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Institutional and architectural design of organisational development of large-scale economic and industrial systems

Abstract

Introduction. There exist a great number of researches devoted to integration interaction of enterprises in this scientific field. Typically, they focus only on studying corporate relations and require expansion in the area of all possible organizational forms of enterprises interaction within the formation of large-scale economic and industrial systems (LSEIS).

The purpose of this article is to prove the hypothesis about the appropriateness of proceeding organisational transformation of business entities through involving enterprises in integration interaction. Accordingly, the purpose can be achieved by applying methodologies of institutional and architectural design of LSEIS organizational development.

Methods. To achieve the purpose, the authors have used the technology of conceptual design. By its means, a model of substantive research and the system of hypothesis is formed to implement organizational development. The adjustment of interaction between LSEIS participants has been carried out according to the multi-agent approach and standards of architectural description of the systems.

Results. The application of these methods allows developing spiral submission of the process of organisational development, as well as presenting the developed conceptual model to form institutional and architectural description of LSEIS. The model designed to operate the mechanism of organisational development of integrated association of enterprises is based on the principles of reflexive management and recursive coordination of the concerns of the target system with the interests of all its stakeholders.

Conclusion. The proposed concept allows coordinating the guiding influences of the mechanism of LSEIS development management at micro- and mesolevels (at the level of LSEIS participants and LSEIS interaction with other integrated associations).

Keywords: Institutional Design; Enterprise Architecture; Organisational Development; Large-scale Economic and Production System; Change Management

JEL Classification: G34; M14; O16

DOI: <https://doi.org/10.21003/ea.V165-16>

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Інституційно-архітектурне проектування організаційного розвитку великомасштабних економіко-виробничих систем

Анотація

У статті представлено концепцію інституціонального проектування організаційного розвитку інтегрованих об'єднань підприємств, в основу якої покладено стандарти архітектурного опису складних соціально-економічних систем та розширення методології управління змінами. В основу розробки концепції покладено онтологічне та мультиагентське моделювання механізму управління розвитком великомасштабних економіко-виробничих систем.

Ключові слова: інституціональне проектування; архітектура підприємства; організаційний розвиток; великомасштабна економіко-виробнича система; управління змінами.

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Институционально-архитектурное проектирование организационного развития крупномасштабных экономико-производственных систем

Аннотация

В статье представлена концепция институционального проектирования организационного развития интегрированных объединений предприятий, основанная на стандартах архитектурного описания сложных социально-экономических систем и применении методологии управления изменениями. В основу разработки концепции положены онтологическое и мультиагентское моделирование механизма управления развитием крупномасштабных экономико-производственных систем.

Ключевые слова: институциональное проектирование; архитектура предприятия; организационное развитие; крупномасштабная экономико-производственная система; управление изменениями.

1. Introduction

The development of national and world economy is possible only in case of consolidation of resources and competences of all types of entities (even those which have never entered into close cooperation before). The relevance of this approach is confirmed by high activity in the field of M&A and growth of the total value of mergers and acquisition agreements in a long term prospective. As it is shown in Figure 1, despite the crisis since 1995, there has been an increase in the number and value of M&A agreements in the global market.

The total value of M&A agreements worldwide in 2015 was USD 4.1 trillion. It is by 16% more if compared with their value in 2014 (although the number of agreements increased by only 2.7%) [1]. A decline in M&A amount took place in 2016. According to [2], it was 18% (from USD 4.66 trillion to USD 3.84 trillion). Although, the income from M&A agreements decreased by only 2% in 2016. This shows that there was a growth in the value of individual M&A agreements. A confirmation of such a trend is provided in Table 1, along with detailed information by region. This information shows us the difference in the structure of M&A agreements in different regions of the world. In any case, this information proves the relevance of studying the integration process, especially in the case when the enterprise is part of a supply chain.

In Figure 1, the flip side of the growth in the value of M&A agreements is the distribution of other forms of interaction between enterprises to create new consumer value or obtain joint competitive advantages. By its legal form, such an interaction differs from M&A agreements. However, its content is similar to the definition of logic and business rules of coexistence typical of the participants of the integrated logistics network. This is confirmed by the relevant information provided in Table 2.

The organizational form which can combine results and benefits of both corporate integration (see Table 1) and cooperative relations (see Table 2) is presented by large-scale economic and industrial systems (LSEIS) which are hypercomplex formations created from a range of diverse

Tab. 2: Characteristics of enterprises' interaction within the value chain

Characteristics surveyed by Pricewaterhouse Coopers	Attitude of enterprise to participate in value chain		
	Minimum attention to the value chain	Average ratio of participation in value chain	Efforts maximised to increase supply chain efficiency
Average margin of EBIT (%) [4, 8]	7	12	16
Average efficiency of delivery (OTIF, On Time and In Full) [4, 8]	79	89	96
Number of supply or value chain configurations [4, 13]	3.1		4.3
Average inventory turnover (quantity) [4, 9]	4	8	16

Source: Calculated by the authors based on [4]

systems characterised by relationships of diverse character and probabilistic behaviour of the participants (M. A. Kizim, 2000) [5, 12-16].

It is within the framework of LSEIS that the consolidation of resources and competences of individual enterprises happens. The effectiveness of such consolidation mainly depends on the completeness of the regulation of functions performed by LSEIS participants, the correctness of distribution and regulation of business roles between strategic units of the integrated formation, the extent to which LSEIS components are linked together within the framework of the fundamental description of the system organisation and the ability of individual entities to implement changes while being involved in the LSEIS structure. Accordingly, the problem of theoretical and methodological development, as well as methodological support, of institutional and architectural design LSEIS activity and its development is actualised. Only the formation of such support will allow achieving the optimal correlation between LSEIS objectives and the parameters of their reflection on integrated business processes.

2. Brief Literature Review

Integration processes and organisational development of enterprises has always been in the area of attention of domestic and foreign scientists and economists. This is primarily due to the constantly changing conditions of business activity and the objective need to adapt to them from the part of economic agents. At the same time, it should

be noted that the existing developments of scientists and economists are quickly losing relevance because of changing economic conditions. One of the related trends is the corporatisation and distribution of integration and cooperative interaction between enterprises. The study in the area of corporate governance is rather widespread: from the development of theoretical and methodological base (V. V. Bokovets, 2015) [6] to the improvement of its specific components (M. Aluchna, S. Idowu, 2017) [7].

A similar situation occurs in the field of proceedings related to cooperative processes (E. G. Popkova, 2017) [8] and

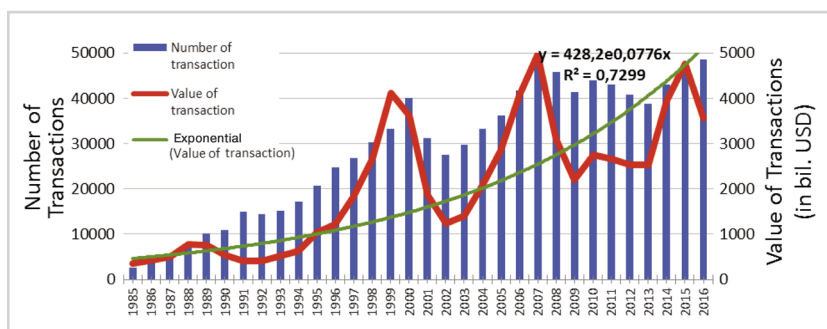


Fig. 1: Dynamics of the world market of mergers and acquisition agreements

Source: Developed by the authors based on [1]

Tab. 1: Detailed cost of M&A agreements by world regions in 2016

Sector breakdown	Global M&A activity		Value and structure (%) of deals				
	Value of deals, billion USD	Market share, %	Europe, billion USD	US, billion USD	Central & South America, million USD	Japan, million USD	Africa & Mid-dle East, million USD
Energy, Mining & Utilities	608.5	18.8%	159.2 (24.9%)	337.4 (25.4%)	43.198 (29.7%)	6.764 (11.3%)	5.799 (7.2%)
Industrials & Chemicals	520.1	16.1%	120.5 (18.9%)	206.6 (15.5%)	10.375 (7.1%)	20.657 (34.5%)	11.418 (14.2%)
Technology	410.2	12.7%	110.8 (17.4%)	176.7 (13.3%)	35.4 (24.4%)	5.473 (9.1%)	7.701 (9.6%)
Financial Services	314.3	9.7%	101.3 (15.9%)	-	5.475 (3.8%)	-	18.635 (23.3%)
Pharma, Medical & Biotech	273.7	8.4%	56.6 (8.9%)	176.7 (13.3%)	-	7.328 (12.2%)	-
Consumer	222.4	6.9%	46.6 (7.3%)	86.3 (6.5%)	40.5 (27.9%)	8.100 (13.5%)	22.075 (27.6%)
Business Services	199.9	6.2%	45.4 (7.1%)	115.2 (8.7%)	5.507 (3.8%)	4.940 (8.3%)	4.302 (5.4%)
Other	691.0	21.3%	157.0 (24.6%)	231.9 (17.4%)	4.808 (3.3%)	6.579 (11.0%)	10.197 (12.7%)

Source: Calculated by the authors based on [2-3]

the development of mild integration forms such as the cluster (A. P. Agarkov, R. S. Golov, 2016) [9] or strategic alliance (G. Griv, A. Shipilov, T. Rouli, 2014) [10]. The existing studies are generally oriented to a limited list of parties concerned. In most cases, the relevant studies are conducted in terms of the entity's management development rather than the whole range of the enterprise's stakeholders (I. V. Gontareva, 2011). Particularly relevant This problem becomes particularly relevant in terms of the interaction between those who represent large-scale economic and industrial systems. The regulation of such interaction allows establishing a system of business rules to determine the institutional basis of LSEIS development.

Developments aimed at presenting corporate governance in the context of institutional theory of economics are already available (Z. Y. Shershnova, 2015) [12]; however, they need to be extended towards the features of LSEIS. The basis for such an extension should be standards for architectural description (L. G. Cretu, 2014) [13] and modeling of complex systems (M. Lankhorst, 2016) [14]. These standards are generally applied with respect to technical systems and require proper development towards their adaptation to social and economic systems. The adaptation of such a tool makes it possible to develop a conceptual basis for organisational LSEIS development. Accordingly, this enables us to extend existing methodological approaches to managing LSEIS. In particular, institutionalisation and establishment of business rules will make it appropriate to use the tools of reflective management in order to develop scenarios of interaction between LSEIS participants (R. N. Lepa, 2012) [15]. Also, it should be noted that the implementation of a new organisational development methodology will certainly go in close contact with certain transformation processes and deal with resistance to change. Taking this into consideration, it is necessary to consider the achievements of change management (J. Hayes, 2014) [16]. However, it is impossible to transmit them directly to LSEIS activities. Some adaptation is needed to the declared architectural and institutional paradigm of the organisational development of LSEIS.

3. The purpose of the article is to prove the hypothesis about the appropriateness of proceeding organisational transformation of business entities through involving enterprises in integration interaction and develop theoretical, methodological and methodical bases for institutional and architectural design of large-scale economic and industrial systems.

4. Results

To prove the designed hypotheses and achieve the purpose of the article, it is proposed to use technology of conceptual design (A. Teslinov, 2009) [17], which provides the submission of aggregate basic concepts (displayed by using circles) and tribal relations (displayed by using arcs). The existing forms of organisational structure of LSEIS and principles to attract businesses to the integration interaction provide a basis for the scheme. The scheme shown in Figure 2 is a formalised representation of LSEIS performance. By using set-theoretical approach and checking basic concepts in figure 2 as certain sets, let us form the following cortege (in terms of mathematical modelling):

$$LSEIS = \langle A, IR, CC, ARC, TS \rangle \tag{1}$$

This cortege (1) reflects a stationary position of LSEIS in a certain period of time t . This stationary position meets the definition of LSEIS architecture in ISO 1471-2000, as «the fundamental organisation of a system that is built into its components and correlated with the principles of its design and evolution». Accordingly, we offer to consider organisational development of LSEIS as transformation or a revolution shift to a new stationary position ($LSEIS(t) \rightarrow LSEIS(t+1)$). Focusing on architectural standards (ISO 15288 and ISO 42010) allows us to consider the development of LSEIS in the context of target and provide systems interaction. The logic of such interaction is shown in Figure 2.

Herewith, the target system will be the result of integration cooperation of enterprises within LSEIS (product or result in the output of integrated business processes). We propose to consider LSEIS to be the implementation system. In this case, characteristics and requirements of the target system form integration restrictions (in cortege (1) and they are formalised as the set $\{IR\}$ in Figure 2. Focusing on the conceptual model shown in Figure 2 allows us to develop the authors' hypotheses as for institutional and architectural modeling of organisational development of LSEIS. The corresponding system of hypotheses in their connection with the concepts reflected in Figure 2 are shown in Table 3.

These hypotheses indicate that, while implementing the organisational development of LSEIS, not only architecture itself but also business rules of the participants are changed. These business rules define the institutional support of LSEIS performance. To formalise, it is proposed to focus on the theory of concepts of control ($\{CC\}$ in Figure 2. V. V. Radayev (Radayev, 2002) defines them as «a set of values and meanings, or certain philosophy that allows agents to interpret existing processes and interpret the actions of others» [18, 8]. Thus, the development of LSEIS involves changes in both its architectural structure and its institutional support. The model of this change is shown in Figure 3.

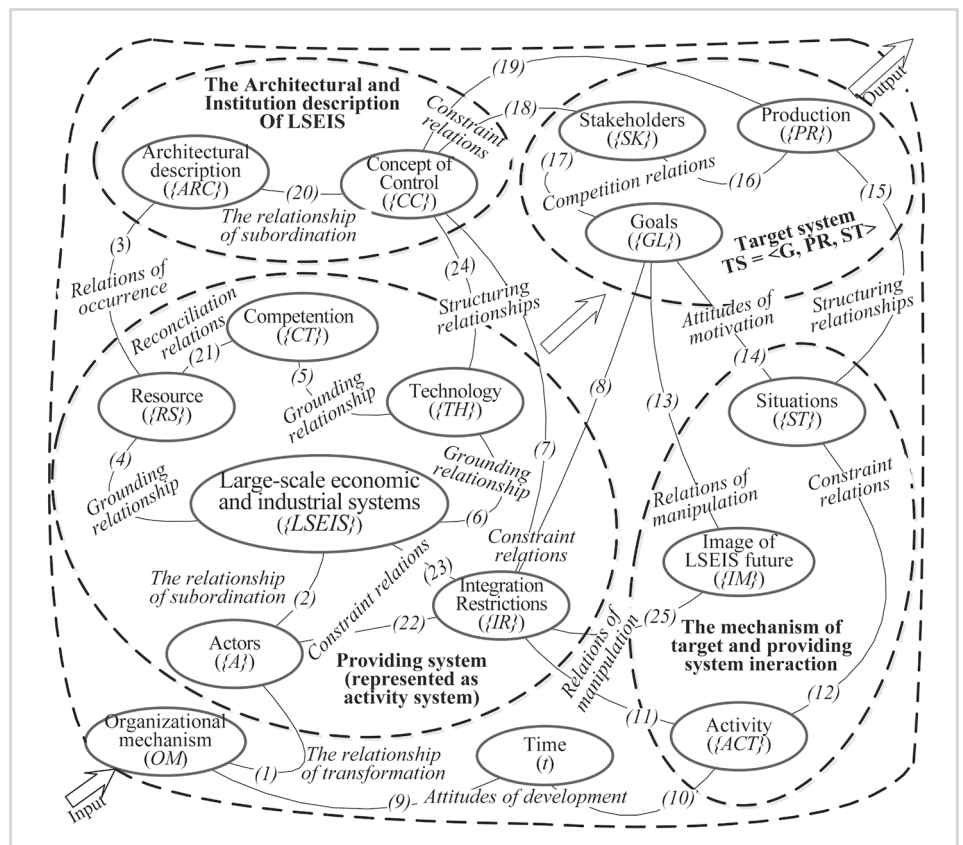


Fig. 2: Conceptual model of institutional and architectural design of organisational development of large-scale economic and production system
Source: Developed by the authors

a mechanism is shown in Figure 4. The presented scheme combines the ORM-methodology (Object-Role Modeling) with the LSEIS spiral of development shown in Figure 3.

The usage of the theory of multiagent systems is a distinctive feature of the scheme shown in Figure 4. The list of agents is determined by the aforementioned concepts in Figure 2. Taking into account the agents' actions, it is proposed to modulate considering predicates presented in Table 3.

5. Conclusions

The article describes the implementation of the authors' hypotheses about the organisation of management development of LSEIS through working-out institutional standards of participants' interaction and transmitting such standards according to the levels of architectural representation of the integrated enterprise association. The novelty of the proposed

approach is, firstly, its complexity and consideration all possible forms of organisational construction of LSEIS. Secondly, the declared focus on architectural design of LSEIS allows expanding the list of stakeholders of organisational development and establishing a system of business rules and the institutional basis of LSEIS development. Thirdly, it is in the determination of directions of adaptation of reflexive management instruments and methods of management changes to the implementation of transformational changes in institutional and architectural representation of LSEIS in development. Accordingly, the prospects for the authors' further developments will be a practical implementation of the usage of each of these instruments under the development of management mechanism of LSEIS through appropriate methodological approaches.

Tab. 3: Disclosure of organizational development management of large-scale economic and production systems

Concept in Fig. 2	Hypothesise ($\{T\}$) in terms of peculiarities of managing organisational development of LSEIS	No. of Relations	Logic of the development management mechanism of LSEIS	
			Elements of architecture	Terms from the multiagent systems
Resource	Hypothesis 1. The consolidation of entities efforts (resources and competences) can achieve competitive advantages only by providing efficient interaction and integration of their business processes and systems of operation.	4	Types of resource ($\{RS\} = \langle \text{material, financial, labour, information, knowledge} \rangle$). Alignment of competence ($\{RS\} = \langle \text{relevant, complementary, current} \rangle$)	Agents' actions are modelled by predicates: availability of competition to perform the functions with some of resource [<i>requires_competition</i> (<i>RS, CT</i>)] or [<i>requires_resource</i> (<i>A, RS</i>)]
Technology		21		
Competition		5		
Actors	Hypothesis 2. Rationalising the formation of large-scale economic and industrial systems is an organisational form of interaction; their complexity requires maintaining viability through priority development and dynamic adaptation to the turbulent environment.	1	List of integration restrictions for LSEIS participants ($\{IR\} = \langle \text{resource } IR, \text{ manufacturing } IR, \text{ sub-contracting } IR, \text{ distribution } IR, \text{ information } IR, \text{ financial } IR, \text{ marketing } IR, \text{ competitive } IR \rangle$)	Within the multiagent system there occurs the regulation of agents' relations. Agent has submitted as a member of some integrated structure [<i>member_of</i> (<i>A, LSEIS</i>)] and is vested some power [<i>has_authority</i> (<i>A, LSEIS</i>)]
LSEIS		22		
Integration		23		
Restrictions		7		
Situations	Hypothesis 3. High adaptive ability of large-scale economic and industrial systems is provided through rationalisation of their institutional and architectural representation, which requires formation of proper theoretical and methodological grounding	9	Set goals ($\{GL\}$) which all members of LSEIS trying to achieve. Characteristics of the target system (production output, given in $\{PR\}$). Interaction of LSEIS members gives us possibility to achieve it	Start of each agent activity is defined by a predicate [<i>occurs</i> (<i>A, ST</i>)]. This predicate connects the agent's action with certain situations. The agent may be associated with resources [<i>use</i> (<i>A, RS</i>)] or product [<i>produce</i> (<i>A, PR</i>)]
Activity		10		
Goals		11		
Production		12		
		13		
Concept of Control	Hypothesis 4. The standards of architectural representation of complex systems should be put in the basis of the concept of institutional design of organisational development of large-scale economic and industrial systems.	7	Establish a hierarchy of roles and business rules. The roles ($\{RL\}$) is defined as scenarios for responding to the challenges. These scenarios take into account the level of LSEIS	Reflects connections between the target system and the support system. Estimate the difference between the goal of LSEIS participants [<i>has_goal</i> (<i>A, LSEIS</i>)] and their activities [<i>has_authority</i> (<i>A, SCM</i>)]
Architectural description		24		
		20		
Time	Hypothesis 5. As the implementation of development processes faces with organisational resistance, it is necessary to create a mechanism to manage transformational changes, agreed with the parameters of institutional and architectural representation of a large-scale economic and production system.	1	Establish institutional norms ($\{IN\} = \langle \text{basic norms, norms of integration support, routine} \rangle$), the followers of norm ($\{FL\} = \langle \text{potential, real, external} \rangle$) and the rules for transformation of norms	For some participant of LSEIS within their integration restrictions, definition the rights [<i>has_right</i> (<i>A, IN</i>)], liability [<i>has_liability</i> (<i>A, IN</i>)] and responsibility [<i>has_responsibility</i> (<i>A, IN</i>)] for norms' transformation
Organisational mechanism		9		
		10		
		13		
Image of LSEIS future		25		

Source: Developed by the authors

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Received 12.06.2017