

A functionally-oriented approach to digitalization of the activities of competence centers in the field of agricultural cooperation

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Abstract. The publication summarizes the experience of digitalization of the activities of the competence center in the field of agricultural cooperation. The concept of digitalization of the competence center in the field of agricultural cooperation has been formulated and practically implemented, including the use of heterogeneous software products, both author's and third-party developers. Software products and their functions that will automate the main activities of the competence center in the field of agricultural cooperation are considered. The author's software product developed for informational and analytical support of the activities of the competence center opened at the Moscow State University of Technology and Management named after K. G. Razumovsky, allows you to automate accounting functions and data mining functions. The main functions of the created and implemented software product are accounting of agricultural producers, established cooperatives and their participation in events organized by the competence center and other organizations, accounting of grantees cooperating with the competence center, implementation of cluster data analysis methods to identify potential members of an agricultural cooperative.

1 Introduction

The Smolensk region belongs to the regions where over the past fifty years there has been a steady decline in the share of the rural population living on its territory.

If in 1970 the number of urban and rural population of the Smolensk region was approximately the same, amounted to 527.4 and 582.8 thousand people, respectively [1], then in 2021 the number of urban population had a significant advantage and amounted to 663.3 thousand people in relation to the number of rural population - 257.8 thousand people. Moreover, since 1979 and until 2021, the dynamics of the urban population of the Smolensk region is only positive, and its number is continuously increasing and exceeds the rural population by more than two times [1]. To overcome the negative trends of population outflow from rural areas in the Smolensk region, the state program "Integrated development of rural areas" is being implemented [2]. The program's activities involve the development of small forms of farming in rural areas, the organization of agricultural cooperatives. The

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creation and successful functioning of production cooperatives, for example, for the processing of agricultural products, will allow organizing new jobs in rural areas, ensuring the sale and processing of dairy, meat and other agricultural products, including farm products, and will provide an opportunity to receive state support for the creation of production facilities using modern processing equipment and technologies. There is a positive experience in the development of agricultural cooperation in many regions of the Russian Federation, an example of which is the Lipetsk, Penza, Belgorod regions, but in the Smolensk region it is still necessary to continue purposeful work in this direction. For this purpose, several competence centers in the field of agricultural cooperation have been created in the region. One of these centers was established in 2018 in a branch of the Moscow State University of Technology and Management named after K. G. Razumovsky in Vyazma, Smolensk region. The competence center's activities are aimed at consulting support for peasant (farmer) enterprises, farm businesses and cooperatives on the issues of grant documentation, preparation of business plans for the development of organizations, training and advanced training of employees of agricultural and processing enterprises, holding thematic events - presentations, exhibitions of agricultural products, masterclasses, etc. According to the results of the work carried out, the employees of the competence center report to the public administration bodies, the Rector's office of the Moscow State University of Technology and Management named after K. G. Razumovsky, Corporation "SME" JSC.

In order to reduce the complexity of accounting for activities and works in diverse areas of the Competence Center of MSUTM, to increase the efficiency of forming the necessary reporting and conducting preparatory analytical work to further motivate farmers to join agricultural cooperatives, the concept of digitalization of the competence center has been developed and tested.

The purpose of this study was to develop a software product to support the accounting and analytical activities of the competence center in the field of agricultural cooperation, on the basis of which the concept of digitalization of its activities was formed.

Within the framework of this concept, the integration of ready-made software products developed by specialists of Corporation "SME" JSC, including the web application "SME Business Navigator", separate programs to support distance learning, two author's developments: a business card site of the competence center and a software product of accounting and analytical type.

2 Materials and methods

During the research, the results of which are presented in this article, the following materials were used:

- statistical data reflecting the population living in urban and rural areas of the Smolensk region in dynamics over the past fifty years,
- statistical data on the number of producers of agricultural products of the Smolensk region of various forms of ownership in dynamics over four years,
- statistical data on the volume of production of the main types of agricultural products by peasant (farmer) enterprises of the Smolensk region in dynamics over the past six years,
- statistical data on the sale of agricultural products by agricultural organizations of the Smolensk region in dynamics over the past six years,
- technical documentation for software products of the IC developer company related to standard software solutions for agriculture implemented on the Russian software market,
- technical documentation describing the purpose and functions of software tools available to registered users of the SME Business Navigator web portal [3],
- various hierarchical algorithms for cluster data analysis.

When developing a software product to support the accounting and analytical activities of the competence center in the field of agricultural cooperation, a structural approach was applied as the main methodology for designing the modular structure of the software product and the "TO-BE" model of the competence center's activities after its implementation. The definition of the program functions is made in the form of a functional IDEF0 (SADT)-model of three hierarchical levels. The modular structure of the software product, which includes the following software modules: the subsystem of reference information processing, the subsystem of accounting for business entities and received support measures, the subsystem of accounting for events and consulting services rendered, the subsystem of data mining, is designed using data flow diagrams (DFD) of three hierarchical levels. All these tools refer to the tools of the structural approach to the design of automated information systems.

Information about the activities of the competence center is accumulated in the database, which is developed by means of the Clarion 10 DBMS, includes 17 relational tables, the design of which uses the method of normal forms. Four normal forms are executed in the created database, including the Boyce-Codd normal form.

When developing the concept of digitalization of the competence center in the field of agricultural cooperation, a systematic approach, a synthesis method was used.

3 Results

At the initial stage of the research work on the topic "The concept of development of modern commodity-producing structures created on the basis of regional associations of agricultural cooperatives on the example of the Smolensk, Lipetsk and Tambov regions", the customer of which was the Association of Interregional Socio-economic Interaction "Central Federal District", the analysis of statistical data on the dynamics of the number of peasant (farmer) enterprises and various types of cooperatives in the Smolensk region was carried out (Table 1).

Table 1. The number of agricultural producers of various forms of ownership of the Smolensk region.

Ser. No.	Form of ownership of the enterprise	Number of (units) 2017	Number of (units) 2018	Number of (units) 2019	Number of (units) 2020
1	Peasant (farm) enterprises	109	95	79	65
2	Production cooperatives (artels)	181	166	157	141
3	Consumer cooperatives	460	453	447	435

Based on the results of the analysis, conclusions are drawn about the negative dynamics of the number of peasant (farmer) enterprises and agricultural cooperatives. Therefore, the Administration of the Smolensk Region decided to develop an infrastructure to support agricultural producers in the form of competence centers.

The performance indicators of the competence center in the field of agricultural cooperation of MSUTM have been determined, which include:

- the number of agricultural cooperatives organized under the leadership of the competence center in the Smolensk region,
- the number of peasant (farm) enterprises created,
- the number of thematic events held on the presentation of products produced by agricultural producers and the organization of its sale to the population,
- the number of grants and subsidies received by agricultural producers for the development of their material base,

- the number of employees of agricultural enterprises who have improved their qualifications or have undergone professional retraining.

In order to organize the effective work of the competence center with agricultural producers, control and accounting of the results of the activities of this unit, a concept of digitalization of its activities has been developed, which covers the following areas:

- presentation of information about the activities of the competence center in the field of agricultural cooperation on the Internet,
- accounting of agricultural producers working in the Smolensk region, accounting of activities carried out by the competence center and representatives of agricultural producers taking part in them,
- accounting of prepared documents for the establishment of agricultural cooperatives,
- accounting of grants and subsidies issued to producers of agricultural products, in the preparation of which employees of the competence center participated,
- analysis of data on agricultural producers from the perspective of their possible entry into the newly created cooperative,
- professional development, training and professional retraining of employees of peasant (farm) enterprises,
- calculation of indicators of business plans, investment projects implemented by agricultural producers,
- obtaining legal, informational and other consulting assistance.

This concept of digitalization involves the use of a number of software products, one of which is the web portal "SME Business Navigator" [3], accessible from the Internet at the URL: <https://navigator.smbn.ru/>. Using the tools of this portal, employees of the competence center can calculate a business plan or an investment project for an agricultural producer, select objects for rent - warehouses, retail space, etc., find markets for products, get the necessary legal advice and advice on grant support. For a number of objective reasons, which include: the lack of Internet connection and high-quality mobile communication in some rural areas of the Smolensk region, the lack of the necessary qualifications of entrepreneurs, not all representatives of agricultural enterprises can use the web portal "SME Business Navigator", the assistance of the staff of the competence center in this matter is relevant.

In the context of digital marketing and the Internet of Things, the competence center should have at least its own business card website on the Internet so that anyone, regardless of its territorial location, can get interesting information about its activities. Web pages about the activities of the competence center in the field of agricultural cooperation are posted in the corresponding section of the official website of MSUTM https://mgutm.ru/staff_unit/czentr-kompetenczij-v-sfere-selskohoz/. This is a necessary element of the concept of digitalization of the competence center's activities.

In modern conditions of work of educational organizations, due to the restrictions imposed by the coronavirus pandemic on the usual methods and forms of organizing the educational process, many educational programs and advanced training courses have been transferred to electronic platforms supported by automated distance learning systems. There are software solutions of Russian and foreign developers for the organization of an automated distance learning support system, for example, the solution of 1C "1C:E-learning. Corporate University" [4]. However, the competence center in the field of agricultural cooperation of MSUTM uses the Moodle system for these purposes, which is implemented in the educational process of the branch of the Moscow State University of Technology and Management named after K. G. Razumovsky in the city of Vyazma back in 2013. The program is a web portal that has proven itself well and has long been tested for the organization of the educational process of the university and the implementation of advanced training programs. With the help of this software product, professional development is currently being carried out in various programs for all categories of students.

The main activities of the competence center in the field of agricultural cooperation could not be automated with the help of standard software products presented on the Russian software market. Therefore, by means of the Clarion DBMS, a software product was developed that made it possible to keep records of agricultural producers of various forms of ownership – limited liability companies, peasant (farmer) enterprises, agricultural cooperatives working with the competence center. At the initial stage of commissioning of the software product, data on these entities received from the Department of Agriculture and Food of the Smolensk Region, more than seven hundred such organizations, were entered into the database table "Small and medium-sized businesses". All other data on the activities of the competence center – the activities carried out, state support measures provided (Figure 1), consulting services provided for the preparation of documents, training of employees, are attached in real time to the relevant business entities. This approach significantly reduces the complexity of generating reports and analyzing the activity of agricultural producers in matters of interaction with the competence center for obtaining consulting services or organizing joint events.

According to the rules of work with the software product, employees of the competence center register information in a timely and purposeful manner, therefore, it is analyzed in the fullest and most up-to-date content by special tools available in the software product. In response to requests from various structures, data is sampled and reports are generated on key indicators characterizing the activities of the competence center and agricultural producers, such indicators primarily include the number of agricultural cooperatives, the volume of production, processing and sale of agricultural products, the number of applicants for grant support.

Statistical data (Table 1) indicate that the number of peasant (farmer) enterprises, production and consumer cooperatives in this branch of the national economy of the Smolensk region has decreased over the past five years. However, statistical data on the sale of agricultural products by agricultural organizations of the Smolensk region (Table 2) over the past six years indicate that the volume of production and sale of agricultural products for certain types of products has not decreased at all, while for others it has decreased slightly, i.e. the material base of agricultural organizations of the Smolensk region is being strengthened, they are increasing volumes production.

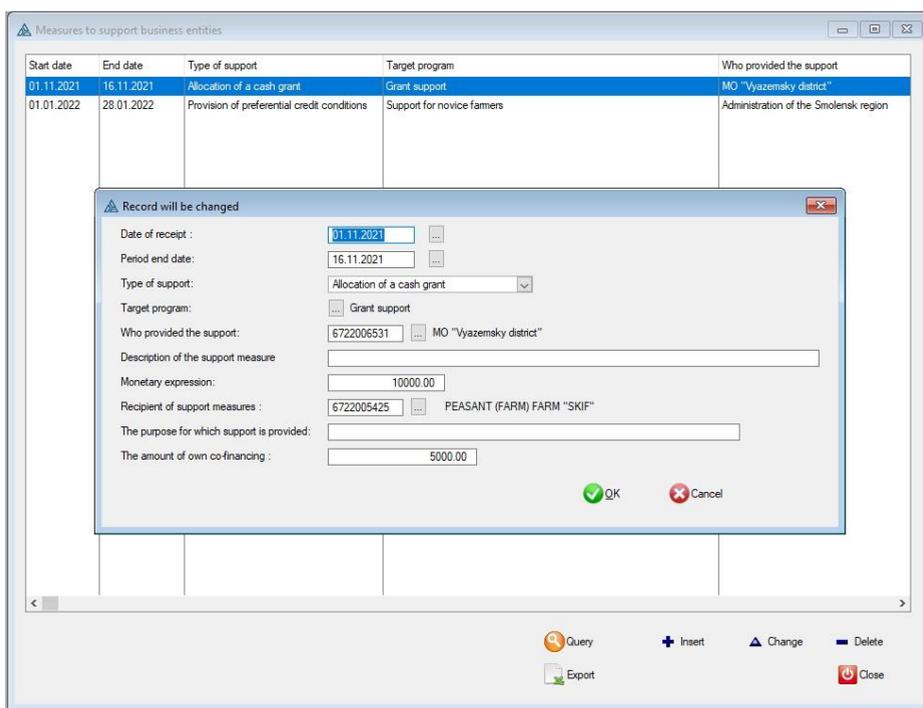


Fig. 1. A form for entering data into the program on support measures provided to the producer of agricultural products.

However, the work on obtaining grants by agricultural producers for the development of their farms and enterprises, the formation of agricultural cooperatives is still inactive. Although it is obvious that large producers or processors of agricultural products are more resistant to fluctuations in the market situation and are less dependent on negative factors (weather conditions, epidemiological situation) affecting the production of agricultural products.

Table 2. Statistical data on the sale of agricultural products by agricultural organizations of the Smolensk region.

Products, in thousands of tons	Grain	Potato	Vegetables	Livestock and poultry (live weight)	Milk	Eggs, million pcs.
2015	100.5	19.8	11.4	52.5	111.2	120.2
2016	111.3	9.1	6.9	59.3	113.0	121.6
2017	123.3	17.9	8.8	71.9	109.3	137.2
2018	111.0	9.1	9.2	76.0	105.4	217.0
2019	136.4	17.2	20.0	79.1	104.5	254.1
2020	111.9	12.6	25.9	79.1	108.1	234.2

The low interest of agricultural producers in the creation of agricultural cooperatives is explained by a number of reasons, which include distrust of government programs to support this area, the complexity of the relationship of cooperative members, the lack of interaction and interrelationships among potential members of cooperatives with each other. To do this, it is proposed to conduct analytical work to identify groups of agricultural producers whose objective performance indicators can lead to their unification with the support of a center of competencies. Various methods of cluster data analysis are used in various fields of scientific

research – agricultural breeding [8], medicine [9], ecology [10], archeology [11], in this study, a practical implementation of the hierarchical clustering method in the software product [7] is undertaken.

In order to carry out systematic motivational work with agricultural producers, aimed, for example, at creating cooperatives, it is necessary to conduct a cluster analysis of the entire set of entrepreneurs attached to the competence center (there are more than 700 of them), according to the signs that, in our opinion, determine their readiness for joint activities. Cluster analysis allows you to form groups of similar objects - agricultural producers for long-distance work with them. In such groups, it must be mandatory to have at least two legal entities, as well as at least five citizens who run a personal subsidiary farm, citizens who are members or employees of agricultural organizations and (or) peasant (farmer) enterprises [5, 6].

The software product implements a hierarchical algorithm for cluster data analysis based on the sequential consolidation of cluster groups [7], which at the initial stage of clustering consist of one business entity. To create cluster groups, lists of members of peasant farms or citizens who run a private subsidiary farm, who, according to previously received information, would not object to becoming members of an agricultural cooperative, are first entered into the program database.

The implemented cluster analysis algorithm is adapted for execution on a PC due to the fact that cluster groups are created in the form of arrays of dynamic variables, which accelerates the auxiliary computational processes of measures of proximity, cohesion, and interconnection of groups.

Classified objects – agricultural producers and potential members of cooperatives can be characterized by two to ten qualitative characteristics, the degree of presence of which in the classified object can be assessed as "good" - 1, "satisfactory" - 0.5, "bad" - 0. M features for N classified objects can be set by the matrix (1):

$$V = \begin{pmatrix} V_{11} & V_{12} & \dots & V_{1M} \\ V_{21} & V_{22} & \dots & V_{2M} \\ \dots & \dots & \dots & \dots \\ V_{N1} & V_{N2} & \dots & V_{NM} \end{pmatrix}, \quad (1)$$

where V_{ij} is the j -th feature of the i -th object; $\vec{P} = (P_1, P_2, \dots, P_M)^T$ is the vector of the

relative significance of the features, and $\sum_{j=1}^M P_j = 1$. Examples of signs characterizing clustering objects are "the need for unification", "the type of agricultural products produced", "planned development of the material base", "interest in state support measures", "accessibility of infrastructure" and others. The measure of proximity between two objects will be the function $\rho(q, l)$, for which the proximity threshold DEL: $0 < \text{DEL} < 1$: $\rho(q, l) = 1$

is set -
$$\sum_{j=1}^M |V_{qj} - V_{lj}| \cdot P_j$$

The $\text{Len}(q, l)$ function characterizes the distance between q and l clustering objects (2):

$$Len(q, l) = \begin{cases} 1, & \text{if } \rho(q, l) \geq DEL \\ 0, & \text{if } \rho(q, l) < DEL \end{cases} \quad (2)$$

At each current step of the program, the number of cluster groups will be obtained, indicated by the Kol_Gr variable, for each pair of which a measure of mutual proximity (3), a measure of the relationship of each group with the others (4), a measure of the cohesion of each group (5), an average measure of the relationship of groups (6), an average measure of the cohesion of groups is calculated (7).

A measure of the mutual proximity of the i-th and k-th groups of objects:

$$MCLOS_{ik} = \frac{1}{DL(i)DL(k)} \sum_{r=1}^{DL(i)} \sum_{q=1}^{DL(k)} Len(S_r^{(i)}, S_q^{(k)}), \quad (3)$$

where $S_r^{(i)}$ is the number of the r-th object from the i-th group; $S_q^{(k)}$ is the number of the q-th object from the k-th group; DL(i) is the number of objects in the i-th group; DL(k) is the number of objects in the k-th group.

A measure of the relationship of the i-th group with the rest of the groups:

$$REL(i) = \frac{1}{Kol_Gr - 1} \sum_{K=1, K \neq i}^{Kol_Gr} MCLOS(i, k) \quad (4)$$

The measure of cohesion (compactness) of the i-th group:

$$KOMP(i) = MCLOS(i, i) - REL(i) \quad (5)$$

An average measure of the relationship of groups:

$$REL_GR = \frac{1}{Kol_Gr} \sum_{i=1}^{Kol_Gr} MCLOS(i, i) \quad (6)$$

An average measure of group cohesion:

$$CLOS_GR = \frac{1}{Kol_Gr} \sum_{i=1}^{Kol_Gr} REL(i) \quad (7)$$

The quality of the breakdown is determined by the criterion: $K = REL_GR - CLOS_GR$, the value of the criterion is chosen as the maximum.

When groups are combined, the criterion is calculated and evaluated. For further evaluation of the correctness of the obtained groups, groups with the maximum value of the criterion are selected. The correctness of the received groups from the position of requirements for the organization of agricultural cooperatives is checked by the presence in them of at least two legal entities and at least five citizens who are members or employees of agricultural organizations and (or) peasant (farmer) enterprises in accordance with the law "On Consumer Cooperation (consumer societies, their unions) in the Russian Federation" [6].

4 Discussion

Currently, the national program "Digital Economy of the Russian Federation" is being implemented in Russia until 2024, according to which extensive and multidimensional work is being carried out on the application and development of end-to-end digitalization technologies defined in the program. This publication examines the experience of developing and implementing the concept of digitalization of the competence center in the field of

agricultural cooperation, which is focused on several end-to-end technologies of the digital economy:

- big data,
- digital marketing,
- Internet of things,
- programming and creation of IT products.

The integration of software products related to these end-to-end technologies made it possible to automate all the main activities of the MSUTM competence center, to build a concept of digitalization of its activities taking into account modern requirements. The practical implementation of the concept of digitalization of the competence center was aimed, among other things, at minimizing the costs of carrying out relevant activities, therefore, an author's software product was developed to collect and analyze information on its activities, a freely distributed Moodle platform was used to organize e-learning for entrepreneurs, the administration of which was previously performed by employees of this department of the Moscow State University of Technology and Management.

Currently, there are quite a lot of offers on the software market to support e-learning, web application development, but software products for the specific needs of accounting and data analysis on the work of competence centers in the field of agricultural cooperation are not presented, so the author's approach outlined in this article may be useful to interested parties.

4 Conclusion

Within the framework of the conducted research, the concept of digitalization of the activities of the competence center in the field of agricultural cooperation of MSUTM was developed and tested, which is based on the integration of multifunctional software products based on different data access technologies. The SME Business Navigator web applications, the competence center website, and the Moodle automated system are based on client-server technology and implement the availability of the services and facilities provided to remote users - producers of agricultural products, and a software product of its own development for information and analytical support of the competence center's activities organizes work with data using the file-server technology and is available to the center's employees only in the corporate information system.

The use of software products within the framework of the digitalization concept allows employees of the competence center to significantly reduce the complexity of analyzing, processing information on its activities and forming the necessary reports, systematize and structure the accumulated information, ensure interaction with agricultural producers, operational calculation of business plans and justifications for the effectiveness of development measures, receive the necessary consulting, including legal assistance, to provide educational services using remote technologies, which is convenient for farmers and other representatives of small and medium-sized businesses, as well as to conduct analytical work for the selection and motivation of members of agricultural cooperatives at the stage of their creation.

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