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Using Optimization Problems for Networks When Choosing the Fish Products Delivery Routes Through Alternative Hubsa

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Abstract

Restrictions on the Russian fish products supply to the People's Republic of China resulted in the emergence of cargo flows to China through other countries and the redirection of flows to the central part of Russia. The possible appearance of new distribution centers in the Russian Far East will create additional fish products delivery routes to the central regions of Russia and China. The paper presents methodological approaches to the selection of routes using a modification of the network problem.

Keywords: Transport leg; Shipment charges; Route choice; Fish products distribution hub

Introduction

The functioning of the Russian economy in the context of the COVID-19 pandemic is forcing the Russian government to change the transport development strategy in the Far East of the country. The changes will also affect the transport system serving the fish products traffic. This is primarily due to the success in marketing the Far Eastern fish brands to the food market in the central part of Russia. This led to an increase in domestic demand for Far Eastern fish products. A significant obstacle to supplies increase was the lack of refrigeration tanks in Russian Pacific ports. Therefore, in the next five years, one should expect the emergence of powerful competing hubs in the territories close to the fishing areas.

First of all, it is the creation of a transport and logistics center in Petropavlovsk-Kamchatsky. The project is being implemented by the "Seroglazka Terminal" company, which actively cooperates with the world leader in the field of container transportation - the Danish company Maersk Line. The terminal will become the base port for the nuclear-powered container-lighter carrier "Sevmorput". The vessel will be used to deliver fish products in containers to the ports of Arkhangelsk and Ust-Luga. The operation of the lighter carrier will create an alternative to the Trans-Siberian Railway. And the use of Siberian rivers for the container's delivery from a lighter carrier to the regions of Siberia, with subsequent shipment to the northern regions of China, can make this route more attractive compared to the route through Dalian or Vladivostok.

One of the ports of the Sakhalin Region may become a major hub after the completion of the bridge building between the mainland and Sakhalin Island. The bridge building is supported by plans for the development of the Baikal-Amur Railway and the Trans-Siberian Railway. A large fish hub is being designed in the Primorsky Territory. The fish producers' interest in the domestic market is supported by a significant drop in fish sales to the People's Republic of China. The rejection of fish caught by Russian producers is associated with the discovery of coronavirus traces on the products packaging. At the same time, the supplies volumes of Russian fish to China through the Republic of Korea increased. Considering the activity of Russian fishing companies in the markets of Japan and South Korea, we can talk about the emergence of new flows from fishing areas to China through intermediate warehouses in South Korea.

Thus, several additional routes arise, in addition to supplies through Qingdao and Dalian. And while eliminating the COVID-19 threats, these routes will be actively used. The emergence of alternative delivery routes makes it urgent to return to solving optimization problems of route selection. The development of simple algorithms for artificial intelligence makes the task in demand for large fish products suppliers and for owners of storage tanks in hubs when making decisions to improve business processes. The use of existing linear programming algorithms for this purpose, a transport problem with intermediate points in particular, encounters a number of obstacles that make the calculation procedures cumbersome and inconvenient for current planning. Particularly, there are restrictions on the availability of refrigerated containers, lack of storage space during peak delivery periods, discrete dispatch to one recipient, and a number of more insignificant factors.

However, this problem can be reduced to a network problem after some modification. And then one can go to the tools of dynamic programming. The essence of the problem is to find interconnected movements along the transport network, which together give the minimum costs for the movement and temporary storage of a fish products batch from the fishing area to the consumer's warehouse (the shortest path network problem). The network is built of nodes and arcs connecting the nodes. The node corresponds to the place of fish products transshipment from one type of transport to another, or to the storage areas of the terminals. An arc is a route section between two nodes, which coincides with any transport artery of the region, and is evaluated by the cost value of passing this route section.

The cost value at each route section depends on the fish products storage time at intermediate distribution refrigerators (or warehouses and sites), tariffs for loading and unloading operations, and transportation costs by sea and land. Thus, the network will be composed of arcs of several types, differing from each other in the ways of generating costs. The first type of arches is arches, which include the costs of transporting fish products from the point of reception at sea to the berth of the marine terminal. The second type is arcs with transportation costs by rail from one warehouse complex (or terminal) to any other. The third type is arcs with transportation costs by road from one warehouse complex (or terminal) to any other. The fourth type is arches with costs of loading and unloading operations, registration, and storage of fish products in the storage tanks of one terminal. On the network diagram, such an arc is indicated by the section Point X (T) - Point X (T).

To reduce storage costs, it is possible to enter into the network of regional distribution hubs, close to the warehouses of the final recipients of fish products. The expediency is associated with a significant difference in tariffs for storage of goods in the Far Eastern warehouses and warehouse complexes of the Siberian and central regions. The choice of the geographical area for the location of the distribution hub is influenced by the amount of cargo traffic to nearby territories, the frequency of fish products deliveries, the availability of storage tanks. The criterion for choosing is the minimum cost of storing and transporting fish products to the adjacent regions.

$$Z = S_{cki} * (Q - Q_i) + \Sigma S_{Tij} * Q_j * L_{ij} \quad \rightarrow \quad min \qquad (1)$$

where:

S_{cki} – storage cost of a conditional ton of fish products at point i, rubles / ton.

Q - freight traffic to the selected federal district, tons.

Q_i - freight traffic to the geographical area of the federal district with the proposed distribution center, tons.

S_{Tij} - tariff for 1 ton transportation from point i to point j, rubles / t-km.

$Q_j * L_{ij}$ - the volume of transport work when carrying goods from point i to point j, t-km.

For the network formed in this way, one uses the shortest path algorithm [1], making the choice of the route in the form (2):

$$u_j = min_i \{u_i + s_{ij}\}$$

u_j - a less costly route from the point of receiving fish products at sea to node j.

s_{ij} – cost value of the cargo being on the arc connecting nodes i and j.

At each step, the least costly route to the previous node i is chosen plus the cost value of the cargo being on the arc connecting nodes i and j. The iterations are repeated until the calculation reaches the end node corresponding to the consumer's warehouse. Minimizing supply chain costs by regulating the leverage of supply and lease of storage distribution terminals will affect the seafood supply management strategy.

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