The object of this study is the transaction costs of agricultural processing enterprises that operate in cooperation with various participants: suppliers of raw materials, buyers of finished products, research enterprises, and other entities. Transaction costs arise at all stages of activity, from the preparation of an agro-processing project to the achievement of the final result.

For this, a simulation modeling system is proposed, including an optimization model that allows estimating the quantitative components of transaction costs. The process of transactions between various participants such as suppliers, customers, and partners is studied using simulation models. To demonstrate the applicability of this model to the example of agro-industrial enterprises, some parameters of transaction costs are modeled when choosing suppliers of raw materials at recommended intervals.

The feasibility of simulating the costs of establishing a relationship with a new partner in the range of 0.5–0.6, and the benefits in the range of 1.05–1.10 has been determined. It has been found that transaction costs associated with raw material suppliers can be saved by 40.0 % in the next 3 years through optimization and digital capabilities.

The presented approach can be useful for a deeper study of the digital environment's impact on the level of transaction costs in agricultural processing enterprises. Such an analysis will reveal potential opportunities for optimization and cost reduction, which is important for improving the efficiency and competitiveness of these enterprises

Keywords: transaction costs, measure of distance, agro-industrial enterprises, modeling, technological and mathematical foundations

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IDENTIFYING THE INFLUENCE OF THE DISTANCE FACTOR ON THE LEVEL OF TRANSACTION COSTS AT AGRICULTURAL PROCESSING ENTERPRISES

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1. Introduction

The modern world is facing serious economic and environmental challenges such as climate change, depletion of natural resources, increased wastage of finished food products, and environmental degradation. This raises the question of the need to move towards sustainable consumption patterns that can help reduce the negative impact on the planet. The rapid development of digital technologies is bringing significant changes to various areas of life, including production, logistics, communications, and consumption.

Currently, the agro-industrial sector is confronted with increasing competition, and effective cost management can be a key factor for the survival and success of enterprises.

Transaction costs are the costs of establishing mutual relations between economic subjects [1]. These costs include any necessary resources that are not directed to the production of economic benefits, but which ensure the successful implementation of that process.

Transaction costs of agrarian-manufacturing enterprises arise in relation to various subjects. This includes suppliers of raw materials, buyers of finished products, scientific research and distribution enterprises, etc. Transaction costs accompany all stages of activity, from the preparation of an agrarian-processing project to the achievement of the final result [2].

The distance factor has a significant special weight in the transaction costs of agrarian-manufacturing enterprises. By limiting physical contact, this factor does not remain unaffected by the cost of quality control of agricultural production and its products. The quality of the agrarian-manufacturing product is directly related to the growing conditions of raw materials of agricultural origin and the agrotechnical care provided to it. Production functions reflecting the dependence of quantitative and qualitative parameters of agricultural raw materials on production factors can be considered in agricultural processing. In practice, it is usually acceptable to use various modifications of the Cobb-Douglas function for this purpose. In this case, the production function is used as a means of interpreting the technological regularities of agricultural production [3].

Transaction costs are classified differently for different characteristics. This process is still ongoing. Therefore, classifications that take into account the realities of the era of

digitalization, in our opinion, are particularly noteworthy [4]. These classifications consider the open infrastructure requirements of the information society in terms of costs.

Based on these reasons, research in the field of transaction costs of agro-processing enterprises is of direct importance for the development of the efficiency, sustainability, and competitiveness of this sector.

2. Literature review and problem statement

From the chronological point of view, in the initial approach, accepting transaction costs as costs necessary for the functioning of the market is acceptable in terms of modern realities. The approach shown in [5] argues that markets are not always efficient and the existence of transaction costs can lead to vertical integrations. However, the calculations showing a positive impact on the reduction of transaction costs from digital technologies are not entirely convincing.

The level of transaction costs in agricultural production enterprises is estimated in [6], and this largely depends on their abilities and the strategic directions that are formed on the basis of these abilities. The problem is that many fruit and vegetable production and processing enterprises do not pay enough attention to marketing and commercial activities. This situation leads to an increase in almost all elements of transaction costs at these enterprises.

In [7], a study of relevant sources is carried out and it is recognized that it is effective to increase the number of transactions with a limited number of partners in order to reduce transaction costs. At the same time, sustainable partnerships are believed to reduce information asymmetries. The authors limit themselves to considering the number of transactions with a limited number of partners to reduce transaction costs associated with shipping companies, without considering other possible strategies or alternative approaches to cost optimization.

In [8], the main focus is on the process of continuous rise in the price of food products, especially products of the agro-industrial sector. [9] confirms this phenomenon. This price increase trend will become more dynamic in the post-Soviet countries starting from 2022. However, these studies do not provide specific numerical or qualitative data on the extent and reasons for the increase in food prices.

As in other countries of the post-Soviet space, in Azerbaijan, where the agrarian production stage is of particular importance, large losses are allowed during the movement of agricultural products to the final consumer. As reasons for this, [10] considers these losses in agrarian and production activities in the context of one-sidedness and a low level of production and processing ties. However, the study does not sufficiently discuss the possible consequences of the continuous increase in the cost of food products, both for the economy and for consumers.

Innovative development and the search for alternatives increase transaction costs. [11] reveals the possibilities of using advanced technologies in the supply of processing enterprises. Probably, a more detailed consideration of the benefits that can be obtained through the use of advanced technologies in supply could enhance the practical significance of the article.

It is believed that there is a fairly close relationship between the level of transaction costs, the market share of suppliers, and the characteristics of the vegetable supply chain as a whole.

For these and other reasons, reducing costs, including transaction costs, in the agri-food sector is of great importance. [12] considers the impact of digital environment factors on transaction costs at agricultural production enterprises in different countries and in different aspects.

Although in the related literature it was important to assess the dependence of transaction costs on various factors, specific calculations have not yet been carried out, especially taking into account factors of distance and the digital environment. All this allows to assert that it is expedient to conduct a study on reduce transaction costs by optimizing the range of raw material supplies to agro-processing enterprises in the digital environment.

3. The aim and objectives of the study

The aim of the study is to assess the impact of digital technologies on transaction costs. It will allow agro-processing enterprises to reduce their transaction costs in dealing with partners.

To achieve this aim, the following objectives are accomplished:

– to differentiate the quantifiable and unknown components of transaction costs;

– to model the elements of transaction costs that can be evaluated quantitatively on the example of an agrarian-manufacturing enterprise;

– to determine the influence of distance and technology factors on the dynamics of transaction costs.

4. Materials and methods of research

The Guba Cannery, which operates in the region of the Republic of Azerbaijan specializing in fruit and vegetable production, was taken as the research object. The main hypothesis consists of determining the role of the distance factor in transaction costs in agrarian-manufacturing enterprises and evaluating the impact of digital technologies on those costs.

The research hypotheses are based on the fact that the distance factor plays a significant role in transaction costs and that the digital environment has real opportunities to reduce those costs.

The approach involves determining the simulation intervals using the «weighted average distance of transportation» indicator proposed by us to study the changes occurring in the area of transportation of agricultural raw materials (fruits and vegetables) to the agrarian-manufacturing enterprise in the simulation system.

Although certain simplifications are allowed in the approach, due to limitations in the database, including in the mathematical construction, the simulations take into account the requirements of the ordinal evaluation of the transaction costs of the agricultural production enterprises operating in the zone of fruit and vegetable transportation to the Guba Cannery by creating a system, almost in experimental conditions.

Real statistical data were used in the calculations. The model was implemented with the help of the MATHCAD mathematical software package.

5. Results of the study of the impact of the digital environment on the level of transaction costs

5. 1. Differentiation of quantifiable components of transaction costs

In order to study the changes in the area of raw material transportation to the agrarian-manufacturing enterprise,

let's propose the «weighted average distance of transportation» indicator (L):

$$L = \frac{\sum_{i=1}^{n}(m_i l_i)}{\sum_{i=1}^{n}(m_i)}. \quad (1)$$

Here:

– n is the number of production points;

– m_i is the mass of the product produced in the i station and intended to be transported to the city ($i=1, ..., n$);

– l_i indicates the distance from the i-point to the city ($i=1, ..., n$). The L indicator allows to determine the degree of compactness of the transport zone of perishable and non-transportable food products to the city [13].

Passive communicative methods between a knowledge engineer and an expert, which allow replacing the observation of real processes with their simulation, are the most developed and experimentally tested methods of knowledge engineering [14]. Therefore, it was considered acceptable to obtain data on the control of agricultural production and its results using production functions thanks to digital technologies. For this purpose, the modification of the Cobb-Douglas function that takes into account scientific and technical progress ($Y=AK^{\alpha}L^{\beta}e^{\lambda t}\varepsilon$, where t is time, λ is the growth rate of production volume due to scientific and technical progress) was taken.

The stationarity of per capita agricultural output data in the official statistical indicators database of Azerbaijan for the years from 1995 to 2021 was tested using the Eviews software package, and the hypothesis about the existence of Unit Roots in the natural logarithm of the population output (per capita) engaged in agriculture was tested by Dickey-Fuller statistical test (Augmented Dickey-Fuller test statistic). Thanks to the calculations, the standard form of the estimated Cobb-Douglas production function for agriculture in Azerbaijan was adopted as follows:

$$Y=AK^{0.69}L^{0.31}e^{0.03t}.$$

In Azerbaijan, the coefficient of elasticity of output in agriculture according to labor consumption was equal to 0.31, and the coefficient of elasticity according to capital was equal to 0.69.

Due to the scientific and technical progress in the Cobb-Douglas production function with a standard shape, let's simulate the production volume growth rate (λ) in the range from 0.025 to 0.030 [15].

The approach also includes the construction and implementation of a model for analysis and forecasting of quantifiable elements of transaction costs as a component of the simulation system.

In order to reduce the transaction costs related to raw material suppliers of the agrarian-manufacturing enterprise, it is recommended to use digital twins as a possibility of the digital environment [16].

Approaches to the quantitative assessment of transaction costs are diverse [17]. The following classification of transaction costs is more common:

1. Costs of finding alternatives.
2. Costs of settlement.
3. Costs of measurement.
4. Costs of concluding a contract.
5. Costs of specifying and protecting property rights.
6. Costs of opportunistic behavior» [18].

The following steps are recommended for the quantitative assessment of transaction costs:

1) differentiation of types of transaction costs, such as local and public;

2) decomposition of the full cost into elements;

3) acceptance of the classification of transaction costs at the research or enterprise level;

4) differentiation of transaction and transformation elements at full cost [19].

In cases where transaction costs are viewed as the costs of buying and selling a product or service [20], reducing those costs can be brought to the issue of reducing exchange costs. Thus, finding an alternative in agrarian-manufacturing activity can be brought to the question of finding a supplier of raw materials or a buyer of finished products at a more reasonable price. Information asymmetry is more common in this process. Studies show that information asymmetry prevents the reduction of transaction costs [21].

Let's also say that studies show that there is a relationship between the level of business legitimacy and the ability to quantify transaction costs [22]. Legitimacy can have a significant impact on agrarian-manufacturing enterprises in reducing uncertainty in their search for partners. The uncertainty faced by those enterprises in the shipment of goods (raw materials) may be related to the inability to reliably predict demand, technological innovations, and unexpected changes in the behavior of partners [23].

In a number of studies devoted to institutional economics, it is considered that economic, legal, and ethical approaches should be applied together [24]. Such an approach does not, in our opinion, increase the number of quantifiable elements of transaction costs.

The level of transaction costs can be related to the psychological state, differences in knowledge levels, and many ethical factors, expressed in the position and irrationality of the bargaining parties' behavior. These are not unambiguously measurable elements [25].

In the absence of an unambiguously accepted approach to the use of mathematical methods and tools in the management of transaction costs, when the database is not reliable, information is incomplete and its asymmetry is large, unexpected situations occur in management, including relationship management, the use of an expert evaluation system is considered acceptable.

The disadvantages of expert assessment methods (dependency of the result on the expert level, subjectivity, high labor intensity of information collection, demand for highly qualified specialists) with its advantages (at least in agrarian-manufacturing enterprises) synthesis of experience and intuition for obtaining new knowledge, lack of statistical data (or when the indicator is qualitative), the possibility of obtaining quantitative assessments can be largely compensated by the possibility of obtaining results in a short time [26].

It is appropriate to use the knowledge engineering arsenal to ensure an acceptable level of database reliability in a digital environment [27].

5. 2. Mathematical interpretation of the problem of optimization (minimization) of quantifiable elements of transaction costs

The following source is noteworthy in terms of examining the issues of modeling changes in the quantifiable elements of transaction costs [28]. Here, the approach to modeling the transaction costs of buyers in electronic commerce shows the

relevance of practical problems of quantitative assessment of transaction costs in the digital environment.

The following model is recommended for analyzing and predicting the relationship-building processes between the agrarian-manufacturing enterprise and the raw material-sending enterprises (partners): it is required to determine the choice of partner $x=\{x_{ij}, i=1, ..., n\}$ so that the result of B (during the acquisition of benefit) let the transaction costs (t_i) be minimum for $i=1, ..., n$:

$$\sum t_i x_i \to \min. \quad (2)$$

The limiting conditions are as follows:

$$\sum_i e_i x_i \geq B, \quad (3)$$

$$\sum_{i \in L_1} c_i x_i \leq I_y, \quad (4)$$

$$\sum_{i \in L_2} c_i x_i \leq I_o. \quad (5)$$

Here:

– n is the number of potential partners;

– c_i are the costs required to establish a relationship with the i-th partner;

– e_i are benefits of relationship with i-th partner;

– L_1 is a high-risk partnership;

– L_2 is a medium risk partnership;

– I_y are restrictions on high-risk partnerships;

– I_o are means restrictions on medium risk partnership.

If the potential partner is not included in the composition (its participation is not considered acceptable), its number is taken as zero. The model can be presented as follows:

$$\sum_{i=1}^{n} \sum_{j=1}^{r} c_{ij} x_{ij} + \sum_{i=1}^{n} c_i f_i \to \min, \quad (6)$$

$$\sum_{j=1}^{r} e_{ij} x_{ij} = 1, \quad (7)$$

$$\sum_{i,j} e_{ij} x_{ij} + \sum_{i=1}^{n} f_i e_i \geq B. \quad (8)$$

Here:

– B is the required increase in efficiency;

– n is the number of potential partners;

– r is the number of selection options of new partners to be included in the composition (in a specific case, three options are considered, i. e. $j=1, r$; $r=3$);

– c_{i1}, e_{i1} are the costs and benefits of terminating the relationship with i-th partner (e_{i1} is taken equal to zero);

– c_{i2}, e_{i2} are the costs and benefits of completing the partnership in the current situation;

– c_{i3}, e_{i3} are the costs and benefits of the partner's alternative choice;

– f_i, e_i represents the costs and benefits of establishing a relationship with a new partner.

5. 3. Realization of transaction cost analysis and forecasting model

Guba Cannery, which activity is being analyzed, receives raw materials (a wide variety of fruits and vegetables) for processing from farms within a 75 km radius of the administrative regions (Guba, Khachmaz, Gusar, Siyazan, Shabran) that are part of the Guba-Khachmaz economic region specializing in the production of fruits and vegetables of Azerbaijan. At the same time, strawberries are brought to the plant from a distance of more than 320 km (Sabirabad region).

Apples, green walnuts, quinces, cherries, strawberries, eggplants, tomatoes, cucumbers, beans, figs, cranberries, and blackberries are aimed for the production of preserves and juices. In a factory without cold storage, raw materials enter the enterprise in May-December. Tar is imported for packaging canned goods and juices. The plant produces 20 types of products (canned fruits and vegetables and juices). The annual production capacity is 6 million conventional cans. On average, 32 percent of the production capacity is used from 2018 to 2020 years, and about 2 million cans of canned fruit and vegetables are produced. There is an opportunity to expand production. During that period, the annual production cost was 5.3 million manats, and expenses were 1.95 million manats. The finished product is sold in domestic and foreign markets (Israel, Turkey, USA, United Arab Emirates).

In practice, it is not uncommon to estimate a number of parameters of the selection model for minimizing transaction costs in the interval [0,1].

In this regard, the following condition obtained as a result of research deserves attention: «A firm that wants to optimize transaction costs must keep the ratio of total revenue to transaction costs for information search in the interval from 0 to 1» [29].

The prices of some parameters of the model of minimization of transaction costs for farms sending fruits and vegetables of the Guba Canning Plant are as follows (Table 1).

Table 1

Some parameters of the selection model for the optimization of transaction costs arising in partnership with farms that send raw materials to an agrarian-manufacturing enterprise

Conventional signs and names of parameters	Value
n is the number of potential partners for raw material supply, unit, $i=1, ..., n$	21
r is the number of choice options of new partners, unit, $j=1, ..., r$	3
c_i are costs required to establish a relationship with partner i, ratio	1
e_i are costs required to establish a relationship with the i-th partner, ratio	1
c_{i1} are costs of termination of the relationship building process with i-th partner	0
e_{i1} is the effect of terminating the relationship building process with i-th partner	0
c_{i2} is the costs of completing the partnership in its current state	1
e_{i2} is the benefit of ending the partnership in its current state	1

The transaction costs at the Guba canning plant were determined at the level of 3.8 % of the average price of the last 3 years (1.95 million manats). The cost-benefit ratio of partnering with a regular raw material supplier over the last 3 years is taken as 1.

Table 2 presents simulation intervals for optimizing transaction costs associated with raw material suppliers to the agro-processing enterprise under study.

The raw material suppliers of the Guba canning factory (a total of 20 fruit and vegetable producers) are located in the territory of Guba, Khachmaz, Gusar, Shabran, and

Siyazan administrative districts. Dozens of surveys and expert opinions have shown that the cannery prefers relatively larger production entities in the selection of raw material suppliers. However, most of the raw material suppliers mentioned are small and medium agricultural production subjects [30].

Table 2

The parameters of the choice model for optimization of transaction costs related to the senders of raw materials to the agrarian-manufacturing enterprise are intended to be simulated by intervals

Conventional signs and names of parameters	Range
P_1 are high-risk partners, ratio	0.10–0.20
P_2 are moderate risk partners, ratio	0.15–0.30
I_y are restrictions on high-risk partnerships, ratio	0.08–0.10
I_o are restrictions on medium-risk partnerships, ratio	0.17–0.25
B is the required increase in benefit, ratio	1.05–1.07
c_{i3} are costs of alternative partner selection	0.2–0.3
e_{i3} is the benefit of alternative partner selection	1.1–1.3
f_i are the costs of establishing a relationship with a new partner	0.5–0.6
e_i is the benefit of building a relationship with a new partner	1.05–1.10

Table 3 lists the parameters that need to be modeled when choosing suppliers in order to optimize transaction costs, taking into account the distance factor to the considered agro-processing enterprise.

Table 3

The parameters intended for the simulation of the selection model for the optimization of the transaction costs related to the senders of raw materials to the agrarian-manufacturing enterprise for the expansion of the partnership area

Parameters	Weighted average distance of transportation (L), km		
	≤75	≤85	≤100
P_1	0.20	0.15	0.10
P_2	0.30	0.25	0.15
I_y	0.100	0.09	0.08
I_o	0.25	0.22	0.17
B	1.05	1.06	1.07
c_{i3}	0.20	0.26	0.30
e_{i3}	1.3	1.2	1.1
f_i	0.50	0.55	0.60
e_i	1.10	1.08	1.05

When determining the simulation interval, it was taken into account that as the distance between the agrarian-manufacturing enterprise and raw material senders increases, the specific weight of high-risk partners (raw material senders) will decrease. In relation to new partners, the required increase in benefits (B) should increase as the distance between the agrarian-manufacturing enterprise and the raw material senders Both considerations are based on the opinion of cannery experts and, in our opinion, do not contradict logic.

The following scenarios were simulated using digital tools and technologies:

– option I – use of digital communication and joint activity services in the presence of official websites of suppliers, open databases;

– option II – use of programs for remote management of partnership projects under the conditions of Option I;

– option III – implementation of result-oriented cyber security solutions within the conditions of Option II.

At this time, considering the change of transaction costs depending on the transportation distance in the current economic conditions, the actual level of those costs was taken equal to 1 (Fig. 1).

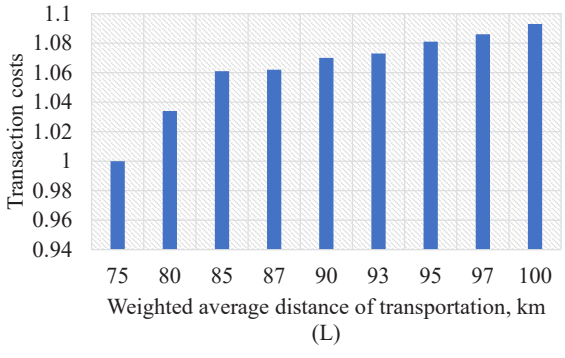

Fig. 1. Expected dynamics of transaction costs depending on the distance of transportation in the current economic conditions at an actual level equal to 1

The implementation of the simulation system described above and the optimization model included in it can reduce transaction costs by 40.0–54.0 % even if the radius of the raw material transportation zone to the canning plant increases from 75 km to 100 km in the next 3 years thanks to the possibilities of the digital environment.

The calculation results (Table 4) clearly show the dependence of transaction costs on the weighted average transportation distance, as well as on the options for using digital technologies and tools.

Table 4

The results for 2025–2026 of the implementations of the selection model included in the simulation system for the optimization of transaction costs related to raw materials senders (the expected level of transaction costs in the current economic conditions is taken equal to 1)

The weighted average distance of transportation, km (L)	Application options of digital technologies		
	I	II	III
L≤75	0.66	0.52	0.41
L≤80	0.66	0.54	0.49
L≤85	0.59	0.49	0.50
L≤90	0.61	0.50	0.53
L≤95	0.62	0.51	0.45
L≤100	0.60	0.52	0.46

The study of the dependence of transaction costs on the average weighted distance of transportation and the use of digital technologies can help the management of agro-processing enterprises to make more informed management

decisions. For example, based on these results, it is possible to identify optimal strategies for organizing logistics, and selecting suppliers and partners.

The results of Table 4 are based on selected data from the stated study period. This data includes a literature review, time series, statistical indicators, and other sources of information. The collected data was analyzed to build an optimization model. The created model explains and predicts changes in transaction costs based on selected factors.

6. Discussion of the impact of the digital environment on transaction costs and evaluation of experimental results in this regard

As part of this study, differentiation of the quantitative components of transaction costs was carried out in an agro-processing enterprise. The factor of remoteness of suppliers of agricultural raw materials was chosen as the main factor influencing the value of transaction costs. To quantify this factor and its interaction with digital technologies, the weighted average indicator of the transportation distance, described by (1) was used for the first time.

With the help of those digital tools, the enterprise whose activity is being studied has the opportunity to determine the main characteristics of the fruits and vegetables it receives for processing. Thanks to the analysis of the data on the official websites of the suppliers, it is possible to reduce the costs of advanced quality control of the fruits and vegetables to be brought to the processing facility. By consulting open databases, potential raw material suppliers can be screened before signing a contract without direct contact. Thanks to electronic document circulation, it is possible to prepare the legal terms of the transaction, etc. [31]. The article presented a model for selecting such partners who provide minimal transaction costs while achieving beneficial results of cooperation. This optimization model was described by formulas (2)–(8).

The results obtained can be applied to medium-sized agricultural processing enterprises. In this case, external effects associated with large enterprises can be discarded [6]. Unlike some existing studies that focus on other aspects [12, 17, 19], this method analyzes how digital technologies can reduce the costs associated with the remoteness of raw material senders. The influence of distance and technological factors on the dynamics of transaction costs were reflected in tables (1)–(4).

The restrictions of this study stem from the limited nature of the primary data, i.e., the presence of incomplete or limited data may limit the ability to generalize and apply the results in broader contexts. Incomplete data can affect the accuracy and validity of conclusions and analyses, as well as the ability of a study to take into account all possible factors and variables that affect the problem under study. This may limit the ability to identify more complex and deeper relationships between variables.

One of the main disadvantages of this study is the constraints in accounting for changes in the market. This is due to the fact that the securities market is in the process of formation in Azerbaijan. Research, based on data from such a market, may limit the completeness of the analysis and the impact of factors that are just beginning to emerge.

It is important to emphasize that this disadvantage not only restricts the prediction of results in the current context but may also affect the generalization of findings for wider practical implementation. Changes in the market, such as changes in regulations, competitive dynamics, and external factors, can have a significant impact on the variables under study and their relationships.

One future direction for the proposed approach could be a deeper study of how various aspects of digital transformation, such as business process automation, the use of big data, artificial intelligence, and the Internet of Things, affect transaction costs. Also, the development of more effective strategies and methods for managing transaction costs in a remote work environment also appears to be one of the possible development paths. This may include developing tools and technologies to optimize business processes.

7. Conclusions

1. Measurable and unknown components of transaction costs are identified, and the possibility of quantifying transaction costs is assessed. To this end, qualitative and quantitative analyzes are carried out to assess their impact on business processes and decision-making. In accordance, the feasibility of using the proposed indicator «weighted average transportation distance» (L) was justified to study changes in the field of transportation of raw materials to an agro-processing enterprise, including the dependence of transaction costs on distance. tested and confirmed in practice.

2. Elements of transaction costs are modeled, which can be quantified using the example of an agricultural production enterprise. A modeling system is proposed, including a model for optimizing the quantitative elements of transaction costs using the example of agricultural enterprises. To select suppliers of raw materials, some parameters of transaction costs are also modeled at recommended intervals and an optimization model is implemented based on the obtained numerical data. With the expected level of transaction costs (3.8 %) at the enterprise taken as the object of study, as well as the costs and benefits of partnership with a permanent supplier of raw materials, taken as 1, in the proposed model the costs of establishing connections with a new partner are within 0.5–0.6 and the benefit from imitation is determined in the range of 1.05–1.10.

3. Through an expert assessment of the results of the experiment, the influence of remote factors and technologies on the dynamics of transaction costs at the cannery taken as the object of study is determined. As a result of the implementation of a modeling system, which includes an optimization model, it is established that during 2024–2026, thanks to the capabilities of the digital environment, transaction costs associated with partners who are suppliers of raw materials for fruits, and the vegetable canning plant whose activities are being studied can be reduced by less than 40.0 %. The uniqueness of the obtained result lies in the fact that the expected savings can be achieved even if the radius of the raw material transportation zone to the processing plant is increased from 75 km to 100 km.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

Data will be made available on reasonable request.

References

1. Ketokivi, M., Mahoney, J. T. (2017). Transaction Cost Economics as a Theory of the Firm, Management, and Governance. Oxford Research Encyclopedia of Business and Management. doi: https://doi.org/10.1093/acrefore/9780190224851.013.6
2. Stifel, D. C., Minten, B., Dorosh, P. (2003). Transactions Costs and Agricultural Productivity: Implications of Isolation for Rural Poverty in Madagascar. SSRN Electronic Journal. doi: https://doi.org/10.2139/ssrn.449220
3. Blanco, C., Raurich, X. (2022). Agricultural composition and labor productivity. Journal of Development Economics, 158, 102934. doi: https://doi.org/10.1016/j.jdeveco.2022.102934
4. Rindfleisch, A. (2019). Transaction cost theory: past, present and future. AMS Review, 10 (1-2), 85–97. doi: https://doi.org/10.1007/s13162-019-00151-x
5. Coase, R. H. (1937). The Nature of the Firm. Economica, 4 (16), 386–405. doi: https://doi.org/10.1111/j.1468-0335.1937.tb00002.x
6. Sgroi, F., Sciancalepore, V. D. (2022). Dynamics of structural change in agriculture, transaction cost theory and market efficiency: The case of cultivation contracts between agricultural enterprises and the food industry. Journal of Agriculture and Food Research, 10, 100396. doi: https://doi.org/10.1016/j.jafr.2022.100396
7. Yousuf, A. (2017). Transaction Costs: A Conceptual Framework. International Journal of Engineering and Management Sciences, 2 (3), 131–139. doi: https://doi.org/10.21791/ijems.2017.3.13.
8. Smith, K. A., Bailie, K. (2022). Why Are Food Prices Still Rising? Forbes. Available at: https://www.forbes.com/advisor/personal-finance/why-are-food-prices-still-rising/
9. Agriculture and Food Security: Casualties of the War in Ukraine. CSIS. Available at: https://www.csis.org/analysis/agriculture-and-food-security-casualties-war-ukraine
10. Alexander, P., Brown, C., Arneth, A., Finnigan, J., Moran, D., Rounsevell, M. D. A. (2017). Losses, inefficiencies and waste in the global food system. Agricultural Systems, 153, 190–200. doi: https://doi.org/10.1016/j.agsy.2017.01.014
11. Baraka, B., Mburu, J., Muriithi, B. (2019). Transaction costs magnitudes, market participation, and smallholder profitability in rural-urban vegetable supply chain. International Journal of Vegetable Science, 27 (1), 54–64. doi: https://doi.org/10.1080/19315260.2019.1700204
12. Fu, W., Zhang, R. (2022). Can Digitalization Levels Affect Agricultural Total Factor Productivity? Evidence From China. Frontiers in Sustainable Food Systems, 6. doi: https://doi.org/10.3389/fsufs.2022.860780
13. Balayev, R. A., Mirzayev, N. S., Bayramov, H. M. (2021). Sustainability of urbanization processes in the digital environment: food security factors. Acta Scientiarum Polonorum Administratio Locorum, 20 (4), 283–294. doi: https://doi.org/10.31648/aspal.6819
14. Keusch, F., Sugie, N. (2022). How to Distinguish Between Passive and Active Mobile Data Collection. SAGE Publications, Ltd. doi: https://doi.org/10.4135/9781529608304
15. Hasanli, Y., Guliyev, G. (2017). Analysis of agricultural products production in Azerbaijan using the Cobb-Douglas function. Statistical News Journal.
16. Ibrahimov, F., Rzayeva, U., Balayev, R. (2023). Opportunities and perspectives of the digital twins' conception: the case in agriculture. Eastern-European Journal of Enterprise Technologies, 1 (13 (121)), 102–112. doi: https://doi.org/10.15587/1729-4061.2023.273975
17. Chintagunta, P. K., Chu, J., Cebollada, J. (2012). Quantifying Transaction Costs in Online/Off-line Grocery Channel Choice. Marketing Science, 31 (1), 96–114. doi: https://doi.org/10.1287/mksc.1110.0678
18. Coase, R. H. (1984). The New Institutional Economics. Zeitschrift Für Die Gesamte Staatswissenschaft / Journal of Institutional and Theoretical Economics, 140 (1), 229–231. Available at: http://www.jstor.org/stable/40750690
19. Loch, A., Santato, S., Pérez-Blanco, C. D., Mysiak, J. (2020). Measuring the Transaction Costs of Historical Shifts to Informal Drought Management Institutions in Italy. Water, 12 (7), 1866. doi: https://doi.org/10.3390/w12071866
20. Nooteboom, B. (1992). Information technology, transaction costs and the decision to «make or buy». Technology Analysis & Strategic Management, 4 (4), 339–350. doi: https://doi.org/10.1080/09537329208524105
21. Bloomenthal, A. Asymmetric Information in Economics Explained. Available at: https://www.investopedia.com/terms/a/asymmetricinformation.asp
22. Wieland, J., Fischer, D. (2019). Transaction Cost Theory and Business Legitimacy. Handbook of Business Legitimacy, 1–21. doi: https://doi.org/10.1007/978-3-319-68845-9_14-1
23. Crook, T. R., Combs, J. G., Ketchen, D. J., Aguinis, H. (2013). Organizing Around Transaction Costs: What Have We Learned and Where Do We Go from Here? Academy of Management Perspectives, 27 (1), 63–79. doi: https://doi.org/10.5465/amp.2012.0008

24. Smelser, N. J., Baltes, P. B. (2001). International Encyclopedia of the Social & Behavioral Sciences. Pergamon.
25. Alaghehband, F. K., Rivard, S., Wu, S., Goyette, S. (2011). An assessment of the use of Transaction Cost Theory in information technology outsourcing. The Journal of Strategic Information Systems, 20 (2), 125–138. doi: https://doi.org/10.1016/j.jsis.2011.04.003
26. Das, N. (2018). Advantages and disadvantages of Expert Systems. Available at: https://www.ilearnlot.com/expert-system-advantages-disadvantages/34332/
27. de Rosa, F., De Gloria, A., Jousselme, A.-L. (2019). Analytical games for knowledge engineering of expert systems in support to Situational Awareness: The Reliability Game case study. Expert Systems with Applications, 138, 112800. doi: https://doi.org/10.1016/j.eswa.2019.07.017
28. Argilés-Bosch, J. M., Garcia-Blandón, J., Ravenda, D. (2022). Cost behavior in e-commerce firms. Electronic Commerce Research. doi: https://doi.org/10.1007/s10660-021-09528-2
29. Yan, Q., Zhang, Q., Zou, X. (2016). A Cost Optimization Model for Multiresource Leveling Problem without Project Duration Constraint. Discrete Dynamics in Nature and Society, 2016, 1–8. doi: https://doi.org/10.1155/2016/1514959
30. Micro, small, and medium entrepreneurship in Azerbaijan (2022). Baku.
31. Su, J., Wei, Y., Wang, S., Liu, Q. (2023). The impact of digital transformation on the total factor productivity of heavily polluting enterprises. Scientific Reports, 13 (1). doi: https://doi.org/10.1038/s41598-023-33553-w