharts have been developed as well [3].

The system studies of the supply intermodal systems have been carried out on the basis of the parameter systematization and classification, and its structural parameter model has been constructed and the outline flowchart has been offered in the expression «inlet-process-outlet». The input and output parameters as well as functional parameters of the developed market logistical sub-systems have been classified. A summary table of the technical and economic parameters has been also developed.

Intermodal supply systems of subtropical export cultures have been decomposed into the following subsystems :

1. Optimization of citrus fruits motor transportation on route «farming enterprises- agrarian logistics center»;
2. Optimization of structural-functional and technical equipment of regional agrarian logistics centers;
3. An optimization mathematical model of a transport subsystem of intermodal supply chain of export citrus fruits to international markets ;

4. A optimization and planning mathematical model of a transport subsystem of rail packaging transportations;
5. An optimization mathematical model of citru export supplies by motor transportation on route « destination terminal – destination station ».

Based on the optimization criteria, there have been developed formalization of mathematical models, studied parameters and developed the optimization algorithm flowcharts. In accordance with the developed optimization procedures, the optimization parameters and the value of studying parameter have been identified at a reliable probality level  $P = 0,95$  .

### 3. Conclusion

1. The citrus fruits export supply system is a complex micro-logistics international transport logistical system. It pertains to intermodal transport supply chain of exported products. The central link in the chain is a regional agricultural logistic center (focusing company) with a plurality of connections with suppliers (upstream) and consumers (downstream).
2. The goal of the logistic system studies as a complex structure, is to create an optimally functioning logistic system and develop a scientific-technical methodology of development on the basis of principles of intermodality, international marketing and supply chain management in the conditions of an indeterminate impact of external factors.
3. As a general model of intermodal supply system optimization in the conditions of an indeterminate impact of external factors, it is expedient to choose a combined model of supply chains strategic management, which implies planning of transportation processes and production and storage processes simultaneously, but as an optimality criterion, there must be used a combined system of criteria using, which brings together the maximum of the combination of purely discounted revenues, profitability index and internal rate of return.

### 4. Literature

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