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Selection of the Optimal Product Delivery Model by Solving the Linear Programming Problem by the Combinatorial Method

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ABSTRACT. Optimization of the supply chain presupposes the presence of an existing, functioning system in one way or another. This paper will consider the model of export of Uzbek fruit and vegetable products to markets interested in it. The aim of the study is to create a mechanism that allows a balanced assessment of various options for the delivery of goods to the final (section of the chain) for the manufacturer.

KEYWORDS. Supply chain, optimization, ABC analysis, XYZ analysis, delivery, transportation, cargo.

I.INTRODUCTION

The supply chain is a set of processes and information flows that connect the participants in the production process, the main goal of which is to meet the requirements of the consumer in goods and services.

In turn, supply chain management is a management concept and organizational strategy, which consists in an integrated approach to planning and managing the entire flow of information about raw materials, materials, products, services that arise and transform in the logistics and production processes of an enterprise, aimed at a measurable total economic effect , the main criteria of which are: minimizing costs and maximizing profits, including long-term ones. For the participants in the chain, this is expressed in finding the right amount of products, at the right time and in the right place.[1]

Optimization of the supply chain presupposes the presence of an existing, functioning system in one way or another. This paper will consider the model of export of Uzbek fruit and vegetable products to markets interested in it. The aim of the study is to create a mechanism that allows a balanced assessment of various options for the delivery of goods to the final (section of the chain) for the manufacturer.

II. LITERATURE SURVEY

Linear programming provides a method for finding the optimum for a wide class of functions that depend on many variables and obey certain constraining conditions. It is the most famous and one of the most widely used management science tools. This is a mathematical method for solving the problem of optimal distribution of available resources (or money, or materials, or time) to achieve a certain goal (the highest income or the lowest costs) [2–4].

III. METHODOLOGY

In general, the supply chain itself is fundamentally amenable to optimization for two key streams.:

- Material flow. Includes distribution, movement and storage of goods or materials.
- Information flow. Allows various supply chain partners to plan and coordinate joint actions.

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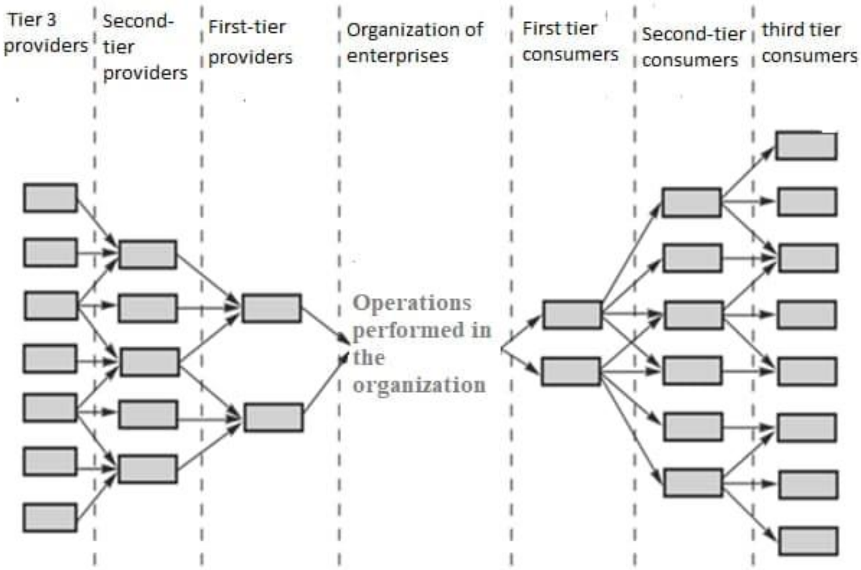

Picture 1. A classic example of an extended supply chain.

Information flows allow various partners in the supply chain to plan and coordinate joint actions. Effective exchange of information requires the use of modern technology, as well as a willingness to cooperate and integrate. Enterprises integrated into the supply chain will be "connected" to each other through material and information flows. Working in such a tandem will allow the system to be managed as a whole, which will improve the efficiency of demand management on a global scale [5-6].

IV.EXPERIMENTAL RESULTS

The approach described below directly affects both optimization options using ABC - XYZ analysis:

For example, taken (calculations) data on the export of agricultural products from Uzbekistan, in the context of regions and an interval of 10 years: **Table 1**

Data on the export of vegetables by regions of the Republic of Uzbekistan.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Tashkent	1299	1418	1572	1717	1842	2037	2244	1239	1082	1066	1067
Samarkand	1050	1149	1253	1351	1458	1584	1768	1787	1439	1585	1636
Andijan	862	952	1077	1203	1309	1411	1596	1478	1571	1597	1611
Surkhandarya	486	540	633	690	807	897	967	1014	914	972	1014
Fergana	459	520	578	639	712	783	867	874	1008	1090	1129
Namangan	439	489	530	575	623	655	722	766	795	811	832
Bukhara	355	391	438	478	520	567	659	696	689	729	769
Khorezm	378	401	438	472	502	548	635	631	569	586	596
Kashkadarya	322	363	398	434	467	507	564	525	496	495	496
Jizzakh	231	258	282	309	341	378	421	399	395	424	425
Syrdarya	183	196	217	248	264	286	318	303	271	301	307
Navoi	149	171	184	202	215	237	259	266	279	285	291

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Let's apply primary metrics to this set: aggregate ABC –XYZ analysis:

Table 2.
ABC analysis result

Group A	Group B	Group C
Tashkent Samarkand Andijan Surhandarya Fergana Namangan Bukhara	Khorezm Kashkadarya Jizzakh	Syrdarya Navoi

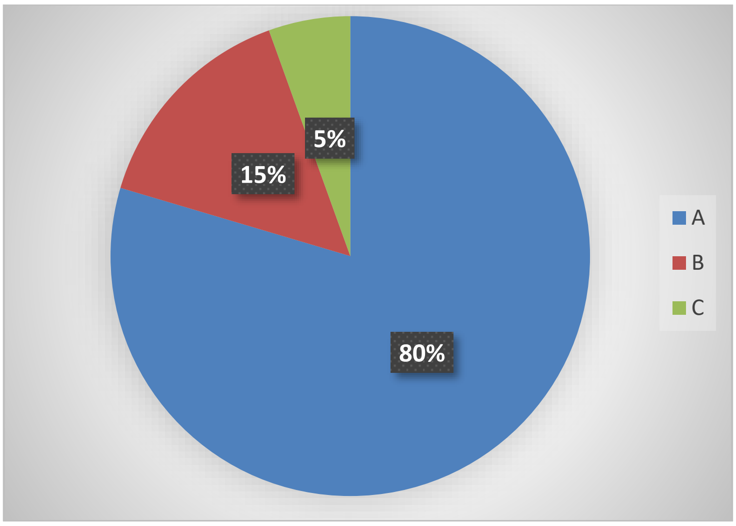

Figure-2 Results of ABC analysis

This approach will allow us to identify areas that generate the maximum stable income over the entire presented interval. So, ABC analysis is the presentation of each of the areas as a percentage contribution to the total export volume. By summing up the indicator when it reaches 80% of the total share, we get the key regions of the republic that generate the maximum income. The best way to illustrate this is:

XYZ analysis - shows the constancy of demand or, in this case, the production of goods, calculated as the ratio of the standard deviation to the mean:

$$XYZ_i = \frac{\sqrt{\frac{\sum_{i=1}^{n}(X_i - X_{\text{cp}})^2}{n-1}}}{\left(\frac{\sum_{i=1}^{n} x}{n}\right)} \quad (1)$$

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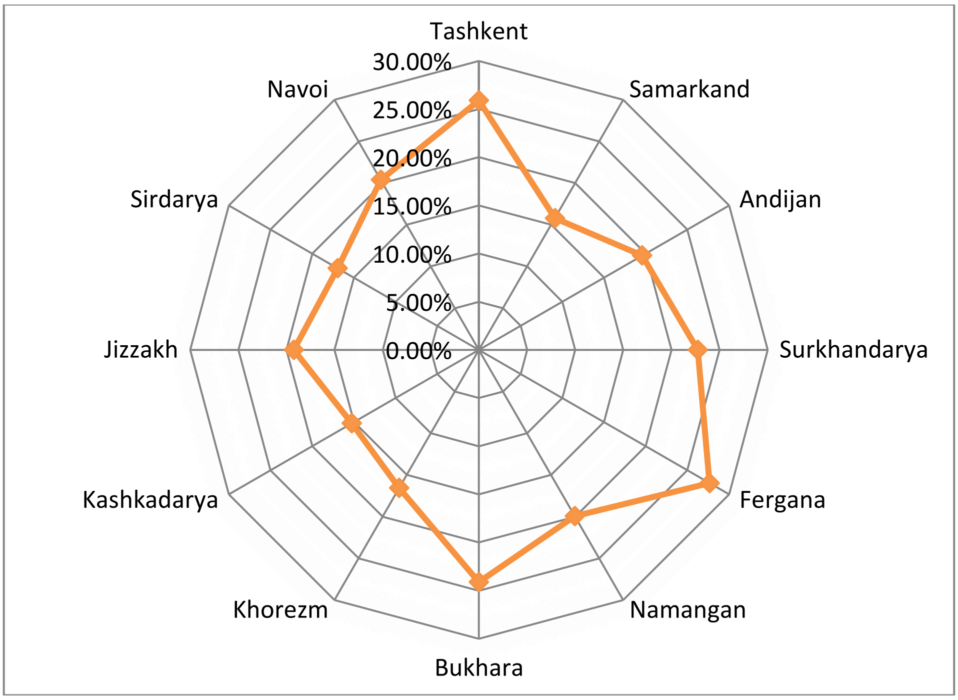

Figure-3. XYZ analysis result

Table 3
XYZ analysis result

Region	XYZ	Group
Tashkent	25,89%	Z
Samarkand	15,78%	Y
Andijan	19,58%	Y
Surkhandarya	22,74%	Y
Fergana	27,66%	Z
Namangan	19,95%	Y
Bukhara	24,11%	Y
Khorezm	16,57%	Y
Kashkadarya	15,25%	Y
Jizzakh	19,24%	Y
Sirdarya	16,94%	Y
Navoi	20,39%	Y

From the results obtained, it can be seen that the most stable in terms of supplies and volumes of products are:

- Andijan A-Y
- Samarkand A-Y
- Surkhandarya A-Y
- Namangan A-Y
- Bukhara A-Y

Further calculations were carried out using data from these areas. This approach will allow you to test the concept of optimizing already the most productive areas, and its extrapolation to neighboring areas and other types of goods will also give a significant increase in profits and reduce costs.

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In the context of the supply chain, costs can be conditionally divided into two key components: the time spent on the delivery of goods from point A to point B and the money that was spent on ensuring this process [7-9].

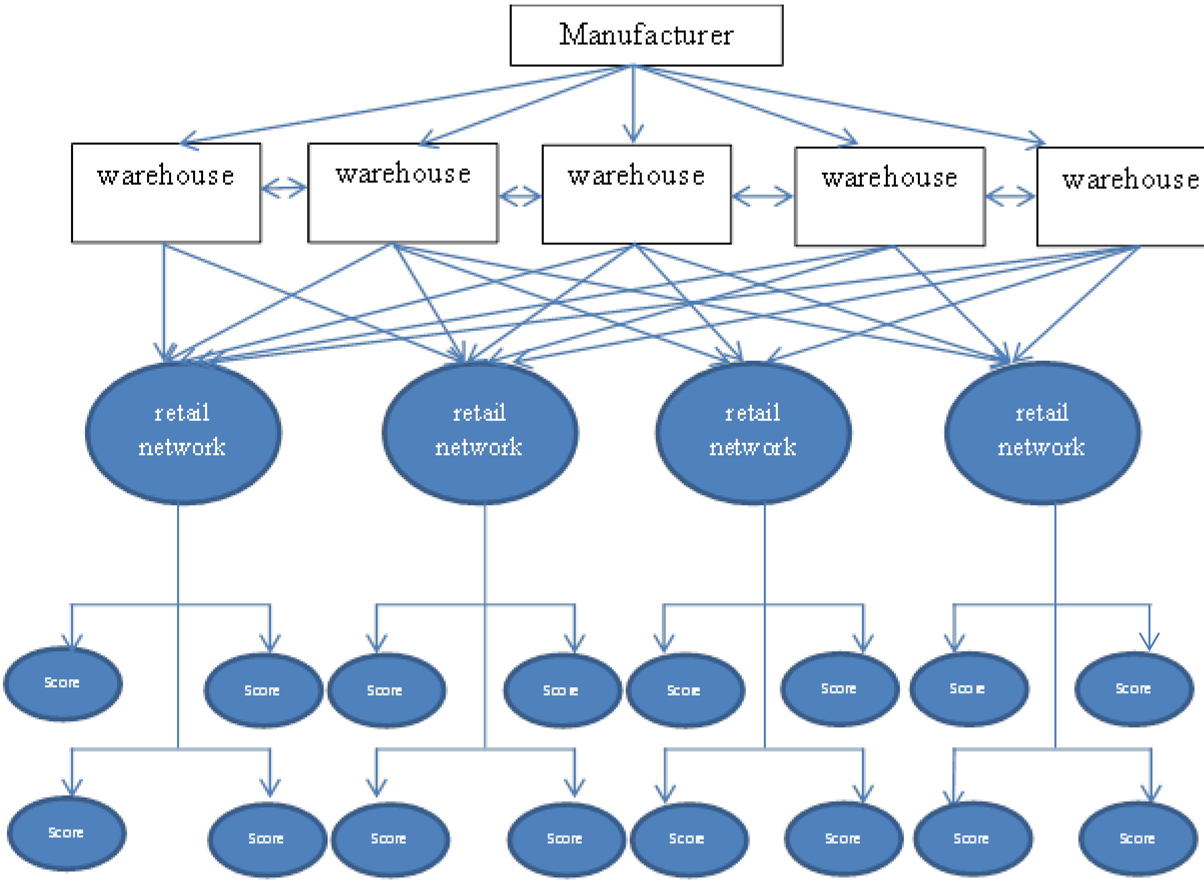

Figure 4. Supply chain using the example of product manufacturing using intermediate distribution points.

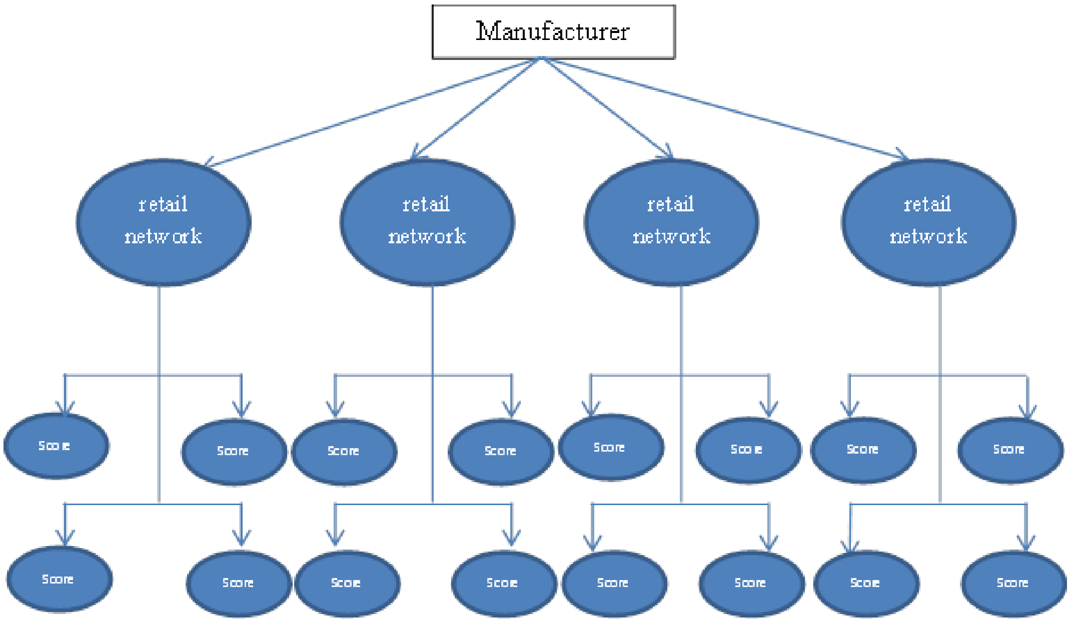

Figure 5. Supply chain using the example of production without intermediate distribution points

From the previous calculations, let us single out the Andijan region with an annual production volume of 1600 thousand tons. And we will present the entire region as a single manufacturer of products. Due to the specifics of international transport and poor integration between participants in the chain, the manufacturer does not have the opportunity for long-term planning and accurate costing throughout the entire supply chain.

Theoretically, this problem can be represented in the form of a classical transport problem:

Departure points	Destinations					Stocks
	B_1	…	B_j	…	B_n	
A_1	c_{11} x_{11}	… …	c_{1j} x_{1j}	… …	c_{1n} x_{1n}	a_1
…	… …	… …	… …	… …	… …	…
A_i	c_{i1} x_{i1}	… …	c_{ij} x_{ij}	… …	c_{in} x_{in}	a_i
…	… …	… …	… …	… …	… …	…
A_m	c_{m1} x_{m1}	… …	c_{mj} x_{mj}	… …	c_{mn} x_{mn}	a_m
Needs	b_1	…	b_j	…	b_n	

Figure-6. Model of the classical transport linear programming problem.

But this approach does not take into account the variability and the composite delivery model and is only suitable for calculating single chain links.

This model illustrates the variability of the delivery process and schematically depicts the process. In reality, each section can be split into smaller sections, points for processing, storage and redistribution of cargo can be added.

To optimize this model, it is necessary to find a cargo delivery option where:

$$costs \rightarrow min$$

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$$delivery\ time \rightarrow min$$

We will also introduce correction factors into the model that will allow us to shift priorities towards saving money or saving time.

To model a specific transportation, it is necessary for each edge of the graph to set its weight - the cost of time and money, bringing them to a single form:

$$weight = time * koef_{time} + cost * koef_{cost} \quad (2)$$

where,
time - the time spent on the delivery of the cargo.
koef_time - correction factor
cost - shipping costs
koef_cost - correction factor
So, for example, the conditional time for the delivery of cargo from Bukhara to Nur-Sultan is 30 hours. Costs - $ 1000.

$$Andijan - NurSultan = 30 * 1 + 1000 * 0.005 = 35$$

It is important that the correction factor may not be one and can be selected depending on a specific section of the chain. Also, the costs should immediately include the entire estimated volume of cargo transportation, in other words, using the example of the Andijan region, the costs should include the cost of transportation of 1600 thousand tons. products to each of the theoretically possible points of sale.

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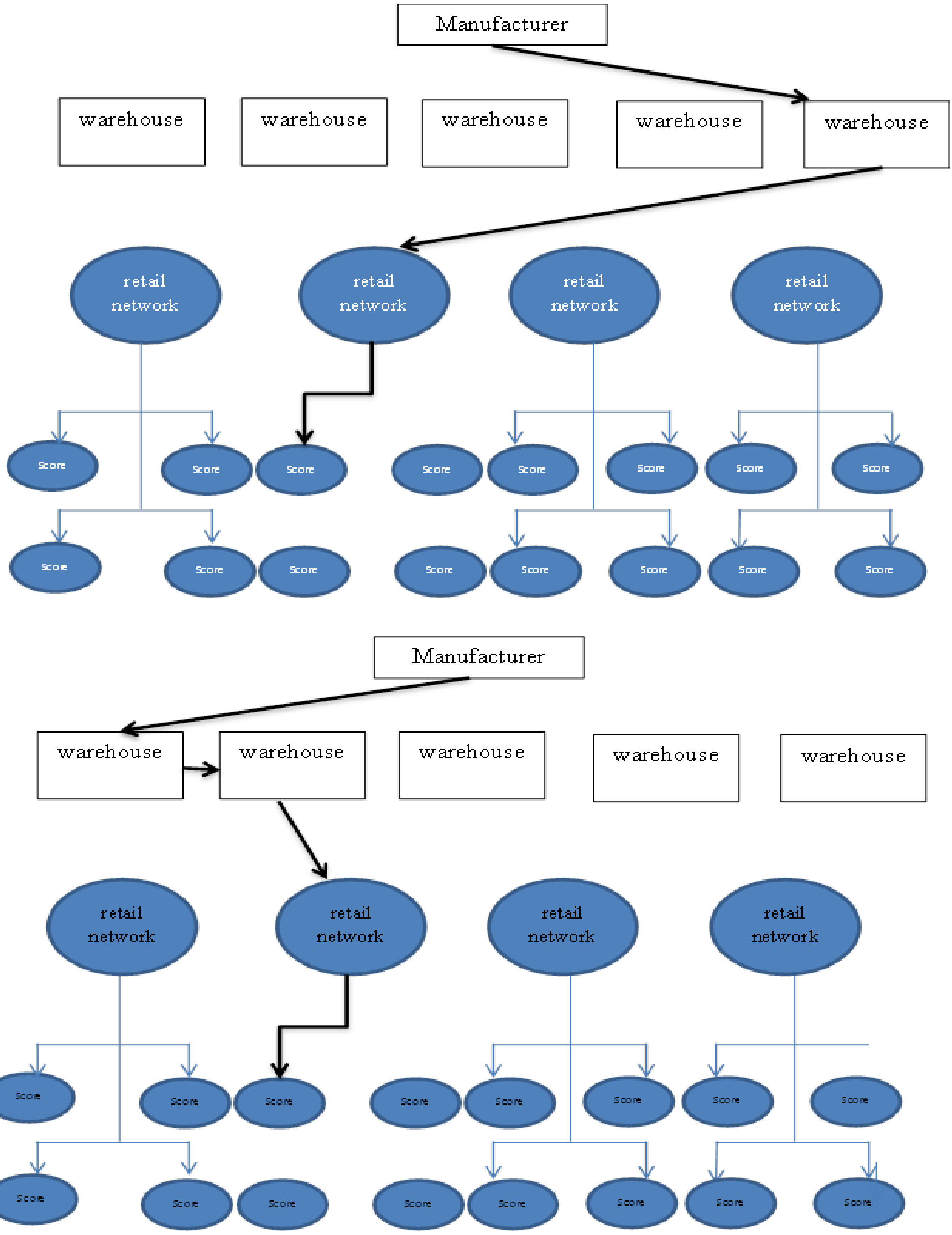

Figure-7. Different methods of delivery of goods from production to point of sale

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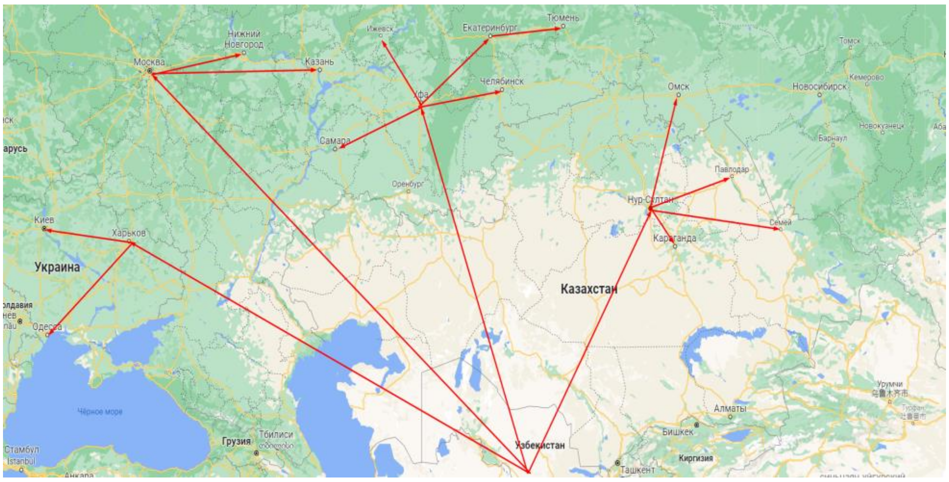

Figure-8. Supply chain of products from Andijan region. Presented as a directed graph

The result of this analytical work will be a matrix equal to the number of edges in the graph, example:

From where	**to where**	$time$	$koef_{time}$	$cost$	$koef_{cost}$	$weight$
Andijan	Nur-Sultan					
Nur-Sultan	Omsk					

Program operation code in the programming language Python[1]:

Block of program code # 1.

Dijkstra's algorithm for a weighted graph

```
nodes = ('Андижан', 'Нур-Султан', 'Омск', 'Москва', 'Казань', 'Харьков', 'Киев')
distances = {
    'Нур-Султан': {},
    'Андижан': {},
    'Москва': {},
    'Киев': {},
    'Омск': {},
    'Казань': {},
    'Харьков': {}}
unvisited = {node: None for node in nodes}
visited = {}
current = 'Андижан'
currentDistance = 0
unvisited[current] = currentDistance
while True:
    for neighbour, distance in distances[current].items():
        if neighbour not in unvisited: continue
        newDistance = currentDistance + distance
```

[1] www.python.org

```
        if unvisited[neighbour] is None or unvisited[neighbour] > newDistance:
            unvisited[neighbour] = newDistance
    visited[current] = currentDistance
    del unvisited[current]
    if not unvisited: break
    candidates = [node for node in unvisited.items() if node[1]]
    current, currentDistance = sorted(candidates, key = lambda x: x[1])[0]
print(visited)
```

In accordance with the real problem, 4 fields of the matrix are filled in, after which the most suitable algorithm for finding the shortest path is applied to it: Dijkstra's algorithm.

In curly brackets I indicated a vector of distances with weights for each available point, for example: 'Andijan': {'Nur-Sultan': 35, 'Moscow': 45}.

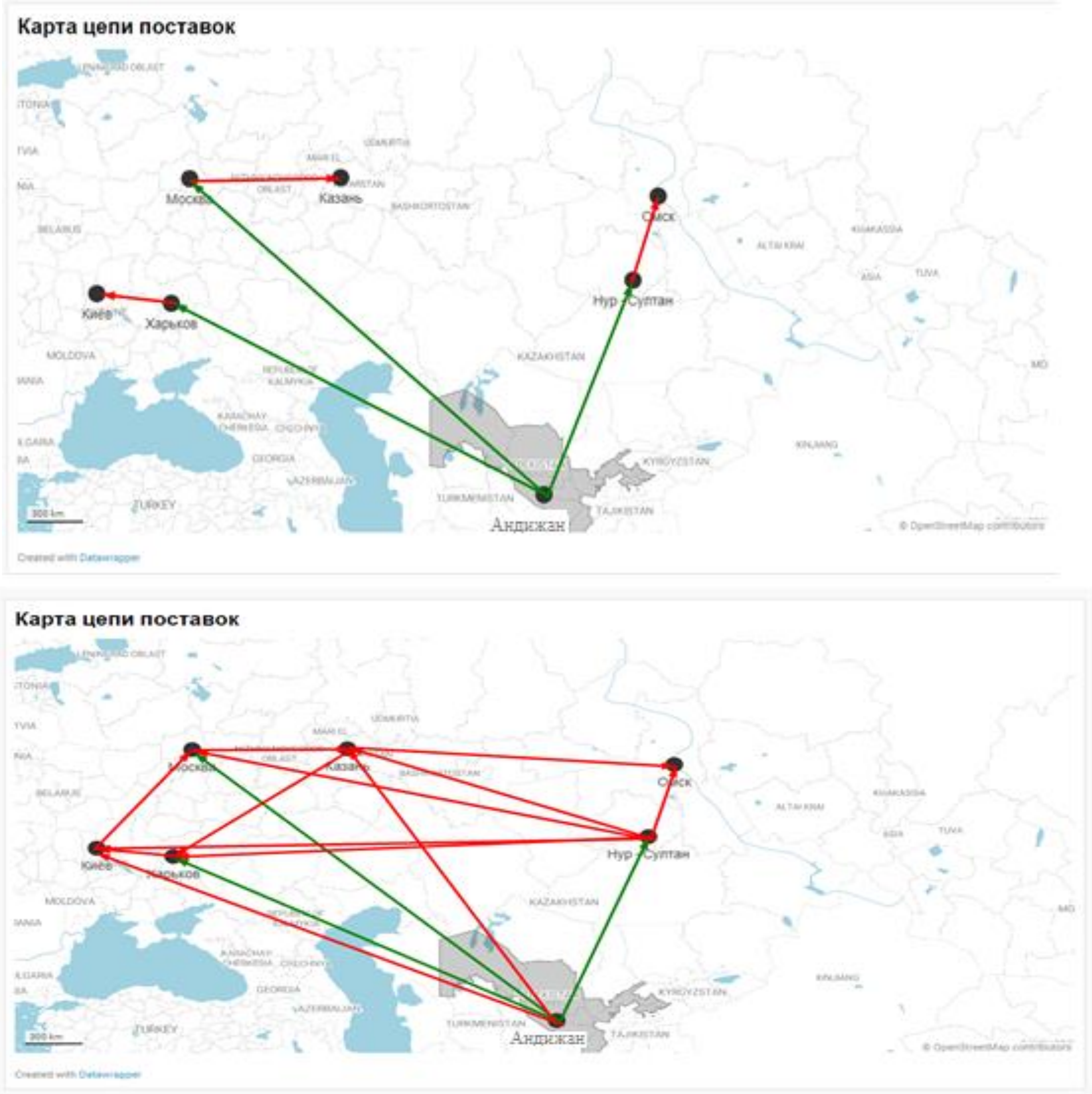

Figure-9. Supply chain example

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The result of this algorithm will be a new matrix containing all possible routes for delivering cargo from Bukhara to the rest of the graph points, taking into account weighted coefficients.

V.CONCLUSION

Using the approach based on solving the transport problem, in the left figure it is possible to calculate only transportation along the green lines, or by a combination of green and red lines. But applying a more modern approach using more modern algorithms (figure on the right), all possible options for cargo delivery will be calculated, from the most efficient to the most unprofitable.

Also, based on this approach, it is possible, among other things, not only to calculate the current links in the supply chain, but to design new ones. It is thanks to this approach that, even at the planning stage, it is possible to determine the profitability of various models of the logistics network, we include various transit points in it, adding or excluding intermediaries.

Separately, it should be noted that this approach is effective only for unimodal transportation. Since multimodal has its own nuances and more effective approaches.

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