Management of integrated agricultural formations based on modeling and evaluation of added value chains

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Abstract. The article substantiates the theoretical provisions and recommendations for the management of integrated agro-industrial formations based on the use of modeling techniques and assessment of value chains. The proposed method is based on the concept of integral logistics and consists in the formation of the structure of integrated systems and the allocation of material and financial flows in them. The developed methodology for managing integrated agro-industrial formations is based on the use of a multidimensional system analysis, which makes it possible to make informed management decisions in the field of strategic management. In the course of the study, the levels of stability or self-preservation of the integrated agro-industrial formation were identified, which made it possible to identify the classification features of the levels based on the numerical values of the self-preservation limits. The scientific and practical significance of the developed models lies in the possibility of carrying out a multivariate calculation of efficiency when changing the parameters of the functioning of product subsystems and choosing the most satisfying alternative, which ensures the validity of management decisions in the operational management of corporate integrated structures.

1. Introduction

Global trends in modern environmental, energy, food, socio-economic, demographic processes determine the objective need for modernization of the Russian agro-industrial complex in the context of intensified integration processes. The sustainability of the development of agricultural territories is associated with external and internal systemic problems of agro-industrial and economic integration, the real state and trends in the development of agricultural production.

The lack of an adequate economic mechanism for managing integrated agro-industrial formations (IAF), as well as a methodology for managing value chains (value added) within a group of production subsystems that form vertical integration, complicates the management process and reduces the effectiveness of the system as a whole. In the context of the need to achieve long-term competitive advantages, the development of such a methodology is an urgent issue.

Various aspects of integration in the agro-industrial sector of the economy have been studied by several generations of scientists. The theory of added value was substantiated by the English scientist Adam Smith in the fundamental work « An Inquiry into the Nature and Causes of the Wealth of Nations » (1776 year) [11]. The main idea of the theory of factors of production J.B. Say, stated in the
book «Catechism of Political Economy» (1833 year), is that the source of all incomes are productive assets, and added value is created by labor, land and capital [10]. One of the followers of this scientific direction - J.B. Clark in his work «The Distribution of Wealth» argues that "the distribution of income is regulated by social law and the law operates without resistance" [2], in other words, all factors of production receive the amount of wealth that they themselves create.

The concept of economic value added (EVA), in fact, is an alternative approach to the concept of profitability (the transition from calculating the return on invested capital to calculating economic value added in monetary terms). This theory has found wide application in the development of measures to increase profitability, mainly by increasing the efficiency of capital use. The concept of economic value added was based on the assertion that the main goal of a company is to maximize revenue. Other approaches used previously did not show the relationship between performance, company value, and incentive systems. At the end of the eighties of the XX century J. Stern and B. Stewart proposed to evaluate the efficiency of a company using the indicator of economic value added; developed incentive schemes for managers; identified the relationship between EVA and company value [12].

The theoretical aspects of the modern concept of economic value added are based on the studies of Marshall and Scovell [8], and are also presented in the work of B. Stewart «The Quest For Value: a Guide for Senior Managers» [12], in the work of D. Young and S. O'Byrne «EVA and value-based management: a practical guide to implementation» [13].

The method of analyzing value chains as an innovative method of management and the formation of long-term competitive strategies has been successfully used by foreign researchers in the analysis of the fresh and canned fruit market [5]. Using this method, the researchers determined the added value at each stage of creating the final product, which made it possible to identify the reason for the different levels of economic development of business entities involved in the designated market segment. This concept has been successfully used by French economists in the study of the agri-food complex. In their interpretation, «filière» («thread») is a static model for describing the process of creating added value in the form of a linear flow of transformation of raw materials and services into the final product.

In the theory of the formation of competitive advantages, a special place is occupied by the cluster-territorial approach, which substantiates the process of creating added value as a system of links between industries and firms. In the works of M. Porter [9], the creation of added value is investigated in the format of a residential association of a number of industries from different industries, between which synergy and functional relationships are possible. This approach substantiates the emergence of competitive advantages when combining interconnected industries (clusters), including institutions of education, industry, science. It has been proven that an efficiently functioning cluster is necessary for the implementation of a new techno-industrial paradigm [3]. Clustered, integrated formations can act as generators of the development of territorial socio-economic systems and the state as a whole.

Currently, the value added chain covers activities that ensure that a product goes through all stages: from the moment of its creation to its delivery to the end consumer. Gereffi G. identified two main types of value chains [4]:
- manufacturer-managed chains;
- customer-driven chains.

Building an effective value-added chain is based on a strategy that ensures the ability to achieve maximum performance and long-term competitive advantage by enterprises and industries involved at every stage.

The growing processes of globalization, the interdependence of the world's economies, the increasing role of production networks, the intensification of integration processes, determine the emergence of the concept of global value chains at the beginning of the 20th century. [6]. The new concept defines the factors of design and organization of global industries, substantiates the methodology and practical tools for the analysis and assessment of value chains and various types of their management [1].
Our point of view is that the methodology for managing integrated agro-industrial formations should be based on the use of a multidimensional system analysis, the application of which will allow:

- make informed management decisions in the field of strategic management, based on multivariate forecasting of the determinants of development not only of a separate production subsystem, but also of the entire integrated formation;
- to determine the strategic centers of income and expenses of the IAF, depending on the transforming strategic guidelines;
- to optimize strategic guidelines in the field of operational management of the functioning of the IAF on the basis of structural modeling and a comprehensive assessment of value chains.

In this regard, this study is aimed at developing conceptual and theoretical and methodological provisions for the operational management of integrated agro-industrial formations on the basis of substantiating the methodology and methods of modeling and quantifying value chains.

2. Materials and methods

The methodological basis of the research is the fundamental concepts and provisions of domestic and foreign scientists in the field of systems theory and systems analysis, sustainable development of integrated agro-industrial formations, design of management systems, management of value added chains.

3. Results

Horizontal integration is the unification of a group of producers or operators operating at the same level of the technological chain in order to bring the produced agricultural products to the consumer. The separate functioning of agricultural producers in the context of narrow production specialization alienates them from the retail market, due to the presence of a significant number of intermediary companies that collect, process, sort, pack, store, transport and sell products. In these conditions, there is a need to control and manage the entire value added chain, which is associated with the emergence of vertical integration.

Thus, technological or vertical integration is associated with the management of the sequence (staging) of the production process and the entire set of main, auxiliary and service processes. At the same time, in the technological chain, in the process of promoting the product to the consumer, additional cost is added to the initial cost of the product produced by the integrator organization. In the agro-industrial sector of the economy, the role of integrator organizations is played by trade or processing enterprises with access to the retail market. The formation of a complete technological chain with an increase in the effectiveness of activities occurs when enterprises of the agro-industrial complex are included in the association.

It should be noted that in Russia, there is no legislative consolidation of the concept of integrated agro-industrial formations, therefore the most common forms of integration are cooperation and a production contract, which is a long-term agreement concluded between an agricultural producer and an integrator organization. The production contract fixes the parameters of products, production technology, prices and delivery times, suppliers of resources. At the same time, the agricultural commodity producer is limited in the right to control the process of redistribution of resources and change the parameters of the production process.

This form of integration in the agro-industrial complex of the North Caucasian Federal District is most widespread in the production of potatoes, seeds, sugar beets, poultry, fresh and canned vegetables.

Integration of ownership (corporate integration) is a technological integration with the rights of the owner, covering several stages of agricultural production. With this form of integration, the integrator organization becomes the owner of the assets of the organizations being integrated. At the same time, the funds of the integrator organization may include assets of enterprises processing agricultural products, fruit and vegetable stores, food producers, wholesale and retail trade enterprises.
Technological integration presupposes the optimization of the financial resources of enterprises and makes it possible to bring to the market competitive goods in the price segment by introducing a mechanism for managing added value chains (value). The management of this process, according to the authors, means the generation and definition of the vector of financial and material flows between the integrator organization and the product subsystems that are part of the integrated agro-industrial formations.

In meso-level systems, integrated agro-industrial formations of the horizontal type are most competitive. The schematic diagram of the horizontal association of production subsystems of integrated agro-industrial formations displays information, material and financial flows arising between the integrator organization, organizations that are part of the combined structure, and the market (Figure 1).

![Figure 1. Schematic diagram of horizontal integration of production subsystems of integrated agro-industrial formations.](image)

Financial flows include the organization's revenues (revenue from products sold) and costs (advanced, current). The effectiveness of the economic activity of this system is expressed in an increase in the volume of manufactured and sold products, as well as in the possibility of obtaining / increasing profits or reducing losses.

A similar ratio in financial management is expressed by the profitability indicator. The main elements of this indicator:
- the volume of net profit (D) received over a certain period of time from the sale of manufactured products;
- the costs (P) incurred by an economic entity in the performance of technological operations aimed at the production of products.

Consequently, the economic efficiency can be described in the form of the ratio [7]:
When adapting this ratio to the peculiarities of the functioning of integrated agro-industrial formations (Figure 1), united according to the principle of horizontal integration, it should be taken into account: the consolidated (integral) economic efficiency, which expresses the effectiveness of the activity of the entire association, is to be measured.

Then the model for assessing the economic efficiency of integrated agro-industrial formations, formed according to the principle of horizontal integration, will look like:

\[ Ea = \frac{a \sum_{i=1}^{n} D_i}{\sum_{i=1}^{n} P_i} \]  

\[ E_a = \frac{\sum_{i=1}^{n} D_i}{\sum_{i=1}^{n} P_i} \]  

(2)

\( E_a \) - consolidated (integral) economic efficiency of the IAF functioning; \( a \) – synergy coefficient \((a > 1)\) IAF with horizontal integration method; \( D_i \) – the amount of net profit of the \( i \)-th element of the IAF; \( P_i \) – costs of the \( i \)-th element of the IAF; \( n \) – number of organizations in the association.

Thus, the consolidated economic efficiency of an integrated agro-industrial formation, formed according to the principle of horizontal integration, is the ratio of the total volume of net profit of each element of the association, multiplied by the synergy coefficient, to the costs of the association. The coefficient of synergy \((a)\) or consistency is represented by the effectiveness of the total efforts in a specific market segment.

If the synergy coefficient tends to one \((a >> 1)\), then the economic effect doubles, which may result in monopolization of the market segment. Therefore, a number of countries do not support or introduce a ban on the development of horizontal integration.

The calculation of consolidated or integral economic efficiency can be carried out in the process of assessing the effectiveness of activities only in the IAF, united according to the principle of horizontal integration. Integrated agro-industrial formations operating in the form of a holding, concern or syndicate can have both horizontal and vertical ties.

Vertical integration is distinguished by an extended range of interaction between structure elements; the presence of multidirectional information, material and financial flows. The assessment of the economic efficiency of structures with vertical integration according to the above methodology may give an incorrect result and cannot be carried out by simply summing up the effective indicators of the elements of the IAF structure, even taking into account the correction for the synergy coefficient.

Thus, there is a need to substantiate methodological tools and develop models for assessing and managing the effectiveness of the IAF with a vertical form of integration. At the same time, we assume that an integrated formation has a complete added value chain, with a dominant management of material and financial flows.

The movement of material flow between production subsystems that form technological or vertical integration is shown in Figure 2. Obviously, the material flow does not pass through the integrator organization, transportation costs are reduced, and the processes of processing the supplied resources are accelerated. It should also be noted that there are no financial flows between the production subsystems, which increases the rhythm of the production subsystems. The above scheme allows you to distinguish two financial flows:

- the first stream \((d_1)\) - from the integrator organization to the first production subsystem;
- the second stream \((d_2)\) - the stream of proceeds from the sale of manufactured products in the market segment to the integrator organization.

4. Discussion

The above reasoning allows us to consider in more detail the process of functioning of the IAF. Financial flow \(d_1\) is directed from the integrator organization to the first production subsystem for the acquisition of resources (inventories) necessary to produce the required volume of agricultural products (Figure 2). It is assumed that the profit received by the first production subsystem is
reinvested in the material flow of the next production subsystem, and the manufactured products are sold at cost.

**Figure 2.** The structure of a production system with a technological (vertical) integration.

In what follows, it should be assumed that the rate of profit received by the production subsystems will be the same for each subsystem and corresponds to \( k \). Such an assumption will be justified only if the production subsystems are part of the IAF, formed in the form of a holding. Studies prove that it is the holding form of integrated formations that allows to obtain an increased synergistic or systemic effect and has optimal controllability by the integrator organization [7].

Thus, in the first block of the scheme, the financial flow \( d_1 \) is transformed into a material flow in the process of purchasing raw materials, while \( M_1 \) will be equal to \( d_1 \). Then, taking into account the profit \((kd_1)\) obtained during the first stage, we can formalize:

\[
M_1 \sim (1+k) d_1
\]

(3)

In this case, the generated material flow \( (M_2) \) will be equal to:

\[
M_2 \sim (1+k)^2 d_1
\]

(4)

In this case, the generated material flow \( (M_3) \) will be equal to: \((1+k)^3d_1\); and \( M_4 \) will be equal \((1+k)^4d_1\) and etc. Then, after the stage of bringing the manufactured goods to the consumer \( M_n \sim (1+k)^nd_1 \), the revenue of the IAF \( (B) \) will be equal to \( d_2 \), which can be formulated as follows:

\[
B = d_2 = (1+k)^nd_1
\]

(5)

Within a certain period of time (for example, a year), it is possible to implement a number of production cycles, or multiple passage of material and financial flows through the blocks of the technological chain. Having designated the number of production cycles in the system for a certain period as \( m \), we transform the formula for revenue in the following form:

\[
B = m(1+k)^nd_1
\]

(6)

The additional cost of converting material flows \( (\rho) \) will be a fraction of \( d_1 \). Then the costs for the study period will be:

\[
P = d_1 + \rho d_1 = d_1 (1+p)
\]

(7)

The net profit \( (D) \) of the integrated formation will look like this:

\[
D = B - P
\]

(8)
Substituting the values for $B$ and $P$ into the resulting expression, we get:

$$D = d_1[m(1+k)^n - (1+\rho)]$$

(9)

Consequently, the economic efficiency for the studied formation, defined as profitability (2), will be:

$$E = \frac{D}{P} = \frac{m(1+k)^n}{1+\rho} - 1$$

(10)

If the rates of return for each production subsystem of the IAF are different, you should write down:

$$E = \frac{m\prod_{i=1}^{n}(1+k_i)_{1+\rho} - 1}{1+\rho}$$

(11)

$i$ – production subsystem number in the chain.

Expressions (10) and (11) show that the economic efficiency of the IAF will nonlinearly depend on the arguments of the expression.

With an increase in the number of production subsystems, or links of the technological chain, an increase in economic efficiency is observed, which is explained by the emergence of a synergistic or systemic effect, characterized by the transfer of added value formed in the previous production subsystem. When such systems operate in certain parameters, the added value created may, as a result, exceed the initial financial flow $d_1$ used to replenish material resources.

To calculate the quantitative value of the synergistic effect arising in the IAF, we consider it expedient to introduce the synergy coefficient ($a_v$):

$$a_v = m(1+k)^n$$

(12)

The synergy coefficient given in (12) can be considered as a resource or potential of the production subsystem, which manifests itself in the transformation of financial and material flows into a product to be sold. Consequently, the higher the value of $a_v$, the more efficient the production process is and the more goods will be produced as a result with equal financial and material flows.

Conclusion: the production subsystem will have a positive profitability and be effective if the following condition is met:

$$a_v > (1+\rho)$$

(13)

When solving the inverse problem, which consists in determining the amount of financial resources required for the production process for a given amount of products $M_n$, which must be produced, it should be assumed:

$$M_n \sim m(1+k)^n d_1 = d_2$$

(14)

$d_2$ – financial equivalent of manufactured products.

Therefore, $d_1$ can be defined as:

$$d_1 = \frac{d_2}{m(1+k)^n} = \frac{d_2}{a_v}$$

(15)

In the above formula, $d_1$ depends on the parameters of the functioning of production subsystems. Whereas expression (15) shows the dependence of the financial flow on the economic efficiency $E$ and the share of additional costs $\rho$. Then, taking into account (15), we write:

$$d_1 = \frac{d_2}{(1+\rho)(1+E)}$$

(16)

The $d_1$ value shows that with an increase in additional costs, the financial flow may decrease. Whereas the variables $\rho$ and $E$ are interrelated. Consequently, with increasing $\rho$, $E$ will decrease and, accordingly, the volume of the financial flow $d_1$ will permanently increase.
The stability of the integrated agro-industrial formation, in accordance with the refined author's position, is formed on the basis of the conservation law for social or biological systems that seek to maintain their viability while enhancing production potential and rational use of resources. This law for socio-economic systems, which include integrated agro-industrial formations, can be described in the form of a mathematical expression:

\[ \sum_{i=1}^{n} (R_{1i} + R_{2i}) > \sum_{i=1}^{n} (V_{1i} + V_{2i}) \] (17)

\( V_{1i} \) – consolidated internal potential of the IAF in the \( i \)-th area; \( V_{2i} \) – the potential of the external environment in the relevant area that has a negative impact on the functioning of the IAF; \( R_{1i} \) – internal potential or resource; \( R_{2i} \) – external consolidated potential of the IAF in the \( i \)-th area, positively affecting the process of functioning of the IAF.

The left side of expression (17) is «creative potential» \( (C) \), the right side is «destructive potential» \( (P) \). Therefore, the IAF must fulfill the requirement: the sum of the creative potential exceeds the sum of the destructive: \( C > P \).

If the sum on the left side of the expression will exceed the value on the right side for a long time, then the IAF must cease to exist. In the event that resources are insufficient, the IAF may receive a negative financial result, which is associated with the emergence of additional financial liabilities or bankruptcy.

In the theory of the IAF, seven levels of stability or self-preservation of an integrated agro-industrial formation should be distinguished. The classification of levels is carried out on the basis of the values of the parameters of self-preservation (Table 1).

| Resilience levels | Limit values \( C_C \) | Characteristic of the stability limits |
|-------------------|-------------------------|--------------------------------------|
| I                 | -10 ÷ -1                | The sum of the destructive factors significantly exceeds the sum of the creative ones. Additional resource provision has no positive effect. The IAF is to be liquidated. |
| II                | -0.4 ÷ -0.1             | IAF, which have a long period of operation, are in the stage of a short-term decline, are subject to liquidation or reorganization. The IAF, created in the recent past, should focus on finding creative resources or on optimizing / reducing activities. |
| III               | 0                       | IAF in the short-term period of activity - is in a competitive struggle. With a long-term period of operation with a similar parameter, it indicates the need for cardinal changes. |
| IV                | 0.1 ÷ 0.5               | IAF performance is assessed as satisfactory |
| V                 | 1 ÷ 2                   | The functioning of the IAF is assessed as good. |
| VI                | 3 ÷ 5                   | The IAF is in a «preferential» operating environment. Monopolization of activities is possible. |
| VII               | 6 ÷ 10                  | The IAF operates in the informal sector of the economy. |

The numerical values of the limits of self-preservation \( (C_C) \), highlighted in Table 1, are the result of determining the quotient of the difference between the creative and destructive potentials and the potential for creation / destruction: if \( C \leq P \).
\[ C_C = \frac{C - P}{C} = 1 - \frac{P}{C} \]  
(18)

and

\[ C_C = \frac{C - P}{P} = \frac{C}{P} - 1, \text{ if } C \geq P \]  
(19)

If the IAF functions with the limit of self-preservation characteristic of the first and seventh levels, then liquidation is a necessary measure (Table 1). The second level of the above classification should take into account the cyclical nature of the IAF development processes, which provide for the rise and fall associated with the seasonality of production and consumption technologies; the purchasing power of the population, political and economic transformations. Both the recession and the rise of the IAF economy are characterized by the inertia of the process. The recession process is characterized by an average duration of 2.8 years, while the recovery process is characterized by a range of 3 years. The third, fourth and fifth levels of self-preservation are characterized by typical indicators ranging from 0 to 2.

Thus, for the efficient and sustainable functioning of the IAF, the following condition must be met:

\[ C_{C_{\text{min}}} \leq C_{C} \leq C_{C_{\text{max}}} \]  
(20)

For the third, fourth and fifth levels, the limiting value of the \( C_C \) corresponds to the indicator of the efficiency of the functioning of the IAF, given in formula (1).

In integrated agro-industrial formations with a predominant form of vertical integration, a synergistic or systemic effect is manifested, which significantly increases the efficiency of the entire set of production subsystems in comparison with a single organization that is part of the association. Consequently, for the IAF with such a form of integration, the upper limit of the stability limit can rise to a level at which each production subsystem included in the association will have a self-preservation limit \( C_{C_{\text{max}}}=2 \). The lower limit for such structures will be \( C_{C_{\text{min}}}=0 \).

Then, taking into account (15), the efficiency indicator for the production subsystem in determining the critical stability boundary will be:

\[ E_{\text{min}} = \frac{m(1+k)^n}{1+mp} - 1 \geq 0 \]  
(21)

From the given relation (21) it can be seen that to ensure the effective functioning of the IAF, it is necessary that the following inequality holds for the variables \( k, m, n, \) and \( \rho \) given in (21):

\[ (1 + k)^n \cdot \frac{1}{m} > \rho \]  
(22)

Consequently, with an increase in the values of the variables on the left side of the expression, the risk of reducing the stability of the IAF will decrease.

The models for managing the sustainability of integrated agro-industrial formations presented in the study are focused on associations with a single rate of return and level of costs.

5. Conclusion
The work obtained independent scientific results that generalize, concretize and supplement modern ideas about the process of managing the development of integrated agro-industrial formations; on the methods of managing value chains that ensure the operational management of the sustainable functioning of corporate integrated structures, including:

1. The mechanism for managing added value (value) chains is substantiated, based on the generation and determination of the vector of financial and material flows between the integrator organization and production subsystems that are part of the integrated agro-industrial formations. At the same time, it is argued that integrated agro-industrial formations of the horizontal type are the most competitive in meso-level systems. The schematic diagram of the horizontal association of production subsystems reflects the information, material and financial flows that arise between the integrator organization, the organizations that are part of the combined structure, and the market.
2. A methodological toolkit has been developed for calculating the parameters of a technologically complete production chain, which differ from model analogs:
- introduction of additional variables into them (coefficients of technological norms and standard unit costs);
- the ability to calculate the minimum price for socially significant agricultural products;
- the possibility of carrying out a multivariate calculation of efficiency when changing the parameters of the functioning of production subsystems and choosing the optimal alternative.

3. The author's idea of the sustainability of an integrated agro-industrial formation, formed in accordance with the conservation law for social or biological systems, striving to maintain their viability while enhancing production potential and rational use of resources, has been substantiated. In the course of the research, the levels of stability or self-preservation of an integrated agro-industrial formation were identified; the classification signs of IAF stability are substantiated taking into account the cyclical nature of development processes based on the values of self-preservation parameters.

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