

Combining methods for designing a regional program of the bakery sector development

Valery Koshelev¹, Ludmila Vorozhtsova¹, Dmitriy Aleksanov¹, Maria Romanyuk¹, Maria Sukharnikova¹, and Natalia Chekmareva^{1}*

¹Moscow Timiryazev Agricultural Academy, 49 Timiryazevskaya street, 127422, Moscow, Russian Federation

Abstract. The analysis of investment projects for the construction of bakery enterprises and infrastructure facilities, based on the results of optimization of their placement, allows designing a program for the development of the bakery sector for remote subsidized regions. The program is aimed at ensuring an increase in the competitiveness of local producers and in the physical and economic availability of bakery products for the population. The proposed method of combined application of methods of mathematical modelling and project analysis has been implemented in one of the remote northern regions of Russia – the Republic of Karelia, where the studied problems were expressed most acutely. The results obtained from the modelling give the opportunity to predict the cash flows of the project for the development of the baking sector of the Republic and evaluate its effectiveness. The results of the analysis show that both the project as a whole and its components are effective and meet the interests of the stakeholders.

1 Introduction

Food security is one of the main goals of the agrarian and socio-economic policy of the state [1-3]. At the same time, attention should be paid to ensuring food security at both the national and regional levels, as it is a powerful geopolitical factor and a tool for ensuring the sustainability of socio-economic processes in the region [4].

Based on a sample of data from 25 different countries, it has been proved that reasonable and effective government support measures aimed at increasing the availability of food have a positive impact on the country's food security [5].

A number of food products are not only social, but also strategic: they include, among others, bakery products, which occupy an important place in food consumption worldwide. Bread with its high nutritional value, neutral flavour, availability and cheapness is the main source of nutrition in the group of bakery products [6]. For consumers, bread is a product of necessity and daily demand, and for the region, it plays a crucial role in ensuring food security.

Back in the Soviet period of Russia's history, the concept of the development of the bakery industry based on large-scale production was introduced. This was due to the intention to

* Corresponding author: cnv2005@yandex.ru

reduce unit costs and make bread more affordable, but this, as a rule, negatively affects the quality of products.

A similar strategy was followed in some other countries, such as Iran, Italy, and the Philippines, where governments sought to mechanize the way bread was produced. The Iranian Ministry of Agriculture, within the framework of this concept, pursued a policy of replacing the share of small bakeries in production at the expense of large factories in order to save energy and materials. However, the quality of bread baked in large-scale production is usually not very high, and its freshness can be maintained for a rather short period. Due to the low quality, a significant part of the bread does not find a consumer, returns increase and, as a result, losses grow [7]. The problem of returns by retail chains of unsold bread products is relevant in Russia to this day.

The European experience suggests a different concept of bread market development: since bread makes up a smaller share in the food basket, its availability is not so much valued, but quality and convenience for consumers. In Europe, the format of mini-bakeries is widespread, in which bread is baked and sold. In the USSR, in almost all sectors of the national economy, economic policy was focused on the implementation of economies of scale, and the European model was considered unpromising. Now the situation on the bread market is changing and medium and small bakeries of various formats produce more and more bakery products.

For example, Belgian scientists have asked the question: is the "local" more preferable in the food market than the "global"? For each commodity group (apples, berries, bread, cheeses, pork, tomatoes, wine), at least two "local" and two "global" supply chains in 7 European countries were analysed, and the efficiency of local and global supply chains in different countries was compared [8].

The authors concluded that the characteristics of the product itself determine the advantages of local production. Moreover, short food chains mobilize local farmers and food producers. Unlike producers involved in global networks, local producers are more actively involved in cultural or gastronomic events, fairs, projects in their region. In this study, the distance between producers and consumers was used as the principle of differentiation. An increasing number of consumers prefer "0-mile products", like in the case with bread in Italy. Small distances between the place of production and sale are fundamentally important for manufacturers, since they lead to an increase in their competitiveness, especially when global chains dominate the market and do not satisfy the need for novelty and naturalness [8].

The local component of bread products (short shelf life) is a factor of competitive advantage for small and medium bakeries. For example, the regional Rural Development Authorities (RDP) in Tuscany [9, 10] is actively considering the problem of supporting local flour and bread producers. The participation of such organizations has a positive effect on ensuring food security, increasing customer confidence in local products, expanding the range and diversification, and leading to a reduction in the market share of low-quality products.

The product of local bakers is traditionally niche quality bread, the price of which can be reduced due to the absence of intermediaries in the chain, returns and high trade margins that significantly exceed the selling costs. The baker can set the final price for his product himself based on production costs, ignore the interests of retail chains. He can also easier adapt his production to the demand, compared with large enterprises. Thus, the development of small and medium-sized bread producers leads to an increase in the physical and economic availability of fresh and high-quality bread for the population, and solves a number of social problems, such as the introduction of new jobs.

In recent years, the so-called premium category has been actively formed in Russia - bakery products with a limited shelf life, complex recipes, low-calorie, and dietary varieties. In part, this trend is due to the growing attention of Russians to their diet. More than 70% of

consumers monitor the composition of the products they buy, and 76% are concerned about the impact of artificial additives on health. So, preservatives and other additives are often added to traditional varieties of long-term storage to increase the freshness of bread.

Due to the competitive environment, it is important to meet the demand as soon as possible. The configuration of the logistics network is one of the most important strategic issues in the design of supply chains of raw materials to bakeries. The goal is to minimize the total cost, delivery time and the number of rejected goods, as well as to maximize the total profit and increase the level of service [7, 9]. Conducted research [11] shows that optimizing the transportation of raw materials and food increases economic efficiency and has a positive impact on ensuring food security.

To analyse the process of transportation and delivery of agricultural products, Filipino researchers use an optimization model that reduces transportation losses and other costs. They emphasize that the principles of product transportation largely influence the development of the industry [12].

In the analysis of the bakery industry in Iran, linear programming methods and the designing of a network of direct and reverse supply chains are also used to find an effective logistics method [7].

An important task is also to increase the competitiveness of small and medium-sized bakery enterprises. Due to the complex nature of the formation of the necessary conditions for creating a full-fledged competitive environment in baking, the most effective form of solving the problem of competition development in the baking market is the program method of work.

There is already a positive domestic experience of implementing such programs in certain regions of Russia. Thus, in 2008, the Mari El Republic developed and implemented the program "Development of competition of small and medium-sized enterprises in the bakery market of the Mari El Republic for 2009-2012". The result of this program was an increase in the level of providing the population with bread and bakery products of its own production, an increase in the number of baking subjects, an increase in production volumes and the creation of new jobs and infrastructure subjects: educational, production, service and raw material distribution centres.

2 Materials and methods

Solving the problem of food security and providing the population of the region with bakery products of proper quality in the right quantity and at affordable prices directly depend on the rational location of production facilities, availability of raw materials and materials at reasonable prices, the level of development of the logistics network. To find the most effective solutions to these problems, the authors propose a planning methodology based on the combined application of methods of project analysis and mathematical modelling.

Since modelling allows you to consider many factors and conditions simultaneously, a correctly compiled mathematical model makes it possible not only to choose the optimal location of bakery enterprises and raw material supply centres, the level of their production capacities and supply zones, but also to choose the most efficient options for transporting both raw materials and final products between settlements.

Due to the fact that the construction of bakeries and new infrastructure facilities requires capital investments, the next step after optimization is calculating cash flows of the investment project and analysing its effectiveness. The calculation of the cash flows of the project is based on the results of the optimal solutions of the models (Fig. 1). Based on these flows, the analysis of the project is performed. Financial analysis allows to determine the conditions under which the project is attractive to initiators/beneficiaries and investors, the expected NPV, IRR, payback period and other indicators of financial efficiency. At the same

time, in order to make the project feasible it is important to achieve the fair distribution of project benefits between participants (by calculating and aligning the BCR indicator). The algorithm assumes a return to the previous stages if it is necessary to adjust individual conditions. It means that the process has an iterative nature.

The developed project has a complex structure and consists of two components: (1) Construction of new bakeries of various capacities in certain areas where there is a shortage of bread and bakery products, not covered by own capacities and potentially possible transportation of products from areas with excess capacity; (2) Construction of distribution centres to ensure the rhythmic supply of raw materials and supplies to all existing and newly built bakery entities.

The methodological approach assumes a certain algorithm for conducting research: data collection, identification of the territories of the most active consumption and requiring expansion of production, compilation of optimization models for the transportation of products and the placement of production capacities of bakery enterprises and raw material distribution centres, forecasting cash flows and analysing the effectiveness of the project.

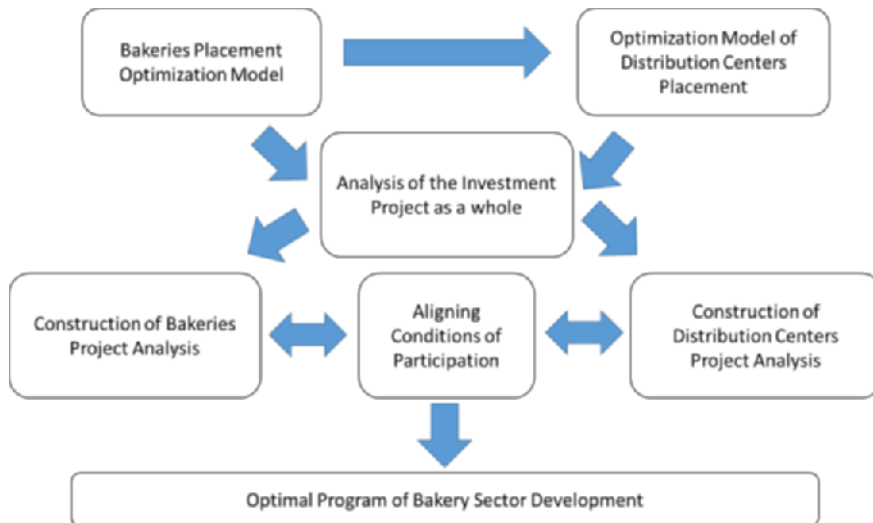


Fig.1. The methodological approach.

This approach was implemented in one of the remote northern regions of Russia – the Republic of Karelia, where the studied problems were expressed most acutely.

The average price of bread in Karelia is higher than the average for the North-Western Federal District and Russia as a whole by 7% and 62%, respectively. At the same time, the average per capita income in Karelia is significantly lower than in neighbouring regions and the national average. This indicates an unfavourable socio-economic situation in the region. Over the past 10 years, there has been a steady decline in production, outpacing the decline in consumption (Figure 2). In 2019, out of 31.5 thousand tons of consumed products, about 13 thousand tons were imported from neighbouring regions (40.6%).

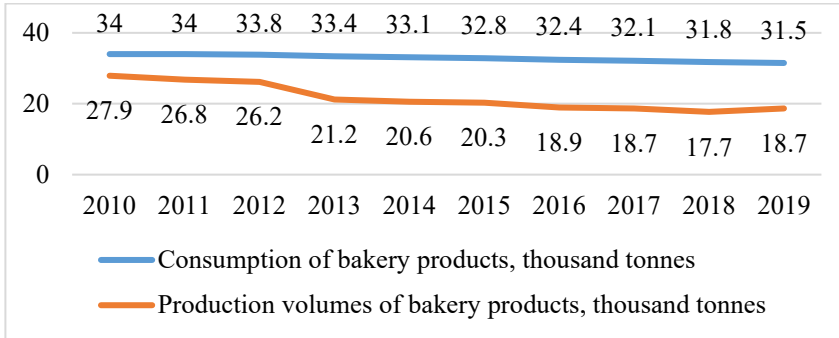


Fig. 2. Dynamics of production and consumption of bread and bakery products in the Republic of Karelia from 2010 to 2019. Source: <https://www.fedstat.ru/>.

The decline in production in the region is caused by the following factors:

1) The growth of the average per capita income of the population has led to a decrease in demand for mass varieties of bread and their replacement in the food basket with other food products and premium varieties of bread products.

2) Reduction of the number of bakeries. To date, the bakery sector of Karelia has only 56 enterprises in 13 cities and 776 rural settlements. At the same time, most enterprises are on the verge of bankruptcy or have a profitability of 2-5%. Eight large bakeries and bakeries in Karelia produce more than 90% of the region's products in kind.

3) Saturation of the market with similar imported products and expansion of large retail chains that set high margins on bread and work mainly with large suppliers from other regions, for example, Fazer in the Leningrad region. This Finnish company, after completing the acquisition (M&A) of the Bread House company, gained an advantage in the market by optimizing logistics and improving the efficiency of business processes, which contributed to the growth of investment attractiveness and business expansion [13]. Now it occupies a leading position in the market.

It can be assumed that the quality and range of products of local bakeries do not sufficiently satisfy the demand of the population, and therefore they lose out in the competition to commodity producers from other regions. As a result, many residents of the republic are forced to buy bread of average quality and at higher prices.

Results and discussion The production of bread and bakery products in the regions of the Republic of Karelia is uneven, in most of them there is a large shortage of products of their domestic production. This is especially true for the remote northern municipalities of the region. In some areas, the lack of the products can be replenished by transportation from areas where there are surpluses. According to the results of the first model, it is necessary to build 40 bakeries of various capacities to replace imports. Among them are 34 medium-sized bakeries, 5 small and 1 large. The total volume of surplus products that can be transported to other regions amounted to 1,046 tons, which allows covering about 8% of the missing volumes of bread production in the Republic. The implementation of the bakery development project in Karelia will cover the shortcomings of its own production in areas with a shortage and reduce the volume of excess production in Petrozavodsk (Table 1). Thus, the production and consumption of bread throughout the region can be more balanced.

Table 1. Compensation of product deficiencies due to the introduction of new facilities and transportation from neighboring areas according to the optimal solution, t.

No	District	Excess (+) / Lack (-) In fact	Growth capacities	Transportation capacity: from (-) / to (+)	Excess (+) / Shortage (-)
					Optimum
1	Petrozavodsk	1080	0	-1046	34
2	Prionezhsky	-648	0	648	0
3	Kondopozhsky	-1729	1750	0	21
4	Segezhskiy	-1725	1750	0	25
5	Kostomukshskiy	-1522	1575	0	53
6	Sortavalskiy	-1063	1225	0	162
7	Medvezhyegorskiy	-1326	1400	0	74
8	Kemskiy	-281	350	0	69
9	Pitkyarantskiy	-835	875	0	40
10	Belomorskiy	-325	350	0	25
11	Suoyarvskiy	-298	350	0	52
12	Pudozhskiy	-867	875	0	8
13	Olonetskiy	-551	525	26	0
14	Ladnepodhskiy	-593	700	0	107
15	Louhskiy	-541	700	0	159
16	Kalevalskiy	-313	350	0	37
17	Muezerskiy	-500	525	0	25
18	Pryazhinskiy	-721	350	371	0
Total		-12759	13650	1046	891

Besides the irrational location of bakeries and an undeveloped logistics network in the region due to its geographical remoteness, the problem of providing bakeries with raw materials is also acute.

The solution of the model for optimizing the distribution of raw materials between enterprises of the bakery industry allowed to determine the number and optimal placement of distribution centers, their capacities and coverage areas.

As a result, an optimal plan for the placement of distribution centers (DC) was found and the required volumes of supplies of raw materials to bakeries were determined (Table 2). The most effective option is the construction of three out of seven potentially possible (according to the model) distribution centres.

Table 2. Results of the optimal solution for the placement of distribution centers in Karelia.

DC	Capacity (t/month)	Occupancy (t/month)	Transportation costs (thousand rubles/month)	Number of bakeries serviced
Petrozavodsk	700	534.1	585.7	55
Kem	350	313.8	518.7	13
Medvezhyegorsk	350	323.6	277.3	20
Total	1400	1171.5	1381.7	88

The results obtained give the opportunity to predict the cash flows of the project for the development of the baking sector of the Republic and evaluate its effectiveness. Calculations

have shown that the payback period of investments is 4 years and 11 months, discounted – 5 years and 4 months. Net present value is positive and is equal to 328.6 million rubles, IRR =16.6%. The Profitability index (PI) is greater than one, which indicates a fairly high financial efficiency of the project. Table 3 shows the performance indicators of the project components and the project as a whole. Under these conditions, the project can be considered effective for all its participants.

Table 3. Financial analysis results for components and the project as a whole.

Indicator	Bakery chain	Distribution centers	Project as a whole
NPV (million rubles)	213	115.6	328.6
Paybackperiod (years)	4.6	5.20	4.85
Discountedpaybackperiod (years)	4.95	5.73	5.26
IRR (%)	18.8%	14%	16.6%
PI	2.07	1.74	1.92
BCR	1.0228	1.0266	-

For multicomponent projects implemented by independent partners, not only their effectiveness plays an important role, but also a fair distribution of gained benefits between participants. Simple logics says that each partner should get equal additional benefits per unit of its capital and operational cost. Otherwise, the partners will not be sufficiently motivated to implement the project. To achieve fair distribution of the net benefits among the participants (distribution centers and bakeries), BCR indicators for all the participants should be of the equal values. Equality of BCR indicators is achieved by selecting the value of the trade margin and the selling price of products: BCR1 (for bakeries) = 1,0228, BCR2 (for the distribution center) = 1,0266, BCR1 – BCR2 \approx 0. Therefore, approximately equal BCR values were obtained for bakeries and distribution centers, which indicates a fair distribution of the project benefits between the participants.

Thus, the project and its components are effective and meet the interests of the participants. It is important to note that the effect is achieved even in the case of decreasing in prices for bread products. In fact, the average market price for bread and bakery products of all types in Karelia in 2019 amounted to 98.47 rubles/kg. At the same time, the average price of 88.29 rubles per 1 kg of finished products is included in the calculations of the project, which is 10% lower than the actual one.

3 Conclusions

The proposed method of combined application of methods of mathematical modelling and project analysis makes it possible to prepare sound solutions for the integrated development of the bakery sector at the regional level.

As a result of the solutions obtained, it is determined:

- 1) optimal placement of baking subjects across the territory of the region, taking into account the production capacities of existing bakeries, distances between settlements, the needs of the population in bakery products, ensuring the rational use of existing and newly introduced facilities and minimizing current and capital costs;
- 2) optimal placement of infrastructure facilities (raw material distribution centers) on the territory of the region, taking into account the needs of bakeries in raw materials and materials, ensuring cost reduction;

3) optimal distribution of project benefits between the participants, ensuring the alignment of the conditions of their participation depending on the size of their contribution to the project, as well as taking into account the individual opportunity cost of their capital.

The results of testing the methodology on the example of the Republic of Karelia prove its validity and adequacy and can be successfully used for long-term planning of the bakery industry development in the region.

References

1. F. Su, Y. Liu, S.J. Chen, S. Fahad, *Journal of Cleaner Production* **386** (2023) DOI: 10.1016/j.jclepro.2022.135792
2. G. Dzhancharova, R. Mukhametzyanov, N. Chekmareva, *Economic Journal* **7(6)** (2022) DOI: 10.55186/2413046X_2022_7_6_387
3. R. Mukhametzyanov, M. Romanyuk, T. Ostapchuk, N. Ivantsova, *Proceedings of International Scientific-Practical Conference “Agriculture and Food Security: Technology, Innovation, Markets, Human Resources” (FIES 2021)* **37** (2021). DOI: 10.1051/bioconf/20213700079
4. R. Araslanov, A.F. Korolkov, R.R. Mukhametzyanov, *Environmental Footprints and Eco-Design of Products and Processes*, 3-11 (2022) DOI: 10.1007/978-981-16-8731-0_1
5. M. Agovino, M. Cerciello, A. Gatto, *Journal of Environmental Management* **218** (2018) DOI: 10.1016/j.jenvman.2018.04.058
6. H. Gül, F.M. Kart, M. Gül, *Economic Engineering in Agriculture and rural Development* **17.2** (2017)
7. A. Mirakhorli, *International Journal of Advanced Manufacturing Technologies* **70**, 1-4 (2014)
8. G. Brunori, *Considerations for evaluation Sustainable Development* **8**, 5 (2016)
9. F. Galli, B. Fabio, B. Gianluca, *Sustainable Development* **8**, 4 (2016)
10. F. Galli, *Italy Economics of Agriculture and Food* **3**, 1 (2015)
11. H. Rohm, *Food products* **6**, 12 (2017)
12. M. Ortanes, R. Villaruel, R. Marañón, K. Latorza, Y. Kurata, *An Agroecological Approach in Food Sustainability* (IEOM Soc, 2020)
13. O. Tretyak, W. Degby, E. Pelto, *Journal of Business and Industrial Marketing* (2013)