Ekonomika i Organizacja Logistyki
3 (2), 2018, 57–69

DOI: 10.22630/EIOL.2018.3.2.14

Vasili Kulakov, Alexei Zhuravskiy
Belarusian State Agriculture Academy

Logistic approach to the formation of the procurement and distribution network of fruit in the region

Logistyczne podejście do tworzenia sieci zakupów i dystrybucji owoców w regionie

Abstract. Over the past few years, the problem of providing high-quality fruit and berries to residents of large cities of Belarus is quite acute. The reasons for this are obsolete storage technologies, large product losses during transportation, uncontrolled transportation costs. The research is devoted to the development of recommendations for determining the optimal number and location of procurement and distribution centers of fruit and berry products in the Mogilev region in order to minimize total costs. The article identifies the most significant items of variable costs and gives their economic interpretation. The economic effect from the introduction of the proposed logistics network and the payback period of the project are calculated.

Key words: logistics, procurement and distribution center, warehouse network, optimization approach

Synopsis. W ciągu ostatnich kilku lat dużym problemem jest zapewnienie wysokiej jakości owoców i jagód dla mieszkańców dużych miast Białorusi. Przyczynami tego są przestarzałe technologie przechowywania, duże straty produktu podczas transportu, niekontrolowane koszty transportu. Badania objęto opracowanie zaleceń dotyczących określania optymalnej liczby i lokalizacji centrów zaopatrzenia i dystrybucji owoców i jagód w regionie Mohylew w celu zminimalizowania kosztów całkowitych. Artykuł identyfikuje najważniejsze pozycje kosztów zmiennych i podaje ich interpretację ekonomiczną. Oblicza się efekt ekonomiczny wynikający z wprowadzenia proponowanej sieci logistycznej i okres zwrotu z inwestycji.

Słowa kluczowe: logistyka, centrum zaopatrzenia i dystrybucji, sieć magazynowa, podejście optymalizacyjne

Introduction

The importance of logistics (both international and domestic) results from the fact that the aim of optimizing logistics processes is precisely achieving the competitive advantage of enterprises operating in the conditions of national and global economy [Klepacki 2016].

The storage network (logistics centers) through which the material flow is procured and distributed is a key element of the logistics system. The construction of this network has a significant effect on the costs that arise in the process of bringing the goods to consumers, and, accordingly, the final cost of the product being sold.

European logistics centers have been developing for many years. They were aimed at solving local problems related to economic development or implementation of plans for shaping spatial order by concentrating economic activities in separate areas of urban agglomerations. As a result of this long-term policy of local authorities and state administration, there were created conditions for the construction of a logistics center. It happened when the concepts of supply chains and logistics networks were crystallized together with the concept of network nodes in the form of logistic centers [Klepacki i in. 2016].

One of the main stages in the formation of the procurement and distribution system is the determination of the required number of storage facilities. It should be borne in mind that when deciding on the formation of a warehouse network, like any logistics task, it is advisable to use an optimization approach aimed at minimizing total costs.

In practice, two variants of forming and placing a warehouse network are used: a centralized system of warehouses and decentralized.

The centralized system includes one large central warehouse where the essential part of the resources is accumulated and warehouse-branches which is located in the regions of sale. In a decentralized system, stores are concentrated in a network of warehouses dispersed in different regions in close proximity to the consumer. Such scheme of warehouses location is expedient in the distribution system of fruit and berry products where the main customer is the retail network, carrying out orders in small lots, but with a more frequent periodicity of delivery.

Purpose and research methodology

The purpose of the research is to develop a model of the procurement and distribution network of fruit and berry products in the region and calculate the economic effect of its implementation and operation based on logistics approaches, adapted to the current market conditions of the Republic of Belarus.

The initial data for the research were statistical materials characterizing the current state of the production and sale of fruits and berries, as well as the consumers questionnaire survey conducted earlier.

The study is based on methodological approaches to the formation of a system of high-tech procurement and distribution centers of fruit and berry products in the region, rooted the use of logistic methods and studying market preferences of consumers. The proposed approaches involve the use of special coefficients, allowing to take into account the effect of production and consumption in private subsidiary plots on the amount of the market demand.

The methodology of the research is based on the dialectical approach to the phenomena studied. The method of comparative analysis made it possible to identify the optimal number of procurement and distribution centers of fruit and berry products in the region. Combined use of logistics methods for determining the center of gravity of cargo flows and the single median problem with the implementation of correction coefficients allowed to determine the optimal location of warehouses centers in the region.

Results of the research

The proposed system presupposes that the controlled atmosphere storage facilities put into operation will perform dual functions for harvesting and distributing fruit and berry raw materials [Kulakou 2013].

A small number of warehouses involves significant transportation costs for the delivery of products. The variant with a large number of distribution centers is based on their maximum nearness to the places of concentration of consumers. In this case, transportation costs for commodity supply will be minimal. However, the construction of such a distribution system leads to an increase in operating and management costs of the entire distribution system. It is not excluded that the additional costs in this case can significantly exceed the economic gain obtained from the reduction in the mileage of the transport that delivers goods to consumers [Zhuravskiy 2009].

Thus, with a change in the number of warehouses in the distribution system, part of the costs associated with the process of bringing products to the consumer tend to increase, and part are reduced.

Proposed research methodology includes five consistent stages presented in Table 1.

Table 1. Methodological framework of the formation of a system of procurement and distribution centers of fruit and berry products in the region

Tabela 1. Ramy metodyczne kształtowania sieci zakupów i dystrybucji owoców i jagód w regionie

Stages	Actions	Methods
1.	determination of the possible number of distribution centers in the region	the method of expert evaluations
2.	calculation of the cost of transportation of products warehouse costs and warehouse management costs	analysis, synthesis, calculation method
3.	determining the optimal number of distribution centers based on total costs	
4.	calculation of the economic efficiency of the creation and operation of the selected number of distribution centers	calculation method, net present value method
5.	determining the geographical location of the selected number of distribution centers	method of determining the center of gravity of cargo traffic; problem of a single average (taking into account the correction factors)

Source: own elaboration.

Calculation of the necessary number of procurement and distribution centers

Calculation of costs, depending on the number of procurement and distribution centers on the average actual data for the Mogilev region at the time of the calculations in 2017 and their optimal number are presented in Table 2.

With an increase in the number of centers in the distribution system, the cost of both short-distance (less than 30 km) and long-distance transportations (more than 30 km) is reduced, which is associated with a curtailment in the mileage of transport. The nature of the dependence is not of a straightforward nature, since there are conditional-constant and conditional-variable components. As a result the delivery costs decrease more slowly than the transportation distance.

Table 2. Dependence of costs on the number of procurement and distribution centers in the logistic system in 2017

Tabela 2. Uzależnienie kosztów od liczby centrów zaopatrzenia i dystrybucji w systemie logistycznym w 2017 roku

Number of centers	Transportation costs (thous. USD)	Warehouse costs (thous. USD)	Warehouse management costs (thous. USD)	Total costs for the maintenance of the distribution center (thous. USD)
1	1270.0	71.9	154.0	1495.9
2	1221.0	83.3	178.3	1482.5
3	1182.5	96.6	195.6	1474.7
4	1148.5	117.7	216.9	1483.1
5	1115.5	148.1	248.2	1511.8
6	1087.0	177.6	269.2	1533.7

Source: own elaboration based on: [Cargo…, 2017, Designing…, 2017].

With an increase in the number of centers in the system, the costs associated with the operation of one warehouse reduce, however, the total costs of the distribution system for the maintenance of the entire warehouses complex increase.

The nature of the dependence of the warehouse management costs for the investigation region is subject to a similar effect. In this regard, with an increase in the number of warehouses, the expenditure curve for management becomes more flat.

The alteration of the total costs on the functioning of the procurement and distribution system in dependence of the number of centers included in it is shown in Figure 1.

The abscissa of the minimum of the total cost curve indicates the optimal number of warehouses under these economic conditions. In our case, these are three warehouses with a total capacity of 11 thous. tons. The proposed number provides a minimum of total costs, which amount to 1474.7 thous. USD.

Thus, for the organization of the procurement and distribution system in the territory of the Mogilev region we are proposing the construction and commissioning of 3 warehouses with a regulated gas environment with a total capacity of 11 thous. tons.

In our case, when organizing the procurement and distribution network, it is most expedient to resort to the construction of new warehouses, in spite of the significant

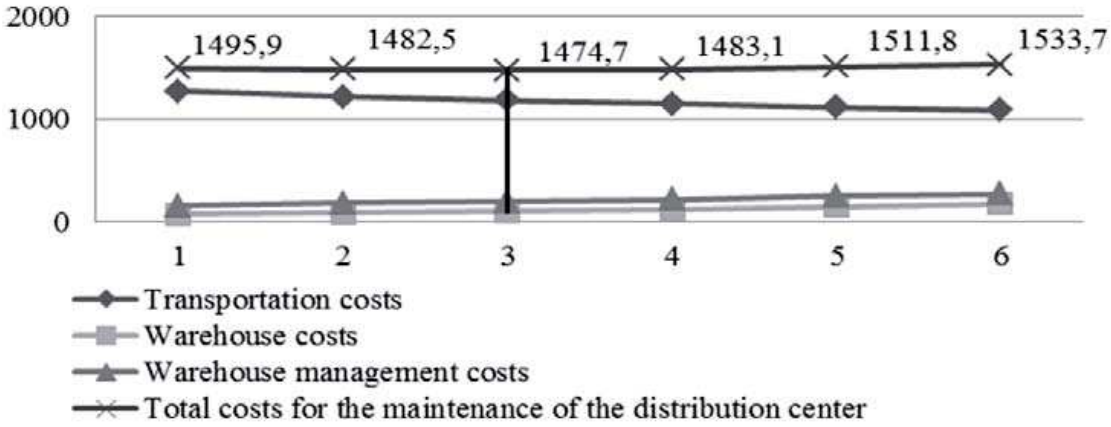

Figure 1. The alteration of the costs on the functioning of the system in dependence of the number of centers included in it

Rysunek 1. Zmiana kosztów funkcjonowania systemu w zależności od liczby zawartych w nim centrów

Source: own elaboration based on [Cargo…, Designing…]

financial costs. In this regard, we calculated the economic efficiency of investments in the construction of new modern warehouses.

For the economic effect of the implementation of the proposed activities, we will take the absolute value of the annual profit, which is formed as a result of the seasonal difference in prices for fresh fruit and berries during storage.

Cost calculation of procuring and storage of fruit and berry products involves cost accounting associated with the construction and technical equipment of three warehouses, transportation costs, storage costs in warehouses, operating costs and costs associated with the management of the distribution system.

Calculation of the necessary amount of investment for the implementation of the project for the formation of procurement and distribution system is presented in the Table 3.

Thus, the investments necessary for the implementation of the project for the formation of the procurement and distribution system will consist 10099.7 thous. USD. Accordingly, the transportation and storage costs per ton of production, taking into account the storage capacity and the lifetime of the storage facilities (10 years), will be:

(8625.0 thous. USD : 10 years + 1474.7 thous. USD) : 11 thous. tons = 212.47 USD

The next step is to calculate the economic effect (profit) per year as a result of the implementation of the project.

The main raw material resource is the marketable apple. According to our analysis of the fruit market in the Republic of Belarus, the average price of harvesting apples during the harvest season in 2017 was 200 USD per ton. Consequently, the full cost of one ton of apples, including storage costs totaled:

200 USD + 212.47 USD = 412.47 USD

Table 3. Investments required for the implementation of the procurement and distribution system project in 2017
Tabela 3. Inwestycje wymagane do realizacji projektu systemu zaopatrzenia i dystrybucji w 2017 roku

Expenses for construction and operation of three storage facilities	Valuation (thous. USD)
Construction and equipment costs	8 625.0
Operating costs per year	96.6
Costs for transportation of fruit and berries for the year per year	1 182.5
System management costs per year	195.6
Total costs	10 099.7

Source: own elaboration based on [Cargo…, Designing…].

Market research showed that the average price of apples from the warehouse in the winter-spring period was 590 USD per ton. At a given level of market prices, the profit per ton will be 177.53 USD and rentability of production and sales – 43.04% and 30.09% accordingly. Herewith, the amount of profit from the functioning of the system per year will be equal to 1952.9 thous. USD.

With a knowledge of economic effect and costs, we will determine the effectiveness of the proposed project of the procurement and distribution system. For said purpose we calculate the efficiency of capital investments:

$$E_{calc} = 1952.9 \text{ thous. USD} : 10099.7 \text{ thous. USD} = 0.19$$

where: E_{calc} – is the calculated efficiency of capital investments.

At the time of the calculations, the normative efficiency of capital investments E_n was assumed to be equal to 0.11 in accordance with the rate of the National Bank of the Republic of Belarus. If the predicted indicator is greater than the normative, then the implementation of the project is considered expedient. In our case, E_{calc} is bigger than E_n, which indicates the effectiveness of the proposed project on the formation of the procurement and distribution system.

The static payback period of the project will be:

$$10099.7 \text{ thous. USD} : 1952.9 \text{ thous. USD} = 5.17 \text{ year (5 years 2 month).}$$

Net present value (NPV) totaled 1401.7 thous. USD, static and dynamic payback period − 5 years 2 month and 8 years 1 month respectively, internal rate of return 25.6% and profitability index 1.14.

The calculated indicators testify to the economic efficiency of the implementation of the project on the formation of the procurement and distribution system.

Finding the location of procurement and distribution centers in the region

The question naturally arises: where in the territory of the region should be built storage facilities in order to get the maximum possible positive effect. Wrong choice the location of the relevant object can lead to underutilization of production capacities, high transportation costs, longer delivery times which in turn will significantly increase the payback period of the project or make it completely unprofitable. It should be kept in mind that the decisions regarding the location of the procurement and distribution center are of a long-term nature and when making a choice, one should not focus on short-term benefits.

A successful location does not guarantee success, but the unsuitable location creates additional difficulties in the implementation of the project. In any case, making a decision on a placement requires consideration of a variety of different factors.

The task of locating a procurement and distribution center (storage facility) becomes relevant with a well-developed transport network. It can be formulated as a search for an optimal solution or a solution which is close to optimal. Science and practice have developed a number of methods for solving these problems.

At the very beginning of the designing a new warehouse, you should study the forecasts of the demand for products, data on the size of stocks, delivery routes.

When choosing the location of the warehouse, many variants are considered. The optimum is one that provides a minimum of total costs for the construction and operation of the warehouse, delivery and dispatch of goods.

In our research, one of the most significant factors influencing the choice of the storage location is the proximity to producers and consumers of fruit and berry raw. This is due to the peculiar properties of products of this type. The remaining factors are largely leveled due to their relative equality throughout the territory of the Mogilev region.

At the first stage of our research, in order to obtain the desired result, we will use the method of determining the center of gravity of cargo flows with a number of assumptions and additions, in order to adapt its application to the conditions of the region.

This method is used to determine the location of one distribution center in the selected geographic region. For this, the method of applying a grid of coordinates to a map of potential locations of warehouses is applied. The coordinate system makes it possible to estimate the cost of delivery from each supplier to a possible warehouse and from the warehouse to the consumer.

The basic formula for calculating the coordinates of the center of gravity is written as:

$$x_c = (\sum p_i x_i + \sum q_i u_i) : (\sum p_i + \sum q_i)$$

$$y_c = (\sum p_i y_i + \sum q_i v_i) : (\sum p_i + \sum q_i)$$

where:
x_c , y_c – coordinates of the center of gravity of cargo flows;
x_i, y_i – supplier coordinates;

u_i, v_i – customer coordinates;
p_i – volumes of supplies to the warehouse from concrete suppliers;
q_i – volumes of supplies from the warehouse to concrete recipients.
Source: [Basko 2007].

In our case, the suppliers of raw materials are mainly agricultural organizations engaged in the production of fruit and berry products, consumers are trading enterprises, individual entrepreneurs, demanding fresh fruit to provide the population they serve.

As the volume of raw material supplies, we take the volume of fruit and berries production at each particular agricultural enterprise. Demand is determined using the average level of consumption of this type of products per person that has developed over the past years.

For greater reliability of the research results, it is necessary to take into account the difference in the demand for fruits from the urban and rural population which also allows us to indirectly take into account, in the final version of the calculation formula, the influence of production volumes in personal part-time farms which is used to meet the personal needs of the population.

According to the National Statistical Committee of the Republic of Belarus the share of fruit and berry products produced in personal part-time farms in the total volume of consumption is 26.5% for the urban population, for the rural population 58.1%, in other words on the market will be purchased 73.5% and 41.9% of the total consumed fruit respectively [Agriculture…, 2017].

Consequently to determine the quantity demanded we need to adjust the population size for both groups by introducing correction coefficients which will compound 0.735 and 0.419 for the urban and rural population respectively. It should be noted that these coefficients will not be constant, as they are subject to change under the influence of economic, demographic, urbanistic and a number of other factors.

Coordinates of suppliers and consumers are determined by applying the map of the Mogilev region to an orthonormal (Cartesian) coordinate system. Because of the inability to determine the coordinates of some small suppliers, the volumes of their production sum up, and as a place location is taken by the middle coordinate of the administrative district. This will not significantly affect the reliability of the results. Coordinates of large manufacturers are found in accordance with the location of each enterprise.

The questionnaire survey of the rural population showed that a large part of it prefers to purchase fruit and berry products in the nearby administrative centers. This allows us to conclude that the bulk of demand is concentrated there. In this case, as the coordinates of the location of the rural population, it is most expedient to use the coordinates of the administrative centers.

Based on the geographical location of the Mogilev region, its size and the volume of planned construction of storage facilities we propose its division into three subregions, based on the principle of geographical compactness:

1) Glusk, Osipovichi, Bobruisk, Kirov, and Klichev districts;

2) Krugloe, Belynichy, Shklov, Mogilev, Bykhov, Gorki, Dribin, Chausy, Slavgorod districts;

3) Mstislavl, Cherikov, Klimovichi, Khotimsk, Krasnopolie, Kostyukovichy, Krichev districts.

Taking into account all the above additions and limitations, we obtain a formula for calculating the coordinates of the center of gravity of cargo flows for each selected sub-region and the region as a whole:

$$x_c = (\sum p_i x_i + \sum (q_g k_1 + q_s k_2) x_j) : (\sum p_i + \sum (q_g k_1 + q_s k_2))$$

$$y_c = (\sum p_i y_i + \sum (q_g k_1 + q_s k_2) y_j) : (\sum p_i + \sum (q_g k_1 + q_s k_2))$$

where:
x_c, y_c – coordinates of the center of gravity of cargo flows;
x_i, y_i – supplier coordinates;
x_j, y_j – customer coordinates;
p_i – volumes of supplies to the warehouse from concrete suppliers;
q_g, q_s – quantity of urban and rural population;
k_1, k_2 – correction factors.
Source: own elaboration.

The calculated coordinates of the centers of gravity of cargo flows are presented in Table 4.

Table 4. Coordinates of the centers of gravity of cargo flows
Tabela 4. Współrzędne punktów ciężkości przepływu ładunków

Name of region	Number of population people		Volume of production of fruit and berry products (tons)	Coordinates of the centers of gravity of cargo flows	
	urban	rural		*X*	*Y*
First sub-region	276 076	68 178	1 930	7.5	5.9
Second sub-region	464 705	136 453	3 403	14.7	13.6
Third sub-region	92 447	61 495	5 927	23.0	10.9

Source: own elaboration.

According to the chosen coordinate system, the centers of gravity of cargo flows situated:

The first sub-region is 2 km to the north-west from the Bobruisk city in the direction of the settlement Sychkovo. The second sub-region is the north-east of the Mogilev city. The third sub-region is 5 kilometers west of the Klimovichi towards the Krichev.

The application of the described method has one limitation. On the model, the distance from the products consumption point to the location of the procurement and distribution center is taken into account as a straight line or as a hypotenuse of an angle, according to the Pythagorean theorem. In this regard, the simulated area should have a developed network of roads, since otherwise the basic principle of modeling will be violated – the principle of similarity of the model and the modeled object.

The suppliers and consumers gravity centers can be located in any place of the coordinate network. In our case, two variants of the location of the storage facilities are located outside the populated areas.

The best location nearly always situated in the inhabited locality or in the immediate proximity of it. This greatly simplifies the task, since it is required to compare the largest settlements and identify the variant that will give the best result for the selected indicator.

In our case, the optimality criterion for evaluating the various alternatives for placing warehouses is the minimum value of the average transportation distance. The search for the smallest value is called single median problem [Waters 2003].

To solve the problem, we need to create a matrix of optimal distances between the inhabited localities of the region and combine these distances with the planned supply volumes.

To determine the number of consumers adjusted for the correction coefficients in each administrative district, we use the following formula:

$$Q_{\mathrm{t}} = q_{\mathrm{g}} \times k_1 + q_s \times k_2$$

where:
Q_{t} – number of consumers adjusted for the correction coefficients in each administrative district;
q_{g} – the number of urban population, thous. people.;
q_{s} – number of rural population, thous. people.;
k_1 and k_2 – correction coefficients, 0.735 and 0.419.
Source: own elaboration

In the capacity of the volume of supplies necessary to meet the demand for products in each locality, we take the aggregate demand from the side urban and rural population. Further calculations were made using the following formula:

$$R_{\mathrm{n}} = \Sigma Q_{\mathrm{ti}} \times D_{ij}$$

where:
R_{n} – total product of weight and distance for each logistics center;
Q_{ti} – number of consumers adjusted for the correction coefficients in each administrative district i;
D_{ij} – distance from the i to the j locality (km).

The optimal location for the procurement and distribution (logistics) center of fruit and berry products will be the option that gives the minimum sum of distances.

As a result of the testing of the proposed methodology, it was revealed that the optimal locations of the procurement and distribution centers of fruit and berry products in the Mogilev region are: the first sub-region – Bobruisk city; the second sub-region – Mogilev city; the third sub-region – Krichev city.

The performed calculations, as well as an empirical analysis of the location of the main producers and consumers of fruit and berry products and the possibility of construction the corresponding objects there give grounds to conclude that the most suitable places for the construction of new storage facilities in the Mogilev region are: the north-western part of the Bobruisk city, the north-eastern part of the Mogilev city, the northern part of the Krichev city (Fig. 2).

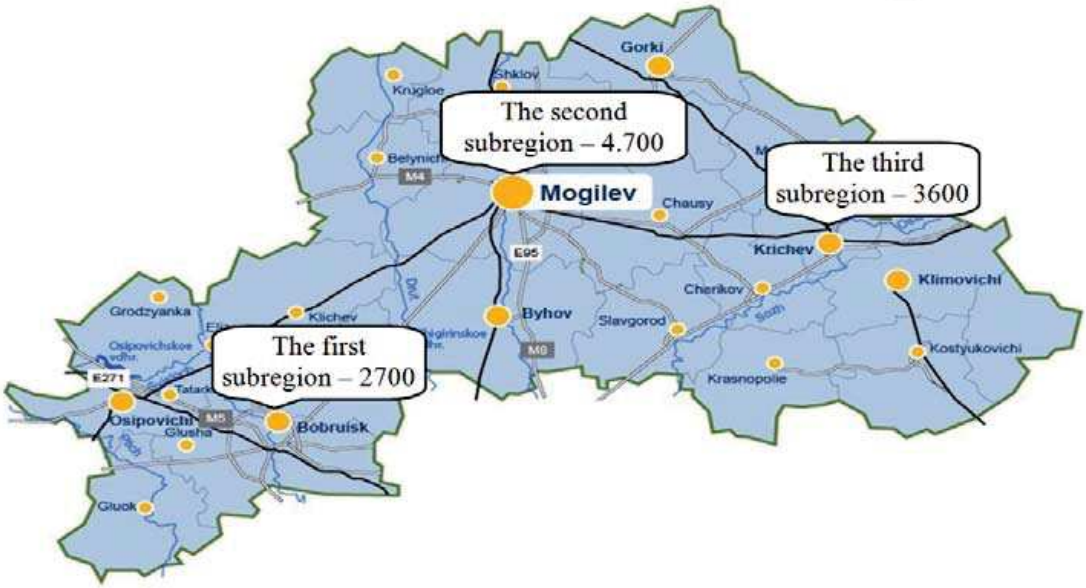

Figure 2. Geographical location of procurement and distribution centers of fruit and berry products in the Mogilev region

Rysunek 2. Lokalizacja geograficzna centrów zaopatrzenia i dystrybucji owoców i jagód na terenie regionu Mohylew

Source: own elaboration.

The capacity of procurement centers is proposed to be calculated based on the share of each sub-region in total production and demand on fruit and berry products (Table 5).

Table 5. Structure of production and consumption of fruit and berry products by selected sub-regions

Tabela 5. Struktura produkcji i konsumpcji owoców i jagód w wybranych podregionach

Sub-regions	Structure by volume of consumption (%)	Structure by volume of production (%)	Average structure (%)
First sub-region	31.80	17.14	24.5
Second sub-region	54.97	30.22	42.6
Third sub-region	13.23	52.64	32.9
Total	100.00	100.00	100.0

Source: own elaboration based on [Agriculture…, 2017].

Based on the data presented in Table 4 and technological features of the construction of storages with a controlled atmosphere we calculated the optimum capacities of the procurement and distribution centers for fruit and berry products for each subregion: the first subregion – 2700 tons; the second subregion – 4.700 tons; the third subregion – 3600 tons (Fig. 2).

The proposed system of allocation of procurement and distribution centers of fruit and berry products will allow to reduce the time interval between the harvesting of fruits and their cooling in the storage, which will positively affect the livability and commercial quality of the products.

Conclusions

Thus, in the course of the research, we determined the optimal number (logistic network) of procurement and distribution centers for fruit and berry products in the Mogilev region, and calculated the economic efficiency of the project implementation.

In accordance with the criterion of minimum total costs, the proposed procurement and distribution network will be represented by three centers with a total capacity of 11 thous. tons. The total amount of investments necessary for the implementation of this project will be 10,099.7 thous. USD. The rentability of production and sales will compound 43.04% and 30.09% accordingly. Herewith, the amount of profit from the functioning of the system per year will be equal to 1952.9 thous. USD. Net present value (NPV) will totald 1401.7 thous. USD, static and dynamic payback period − 5 years 2 month and 8 years 1 month respectively with internal rate of return 25.6% and profitability index 1.14.

The optimal locations of the procurement and distribution centers of fruit and berry products in the Mogilev region are: the north-western part of the Bobruisk city – 2,700 tons; the north-eastern part of the Mogilev city – 4,700 tons, the northern part of the Krichev city 3,600 tons.

Literature

Basko I., 2007: Logistics: tutorial, I.I. Poleshchuk (ed.), BSEU, Minsk.

Cargo and transport: Information portal DellaTM, 2017 [electronic resource] http://www.della.by/search/a16b144d16e 144flolh0ik1m1.html [access: 10.03.2018].

Designing and construction of modern vegetable stores, 2017, [electronic resource] http://www.frukto.stroj.biz/ [access: 10.03.2018].

Klepacki B., 2016: Miejsce i znaczenie logistyki w agrobiznesie, Zeszyty Naukowe SGGW w Warszawie, Ekonomika i Organizacja Logistyki 1.

Klepacki B., Dziedzic-Jagocka I., Piątek E., 2016: Centra logistyczne jako nowoczesna forma gospodarki na przykładzie Świętokrzyskiego Centrum Logistyki i Dystrybucji Alma Alpinex SA, Zeszyty Naukowe SGGW w Warszawie, Ekonomika i Organizacja Logistyki 4.

Kulakov V., 2013: The economic justification of the optimal number of procurement and distribution centers of fruit and berry products in the Mogilev region. In Problems of the economy, The Institute of Economics of the National Academy of Sciences of Belarus, Gorki.

Waters D., 2003 Logistics: An introduction to Supply Chain Management, Palgrave Macmillan, New York.

Zhuravskiy A., 2009 Theoretical aspects of construction of the regional logistical control system of commodity streams, Collection of Scientific Trends Problems of Economics (1)8.

Agriculture of the Republic of Belarus: statistical book, 2017, National Statistical Committee of the Republic of Belarus, Minsk

Corresponding address:

dr. assoc. prof. Vasili Kulakou
(https://orcid.org/0000-0003-1513-5170)
Belarusian state agricultural academy – BSAA
Head of the Department of
Economic and Mathematical Modeling
of Economic Systems in the
Agroindustrial Complex
Tel.: (+37529) 542 49 99
e-mail: vasili-kulakov@yandex.ru

Alexei Zhuravskiy
(https://orcid.org/0000-0002-3974-4563)
Belarusian state agricultural academy – BSAA
Faculty of Economics
Department of production organization
in the agroindustrial complex
Tel.: (+375) 29 356 15 45
e-mail: 3561545@gmail.com