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METHODOLOGICAL APPROACHES TO THE DEVELOPMENT OF MECHANISMS FOR THE SYSTEM INTEGRATION OF AGRICULTURAL, PROCESSING AND MARKETING ENTERPRISES

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Abstract

System integration can be an economically advantageous tool for increasing the competitiveness of the regional agro-industrial complex. The article substantiates a methodological approach to the development of mechanisms for the system integration of agricultural, processing and marketing enterprises, reflecting the views of international and national standards of the Russian Federation. This is a three-stage structured algorithm for constructing elements of functional, informational, organizational and resource subsystems and the relationships between them. At the first stage, the system integration of internal functions and processes of the enterprise is carried out. At the second stage, elements are allocated for the formation of subsystems in the process of combining objects. At the third stage, mechanisms for the functioning of subsystems are built on the basis of mutual interest in the development of integrated objects. The mechanisms form and provide both internal and external inter-economic interaction, movement and synchronization of the flows of the totality of information and resources of the organizations under study. A comprehensive methodology for evaluating system integration performance indicators is presented, including quantitative and qualitative characteristics of five hierarchical levels.

Key words**:** *integration in agribusiness, levels, mechanism, efficiency, system*

INTRODUCTION

Modern levels of business and information technology development have led to the formation of the concept and development of system integration tools – a new in-demand approach to improving the management of all processes of organizations. And if for large industrial, banking, transport and other enterprises that successfully implement automation in their business processes, system integration has become an effective way to optimize and improve the quality of all spheres of activity, then for the vast majority of agricultural enterprises this direction opens up new opportunities for growth. And since it is advisable for the producer of raw materials to strengthen ties with processing and marketing organizations in order to increase competitiveness, the tasks of forming mechanisms for system integration are becoming more complicated.

The theoretical foundation for the study of the concentration of production and integration processes in the economy was laid by A. Smith [28] and further developed by D. Riccardo, K. Marx, [2], D. Mill [5] and other scientists. The author's vision of the essence of modern integration and its conceptual directions of development was presented in their works by B. Balassa [3], I.N. Buzdalov [6], E.S. Gvozdeva [12], A.G. Granberg [11], N.V. Ermalinskaya [9], F. Kanhert [15], O.A. Rodionova [26], O. Williamson [29]. The fundamental contribution to the theory of economic mechanisms was made by L. Hurwitz, R. Myerson and E. Maskin [24], the works of L.I. Abalkin [1], A.N. Bychkova [7], S.B. Izmalkov, K.I. Sonin and M.M. Yudkevich [14], A. Kulman [17], N.V. Sirotkina [27] deserve attention. The

systematic approach as a methodology is revealed in the works of Y.M. Biryukov [4], G.B. Kleiner [16], V.I. Loiko [21], A.V. Ovchinnikova [25], E.Y. Chicherova and P.M. Titov [8].

The transformation of factors of the internal environment and economic relations of enterprises due to the introduction of digital technologies is of scientific interest from a theoretical and practical point of view within the framework of the studied topic of modern integration processes [23, 30]. These include specialization, concentration and methods of farming, forms of organization of production and labor, availability of resources, methods of regulation and interaction. The high level of competition combined with scientific and technological progress stimulate market participants to abandon standard single-circuit management strategies and introduce modern digital solutions into business processes [18, 19, 20]. Therefore, at the first stage, the development of mechanisms for the system integration of functions and processes within individual enterprises of the industry is in demand, at the second stage – the unification of a group of enterprises.

In this context, the purpose of the paper is to substantiate a methodological approach to the development of mechanisms for the system integration of agricultural, processing and marketing enterprises, reflecting the views of international and national standards of the Russian Federation.

MATERIALS AND METHODS

The theoretical, methodological and informational base of the research was made up of the works of classics and modern scientists, materials of the Federal State Statistics Service of the Russian Federation (Rosstat), regional agricultural management bodies, Internet resources and other sources. The normative basis was the international standard ISO 19439:2006 «Enterprise integration - Framework for enterprise modeling» (IDT) [13], the national standard of the Russian Federation GOST R ISO 15746-1-2016 «Industrial automation systems and integration. Integration of advanced process control and optimization capabilities for production systems. Part 1. Structure and functional model» [10]. A set of general scientific (system and process approaches, structural, analysis, generalization, modeling, comparison, formalization) and interdisciplinary (functional approach, statistical, normative, morphological, etc.) research methods were used.

RESULTS AND DISCUSSIONS

In accordance with the international standard ISO 19439:2006 ISO 19439:2006 «Enterprise integration – Framework for enterprise modeling» (IDT) [13], the nature of the enterprise is characterized by four representations of the model, grouping and expressing in various ways its functional, informational, organizational and resource content. According to this concept, we consider it expedient to develop these four mechanisms. They represent a set of structures and ongoing purposeful processes of different levels and properties. To do this, it is necessary to build optimal schemes of interaction within functional, informational, organizational and resource subsystems and between them in the association of organizations for the production and processing of agricultural products and the sale of raw materials and finished food products based on digitalization, automation and intelligent information platforms that contribute to effective working methods and sustainable development of the participants of the association and the system as a whole.

The proposed theoretical and methodological approach to the development of system integration mechanisms (Figure 1) reflects the concepts of the standard adapted to the specifics of agricultural, processing and marketing enterprises, based on the ordering of elements of functional, informational, organizational and resource subsystems and the construction of relationships between them. The sequence of events is structured in three stages.

At the first stage, an autonomous object is investigated and described as a system, its comprehensive analysis is carried out, models

of various types are formed for the characteristics of the functions used and the processes taking place, their system integration is carried out through the capabilities of digital business and intelligent information systems. At the second stage, taking into account the principle of compatibility of the selected higher-level elements or their combinations, the design of subsystems is carried out at the level of combining objects into an interacting structure. At the third stage, mechanisms are being built and the connections between them are being improved, allowing to implement the tasks of optimization, development and forecasting of the state of the integrated system.

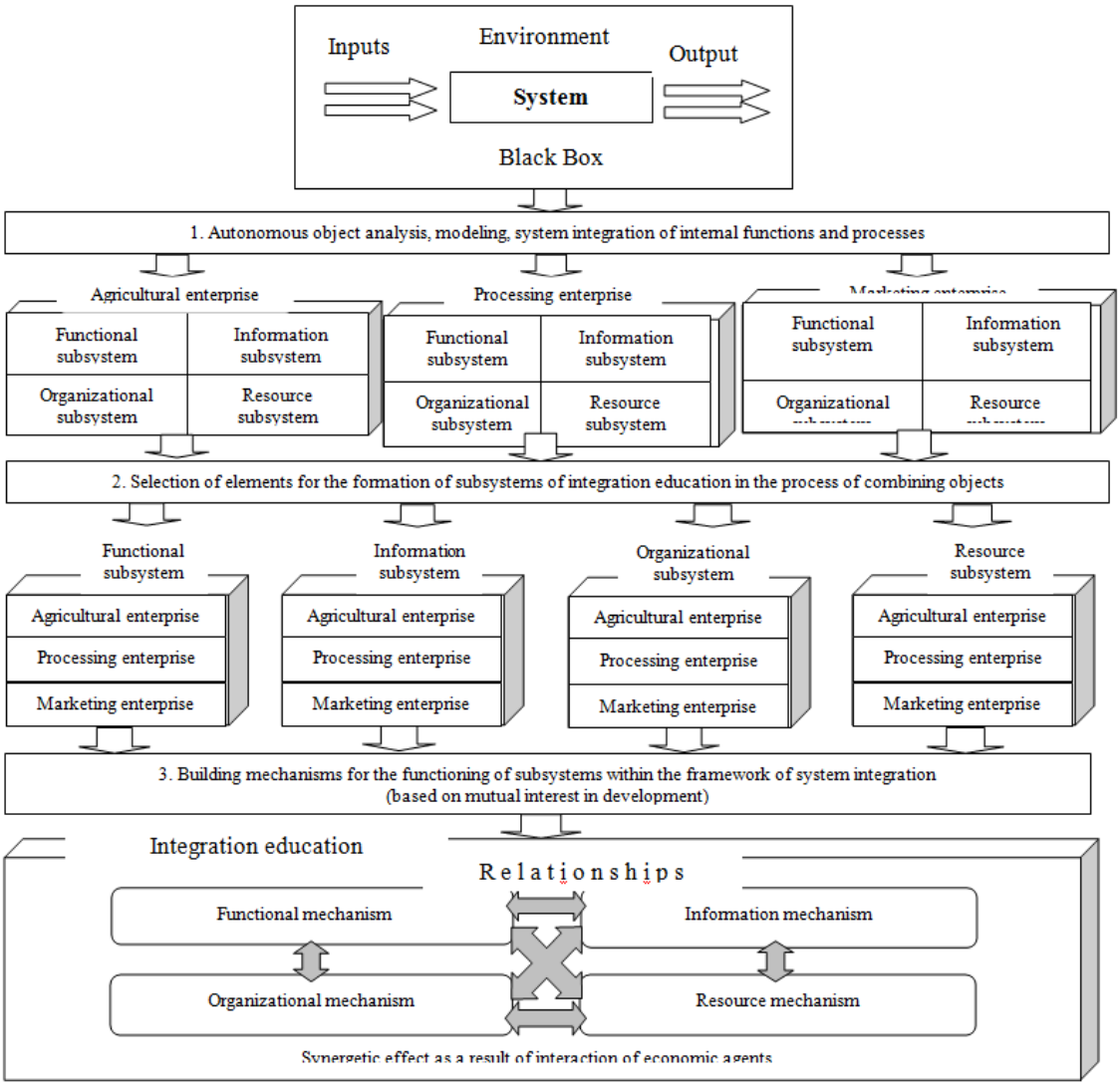

Fig. 1. Methodological approach to the development of mechanisms for the system integration of agricultural, processing and marketing enterprises
Source: Developed by the author.

Modern authors investigate the systems or subsystems of interest to us mainly at the level of business process management of individual enterprises. Within the framework of the research topic, the concept of "subsystem" is considered as an integral component of the formation of mechanisms for the management system of a set of integrated enterprises of various areas of specialization (areas of production, processing, sale of agricultural products). We believe that the mechanisms of functioning of these subsystems form and provide both internal and external inter-economic

interaction, movement and synchronization of the flows of a set of information and resources (labor, material, financial) of the organizations under study.

The identified basic elements for the construction of mechanisms for the functioning of subsystems of integration education are presented in Table 1.

Table 1. Matrix of elements for building system integration mechanisms

Complex of system integration subsystems	Levels of system integration	Agricultural enterprise	Processing enterprise	Marketing enterprises
Functional subsystem	the level of integration association	- combined elements of modules: «Planning», Enterprise Resource Planning (ERP), management systems based on data mining; - control with forecasting and optimization in steady-state modes		
	private enterprise level	systems for accounting of works and agricultural operations, monitoring, scouting, control, reporting and analytics	programmable process control systems, automatic regulation and control, automated process control systems	electronic customer profiles, clustering, business rules management systems, Customer Relationship Management (CRM)
Information subsystem	the level of integration association	- combined components of the modules «Operational planning in production», «Address storage», «Mobile Client», ERP, digital management systems based on an intelligent approach to data storage, analysis and processing (interaction through technical elements based on the Internet); - providing subsystem of movement and interaction of resources of enterprises on the basis of legal, technical, regulatory documentation, means of information transformation of economic and clerical order		
	private enterprise level	enterprise management system based on the «1C: Enterprise 8» platform, including through the application solution «Ear: Grain Accounting and processing», application software solutions for storing, analyzing and processing data on the enterprise personal computers, tools for information conversion	enterprise management systems based on the «1C: Enterprise 8» platform, applied software solutions for storing, analyzing and processing data on personal computers of the enterprise, tools for information conversion	enterprise management systems based on the 1C: Enterprise 8 platform, applied software solutions for storing, analyzing and processing data on personal computers of the enterprise, tools for information conversion
Organiza-tional subsystem	the level of integration association	- decisions of general meetings; - strategic plans; - consolidated budgets (cash flows, income and expenses, forecast balance, purchase and payment limits, planned profitability); - general regulations, instructions		
	private enterprise level	charter, accounting policy, staffing, job descriptions, internal regulations	charter, accounting policy, staffing, job descriptions, internal regulations	charter, accounting policy, staffing, job descriptions, internal regulations
Resource subsystem	the level of integration association	- Supply Chain Planning and Management Systems (ERP), Supply Chain Planning (SCP), Supply Chain Management (SCP), Supply Chain Event Management (SCM); - Customer relationship management systems (BPM – Business Process Management), BSC/KPI (Balanced Scorecard / Key Performance Indicators), CRM (Customer Relationship Management); - Supplier relationship management systems (SRM); - Collaborative planning, forecasting and Resupply (CPFR); - Integrated Sales and Operations planning (S&OP)		
	private enterprise level	«Lean Production» + «Six Sigma», Material Requirements Planning (MRP I), Distribution Resource Planning (DRP /DRP II), Customer Synchronized Resource Planning (CSRP), Manufacturing Execution System (MES)	«Lean Production» + «Six Sigma», Material Requirements Planning (MRP I), Distribution Resource Planning (DRP /DRP II), Customer Synchronized Resource Planning (CSRP), Manufacturing Execution System (MES), Product Lifecycle Management (PLM)	Customer Synchronized Resource Planning (CSRP), Manufacturing Execution System (MES), Product Lifecycle Management (PLM)

Source: Developed by the author.

The internal functions and processes of individual enterprises can be modified based on the capabilities of software services and technologies proposed for the private levels of each of the subsystems. For example, an agricultural producer, by implementing systems for accounting for work and agricultural operations, monitoring, scouting,

control, reporting and analytics, improves and optimizes the implementation of management functions by automating individual operations, and also minimizes subjectivity in the work of managers and specialists. Using management systems based on the «1C: Enterprise 8» platform, including applied software solutions «Ear: Grain Accounting and processing», services for storing, analyzing and processing data on personal computers of employees, means for information conversion, the organization builds a basis for reliable and timely reflection of all events in quantitative and qualitative parameters.

By updating the charter, accounting policy, staffing, job descriptions, internal regulations in a timely manner due to changing requirements, the administrative and managerial staff ensures a clear uninterrupted operation of all structural divisions and individual members of the team.

Using the capabilities of individual «Lean Manufacturing» systems most suited to the specifics of production in combination with «Six Sigma» (Lean Production + Six Sigma), material demand planning (MRP I), resource planning in distribution (DRP/DRP II-technologies), resource planning synchronized with the consumer (MES, CFM, CSRP) or their combined modules, the enterprise forms a modern resource subsystem with the characteristics of rationality and continuity.

The mechanisms of system integration of enterprises in the region are based on the capabilities of software services and technologies proposed for their combined levels within each of the subsystems. In particular, the combined elements of the modules «Planning», ERP systems, information management systems based on data mining, management method with forecasting and optimization in steady-state modes will allow to form elements and organize the work of the functional subsystem of the studied agricultural, processing and marketing business units. Similarly, mechanisms are being developed for the integration of information (based on the components of the modules «Operational planning in Production», «Address storage», «Mobile Client», ERP systems, digital management systems based on an intelligent approach to data storage, analysis and processing, providing subsystems for the movement and interaction of resources), organizational (based on decisions of general meetings, strategic plans, consolidated budgets, general regulations, instructions) and resource (based on planning systems and supply chain management, relationships with customers and suppliers, joint planning, forecasting and restocking, integrated sales and operations planning) subsystems.

Approaches to the integration of advanced process control capabilities and optimization of production systems served as the basis for the implementation of the tasks in the functional sphere. For the information sphere – means of modern electronic and material document management and ERP systems. For the organizational sphere – methods of constructing matrix management structures. For the resource sphere – building relationships and structures based on the platform approach.

According to the materials of the National Research University «Higher School of Economics» [22], in 2019, only 57.2% of the total number of organizations in the business sector of the Russian Federation used software to solve managerial and economic problems, 31.2% worked with databases through global information networks, 23.3% used ERP systems for enterprise resource planning, 18.6% – customer relationship management systems (CRM), 10.6% – supply chain management systems (SCM).Among the types of activities presented by the Institute for Statistical Research, there is no information on the branches of agriculture and the food processing industry, which is due to the lag in the development of adapted system products and their implementation due to the complexity of management. The available data on wholesale and retail trade facilities are significantly higher than the national average: the use of software tools for solving managerial and economic tasks – by 4, the use of databases – by 10.3, ERP systems – by 14.2, CRM systems – by 14.6, SCM systems – by 13.1 percentage points. The current

situation suggests that marketing enterprises focused on final demand can be conduits and stimulators of accelerated implementation of the principles and tools of system integration among processing and agricultural partners.

The proposed methodology for a comprehensive assessment of the effectiveness of the system integration of agricultural, processing and marketing enterprises (Figure 2) allows us to judge the effectiveness of improving functional, informational, organizational and resource mechanisms. The approach is based on the analysis of quantitative and qualitative characteristics of key parameters characterizing the internal processes of organizations and their associations on five hierarchical levels.

The first level (performance indicators of individual elements of the management system) includes assessments of production processes (services) in accordance with specialization.

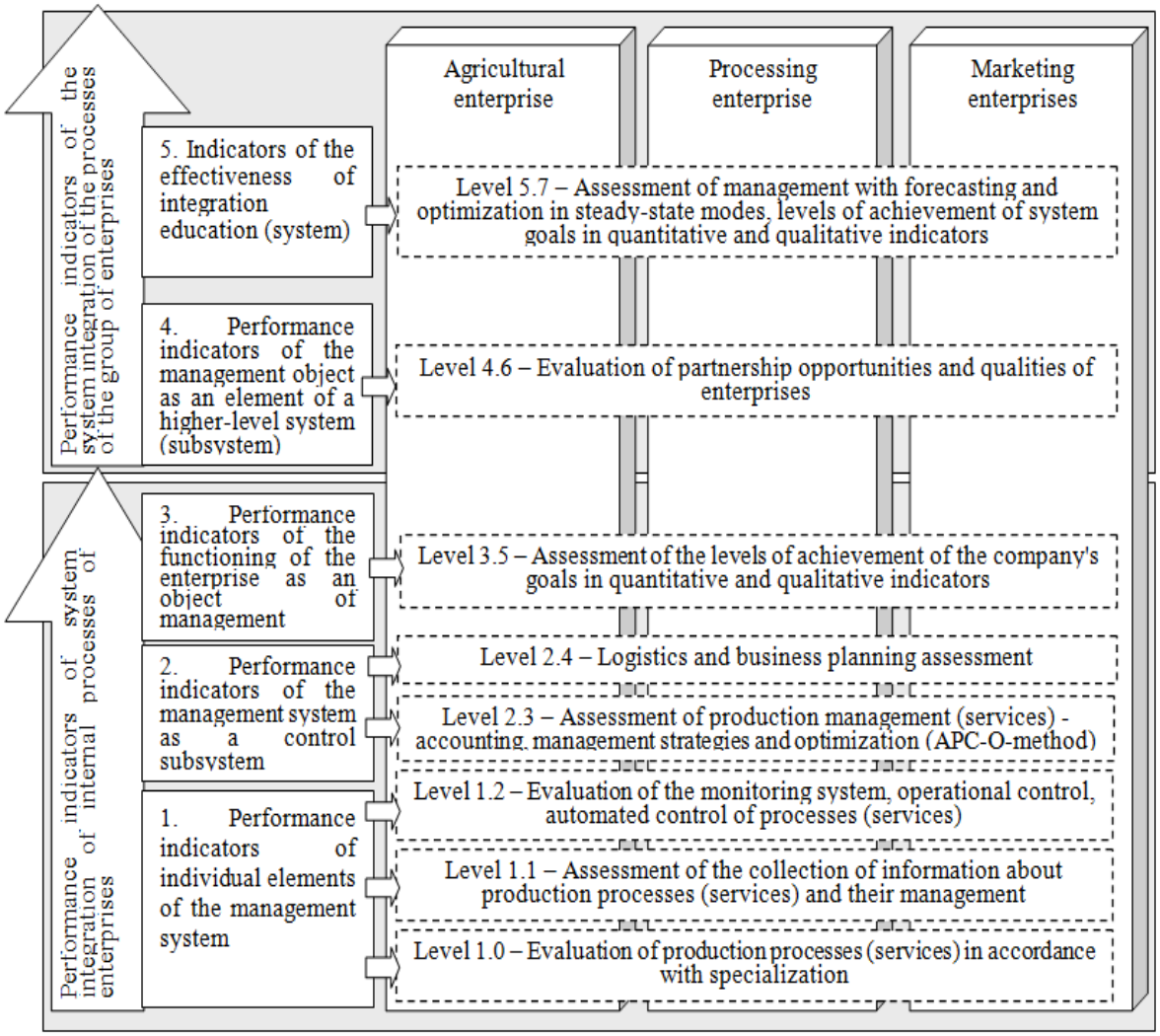

Fig. 2. Methodology for the comprehensive assessment of the effectiveness of the system integration of enterprises
Source: Developed by the author.

These include analysis of the cost of the process and its products, functional and cost analysis, the proportion of defects, errors during orders, the structure of industry according to the method of M. Porter, benchmarking, frequency analysis, causal diagram K. Ishikawa. Also, this level includes the collection of information about production processes (services) and their management, these are the timing and reliability of obtaining information, methods of analyzing statistical materials. The first level also

includes an assessment of the monitoring system, operational and automated control of processes (services). It is possible by such indicators as security, critical control points, execution time, operation without failures, measurement accuracy, checklists, maps, matrices, coefficients of controllability of business processes, resource intensity.

The second level (performance indicators of the management system as a control subsystem) consists of assessments of production (services) management, accounting, optimization, APC-O-method. Estimates are carried out using the following tools: a system of cost accounting and cost calculation methods; analysis of manipulated, controlled variables, disturbing parameters; dynamic models; achievement of the objective function. The second level also includes the assessment of business planning and logistics by analyzing the quality of business planning, the overall performance of the business system, discounting cash flows, costs in the supply chain management, the duration of processes, the level of service quality.

The third level (indicators of the effectiveness of the functioning of the enterprise as an object of management) is an assessment of the levels of achievement of goals in quantitative and qualitative indicators. Here, the effectiveness of the strategy, economic, financial indicators, labor savings and cost reduction in the field of business process management, the time duration of management cycles as a result of the introduction of information technology, methods of expert and heuristic assessments are applicable, indicators of the social efficiency of business process management (increasing the degree of scientific and technical management, the level of integration of management processes, manageability of the system, job satisfaction, increasing the degree of validity of decisions).

The fourth level (indicators of the effectiveness of the management object as an element of a higher-level system (subsystem)) is an assessment of partnership opportunities and qualities of enterprises. The analysis is carried out according to a set of criteria for the level of significance of a group of partner enterprises, the partner's share in the total volume of the group; points are determined based on estimates of durability, depth, possibility of duplication, reliability of dynamics, efficiency; scales of assessments of the organization, development, and effectiveness of partnerships are introduced.

The fifth level (indicators of the effectiveness of integration education (system)) is designed to assess management with forecasting and optimization in steady-state regimes, the levels of achievement of the goals of the system in quantitative and qualitative indicators. Expert forecasting methods, SWOT analysis of business processes, identification of problem areas, indicators of social efficiency are used from the group of qualitative indicators. Among the quantitative ones, formalized forecasting methods, statistical and structural models, product and process indicators, consumer satisfaction levels (external and internal), performance indicators (complexity, processability, controllability, resource intensity, controllability of business processes) are applicable.

CONCLUSIONS

A methodology has been developed for constructing mechanisms for the system integration of agricultural, processing and marketing enterprises based on the ordering of elements of functional, informational, organizational and resource subsystems of the association of economic agents and building relationships between them. The proposed concept complies with ISO 19439:2006 «Enterprise integration – Framework for enterprise modeling» (IDT), is based on the principles of a systematic approach, reflects the nature of enterprises and their economic mechanism with four standard representations of the model.

The methodology of a comprehensive assessment of the effectiveness of the system integration of enterprises after improving the functional, informational, organizational and resource mechanisms of interaction, including groups of indicators of quantitative and qualitative characteristics of the parameters of

internal processes of organizations and their associations, is recommended. The first group allows you to judge the effectiveness of production processes (services) in accordance with specialization, assesses information collection and management, monitoring system, operational and automated control, accounting and optimization, APC-O-method, business planning and logistics, levels of achievement of the organization's goals. The second group is an analysis of partnership opportunities and qualities, management with forecasting and optimization in steady-state modes, levels of achievement of the system's goals.

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