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System Approach to the Process of Institutional Transformation for Industrial Integrations in the Digital Era

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Abstract: The digitalization of the high-tech economy is complicated due to several issues. One can mention non-synchrony and imbalance in the development of industrial enterprises and their integrations; changes in the elements and relations between enterprises and the external environment; as well as contradictions between the actors. Therefore, a new institutional system for industrial integrations needs to be formed. This article proposes a concept and scenario of the institutional change needed to bolster industrial integrations in the digital economy. The structural logic and algorithm of the process provides for the gradual progress through seven phases of institutional transformation. The authors have developed an institutional change management platform for strategic transformation, the core of which is a decision-making system. The platform supports the management of digital and material business processes of industrial integrations. The conceptual approach is based on a comparison of the life cycles of enterprises and their markets. The article proposes a methodology for assessing the readiness of industrial integrations to implement institutional change strategies using modified Shewhart control charts. The methodology is based on a two-criterion approach to the analysis of finances, production reserves, human resources, organizational structures, management technologies, corporate institutions, and a personnel motivation system. This approach allows determining the level of compliance of the resources available with the requirements of the transformation strategy implementation plan. The methodology has been tested at 14 enterprises functioning as industrial integration actors. According to the dynamics of the level of readiness to implement the transformation strategy, enterprises within the framework of industrial integrations are divided into three groups: enterprises with consistently high, medium, and low levels of readiness to implement the strategy.

Keywords: digitalization; industrial integrations; institutional transformation; strategies; Shewhart control charts

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1. Introduction

Systemic challenges, such as the active formation of a digital high-tech economy, the increasing complexity of technologies, and the acceleration of their development, coupled with the imperative to implement resource-efficient and green projects, compel businesses to seek new forms of functioning. According to Larry Greiner's model [1], the fifth (and final) phase of a company's growth finishes with a crisis of internal growth, which leads to the exploration of external growth reserves as the only viable solution. One form of external development is the establishment of industrial integrations, wherein multiple businesses pool their knowledge, resources, and potential capabilities to jointly achieve

strategic objectives. However, transitioning from internal to external development needs a qualitative institutional transformation of the entire industrial system.

In this article, an institutional transformation of industrial integration is understood as the process of causing and controlling fundamental shifts in the industrial system's functioning. This process aims to enhance efficiency and strategic competitiveness by re-solving contradictions arising from systemic challenges and exploring opportunities resulting from the balanced development of integrated businesses. The connections shaping the environment of industrial integration evolve more rapidly than the internal links of individual companies within the integration. The ensuing conflict between the internal environment of integrated companies and the integration environment itself serves as a stimulus for systemic and elemental growth, fostering organizational and structural changes within both individual businesses and the integrated system. An industrial system is the integration of industrial enterprises.

The economic equilibrium of industrial integration is attainable when external influences are offset by the balanced connections between companies and the harmonization of their internal factors. During this phase, minor contradictions and imbalances (referred to as "normal" problems by analogy with Ichak Adizes' concept) can be resolved within the system's current functioning [2]. However, maintaining this equilibrium over an extended period is challenging. The accumulation of systemic contradictions lays the ground for profound structural shifts, changes, and transformations. Failure to address these issues results in the contradictions acting as impediments to business processes, amplifying the impact of accumulated negative factors, and increasing the likelihood of risk.

This study aims to develop conceptual and methodological provisions, as well as recommendations for running institutional transformations of industrial integration, the implementation of which will ensure the accelerated and sustainable development of enterprises and their associations facing systemic challenges.

The authors formulate the following research hypothesis. In the face of challenges, industrial integration emerges as a strategic developmental approach for businesses—a partnership that synergistically combines potentials and distributes the risks associated with implementing innovations. The effectiveness and competitiveness of such collaboration are achievable only through the institutional transformation of both the businesses and their integration. Adequate management reactions are crucial in facilitating the adaptation of the integration's environment and structure to the evolving landscape.

The rest of this paper is structured as follows: in the Section 2, a theoretical analysis of the institutional transformation of industrial integrations is carried out and research questions are formulated. The Section 3 describes the methodology for assessing the readiness of enterprises for industrial integration. The Section 4 is an oriented case study; it presents the results of testing the proposed methodology using the example of 14 industrial enterprises. Section 5 discusses the research results and their interpretation, taking into consideration the results of previous studies and the working hypothesis, which is related to industrial integration. The Section 6 is the conclusion of this paper.

2. Theoretical Analysis and Hypotheses Development

2.1. The Institutional Transformation of Industrial Integration

The active development of a digital high-tech economy fundamentally transforms the market economic system and reshapes the logic of competition. This makes it necessary to accelerate the institutional transformation of industrial integrations to ensure their sustainable and dynamic development.

At the present stage, institutionalism has various implementation opportunities associated with the ability to overcome the limitations imposed by classical and neoclassical economic theories. According to institutional theory representatives, the institution is the driving force of socio-economic development. Defining institutions, ideologists of institutionalism (T. Veblen, C. Hamilton, W. Mitchell, J. Commons) have described them as "habitual ways of thinking", "special systems of social relations", "production or eco-

nomic mechanisms", "habitual ways of responding to stimuli", or "prevailing, and highly standardized, social habits". In their opinion, institutions "set the boundaries and forms of human activity" [3–5]. Neo-institutionalists (D. North, T. Schultz, O. Favoro) view the institution in a different way as "rules, mechanisms that ensure their implementation, and norms of behaviour that structure repeated interactions between people", "restrictions (or barriers) created by men to structure economic, social, and political interaction", or "rules of the game in society" [6]. Institutions are also described as "types of structures that are most important to social space: they represent the content of social life", "systems of established and generally accepted social rules that structure social interactions", "longevous systems of established and ingrained social rules that structure social interactions" [7,8]. Institutional theory proponents believe that institutions play the key role in economic development; their position has largely determined modern scientific and theoretical views on the concept of "institutional transformation" as a process of institutional change. Thus, according to T. Veblen, the economy is continually developing and evolving, but it is not the market mechanism itself that changes, but institutions, the institutional environment, habits, and laws [9]. D. North considers an institutional change as a complex process determined by rules, informal restrictions, and appropriate methods of constraint [10]. G. B. Kleiner proposed his vision of an institution, describing it as "formal and informal norms that are relatively sustainable in relation to changes in the behaviour or interests of individual subjects and their groups, as well as formal and informal norms that continue to operate for a significant period of time". He addresses institutions as systems of norms regulating the decision making, activities, and interaction of socio-economic entities (individuals and legal entities, or organizations) and their groups [11,12]. "A full-fledged, integral and sustainably operating enterprise is, in a certain sense, a micro-model of the state as a whole, and the overwhelming majority of socially significant norms form a projection onto the intra-firm or inter-firm space" [13]. Therefore, institutional transformations are a complex and (in some situations) long-term process, within which the conditions are laid for growth and the innovative and sustainable development of the industrial complex under rapidly changing environmental conditions. The most important aspect of institutional transformations is the alteration and reform of established and ingrained structures, technologies, institutions, and ecosystems.

Institutional transformations in industrial integration encompass a confluence of environmental and structural transformations, marked by qualitative and quantitative changes (Figure 1). As such, the content of institutional transformations significantly differs from industrial modernization, technological upgrades, and similar processes aimed at addressing infrastructure challenges in the development of industrial producers and their integrations.

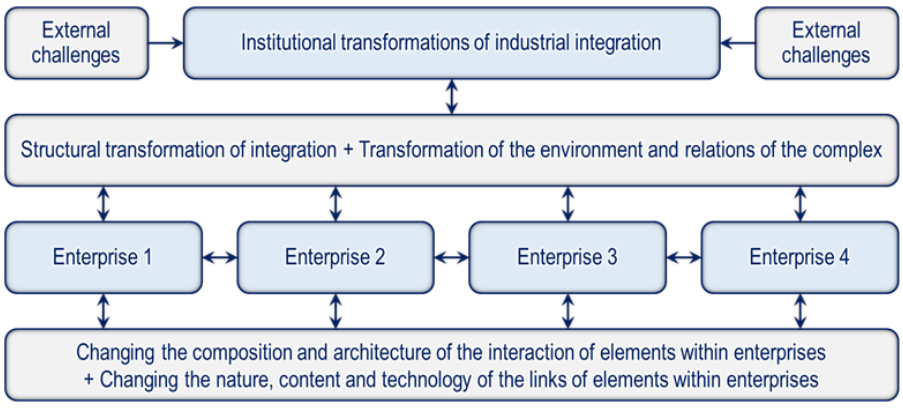

Figure 1. A system of institutional transformations as part of industrial integration. Source: Developed by the authors.

Therefore, we propose the following research hypothesis H1: Proactive and fast (faster than the evolution of technologies and markets) implementation of institutional changes in industrial integration will allow actors to improve their innovative activity, digital maturity, and competitiveness.

2.2. Institutional Platforms for Industrial Integration

Relations between economic systems evolve much faster than the elements (objects) themselves. Accordingly, the driving forces of changes in economic systems are primarily embedded in their relations (or connections). Connections form the basis of institutional interactions and determine the state of the internal environment of any system. Thus, we can conclude that institutional transformations which aim at ensuring the development of the industrial complex as a socio-economic system are predominantly of an environmental nature. At the same time, institutional transformations also lead the organizational and structural changes that regulate the complex of elements and relations between them [14].

In highly turbulent environments, "the competitive advantages of firms can be based on collaborations, in which resources, knowledge, networks, and other conditions are shared" [15]. S. A. Dyatlov notes that the "vertical-horizontal-network integration of companies in the context of global innovation economy makes it possible to integrate innovative ideas, work out technologies and find resources for the development and sale of new goods and services and, as a result, obtain various market and network benefits and effects that cannot be obtained by each participant independently (if they operate alone)" [16]. The authors of the monograph "Methodology for studying network forms of business organization" note that "networks of formal and informal relations form the basis for economic actions, allowing actors to rely on gradually developing trust, exchange of information, resolution of conflicts in accordance with established norms and rules" [17]. J. Lipneck and J. Stamps have defined a network as "a system of formal and informal contracts providing for the sustainable relations between organizations that are formally independent but consolidate their resources to reduce costs and risks and to develop new competencies required for adding value and achieving joint goals of participants" [18]. The key sustainability prerequisites of the organizational model are the dependence of an individual network participant on resources controlled by other participants, and the possibility of combining resources to achieve synergy. In accordance with the definition given by M. Castells, a network structure should be understood as a complex of interconnected nodes [19]. E. Evin, in his work "The Theory of Complex Networks as a New Scientific Paradigm", considers complex networks from the perspective of nodes and the number of connections. "In many real networks, a small number of nodes contain a very large number of links (hubs), while a huge number of nodes contain only a few links" [20]. These are scale-free networks. Currently, "networking is the dominant form of integration, with total coverage. At the same time, the indisputable advantages of networks allow us to predict the further spread of this form of integration interaction" [21]. Network structures, taking various organizational forms, are widely used in business practice. Examples cover industrial complexes, clusters, industrial networks, technology parks, networks of technology transfer centers, industrial symbioses, ecosystems, etc. Industrial complexes are "points of growth and key forms of industrial development, largely determining the directions of structural changes and research-based technological transformation" [22]. Industrial and administrative–economic structures are formed by many subjects of economic relations or contain a significant number of legally separate organizations that are united by solving common market, production, scientific, financial, and management problems. "An industrial complex with a network structure is an open system formed as a result of integration processes" [23]. Thus, synergy is the key desired integration interaction result.

Industrial integration refers to the dynamic process through which different industries integrate and penetrate each other, eventually form a new industry, and developing together, and it is an important way to provide high-quality industrial development [24].

Among industries, the integration of advanced manufacturing and modern service industries is the most important part of industrial integration and the core of economic competitiveness. In the context of the theory of the industrial Internet and the theory of industrial integration and development, digital transformation can promote the integration be-tween different industries [25] and facilitate industrial progress due to the strong permeability and integration ability of digital transformation. It embeds Internet technology into manufacturing, thus promoting the servitization of the manufacturing industry [26].

In recent years, academics have provided in-depth knowledge regarding digital transformation (DT). However, the implementation of DT is complex as it entails initial costs, requires changes, and creates resistance from workers [27]. Thus, DT consists of integrating information technologies in companies' operations, whether internal or external. It can also be considered as "a change that occurs with the implementation of technologies in a system within a company" [28]. This transformation is supported by the implementation of new technologies from which new performance, new processes, and new business models emerge [29,30]. In addition, DT is not only linked to technology, but also to an improvement in the business model, collaboration, and culture [31].

Digital transformation can promote the deep integration of manufacturing and service industries, forming new modes such as smart services and intelligent manufacturing. At the same time, digital transformation has a positive impact on the production methods and organizational models of various industries, and it can also promote the integration of different types of industries [32]. DT adoption may be risky without models and tools that assist its implementation across organizations. However, "not all industries have been able to keep up with this technological pace and adopt digital technologies, either due to investment difficulties or lack of adaptation of their business model" [33].

The most important component of the strategic management system of industrial integration transformations is the digital platform, which also acts as a link between other elements and platforms. Broekhuizen and Parker consider that "the most prominent growth strategy involves the use of digital platforms" [34,35]. The new landscape of productivity and innovation is strongly shaped through the ways in which digital platforms (hereafter mentioned as platforms) have introduced a new organizational logic acting as connective agents and data hubs [36,37]. They have gradually become an inherent aspect of delivering value by introducing processes that act complementary to or independently from traditional space, as well as by forming interactions, new information flows, and network effects [38]. Therefore, platforms can reinforce capabilities for productivity and innovation by increasing their proximity externalities [39]. A reasonable definition of a digital platform is given in a study published by the Massachusetts Institute of Technology: "a digital platform is a high-tech business model that delivers value by facilitating exchanges between two or more interdependent groups of participants" [32]. A similar logic is followed by the largest consulting company Accenture, defining a digital platform as a group of technologies that are used as the basis for developing a specialized system of digital interaction [36]. A digital platform provides for the development of an open and publicly accessible infrastructure, which can be used by the strategic transformation participants to significantly reduce their transaction costs and increase the speed of communications, as well as develop new and more effective interaction models [38]. H. Li et al. have investigated the role of industrial Internet platforms in empowering digital transformation. The industrial Internet platform promotes "knowledge integration on the supply side, empowers cross-domain knowledge sharing and shapes the knowledge-driven digital supply chain system in the digital transformation processes" [40].

Thus, the digital platform of the strategic management system for institutional transformations is a segment of the enterprise's overall digital platform, represented by a set of software and hardware, which is focused on ensuring barrier-free interaction between participants in the strategic management process and the automated performing of individual functions and processes in this area. At the stage of full deployment of new

industrialization, digitalization is a determinant that ensures the effective development of an industry. Based on this analysis, we propose the following hypothesis.

Hypothesis H2: The development of an institutional platform for industrial integration to level out threat-forming factors can become an effective tool for the strategic management of enterprises under conditions of systematic crises.

2.3. Strategies for Developing Industrial Integrations

Nowadays, a variety of digital growth strategies are known. Verhoef et al. [22] identify strategic imperatives according to the phases of digital transformation. The authors define the first phase of digitization as "the action to convert analogues information into digital information". Loske and Klumpp [41] also consider that digitization is a "process of converting analogues data into digital data sets". Furthermore, recent research argues that digitization encodes or shifts analogous tasks and information into a digital format so that computers can store, process, or transmit information without altering value-creating activities [30]. Digital growth strategy has focused on market penetration as well as market and product development. The second phase of digitalization describes how information technology or digital technologies can be used to "alter existing business processes" (Li et al., 2018) [42]. Digitalization is described as digital technologies that can be used to alter existing business processes. In that regard, "companies are investing in products and process innovation through new digital solutions, allowing them to deal with more data and information" [33,43]. Thus, digitalization is not only focused on cost savings but also includes process improvements that may enhance customer experience. The optimal strategy for this phase is platform-based market penetration, in order to promote platform co-creation. The third phase of digital transformation is the most pervasive phase and describes a company-wide change that leads to the development of new business models (Pagani & Pardo, 2017) [44]. For this phase, it is recommended to use a platform diversification digital growth strategy. This growth strategy is often deployed by large, successful platforms aiming to create additional growth in unexplored markets with new products [22,45]. Hence, the different phases of digital changes toward digital transformation have important strategic imperatives for companies.

In the context of shaping a digital economy, industrial systems face the crucial challenge of not only formulating strategies for institutional transformation but also assessing their readiness for executing planned reforms. Preparing industrial systems for accelerated development and the execution of strategies for institutional transformations necessitates a focus on studying and resolving issues obstructing economic, managerial, structural, functional, and other types of changes.

The strategy of institutional transformation is the most important element of industrial system management, integrating key priorities, goals, activities, and projects for its development. According to A. Chandler, "strategies of institutional transformation and development strategy of the industrial complex should be synchronized and not contradict each other". The main tool to ensure their consistency is the formation of a clear hierarchy of strategies with the definition of the place of the transformation strategy in it [46]. Strategies developed by R. Chin, D. Kenneth, and P. Benne mainly characterize the strategies that provide for the use of personnel potential for the transformation of enterprises, as well as the involvement of personnel in the transformation process [47]. L. Kvint believes that strategy is a "systemic, multidisciplinary in nature phenomenon", which, by "its influence, multidimensionality and structure is hierarchical" and should integrate different types and levels of strategies [48]. Under certain conditions, the transformation strategy can act as a general strategy, as it provides for balanced and progressive change in all key elements, institutions, and industrial systems [49,50].

Scientific, consulting, and expert entities play a significant role in investigating this matter by running surveys among the top management of industrial companies, thereby generating lists of current economic development problems.

Drawing on research results from international consulting firms such as KPMG, the Agency for Strategic Initiatives, Strategy Partners [51], and other research and analytical groups, this study formulated a list of key problems impeding the implementation of strategies for the transformation and development of industrial systems:

1. Resource limitations that hinder the funding of strategic measures, the prompt implementation of new production projects, and corporate technological upgrades (including the implementation of modern digital services);
2. Shortage of qualified staff and a lack of relevant competencies, especially in the field of digitalization, limiting the potential for reengineering most business processes in industrial systems and the adoption of new approaches to strategic development;
3. Use of outdated management technologies and ineffective organizational structures that hinder the use of staff potential, the timely solution of complex cross-functional problems, and the achievement of strategic goals in a dynamically changing market environment;
4. Low levels of development in innovation culture and corporate institutions, along with contradictory internal policies within top management.

These prevalent problems significantly complicate the implementation of strategies and programs for institutional transformation across industrial systems. The authors define the readiness of the industrial system to implement a strategy of institutional transformations as the company's ability to carry out all activities required by the developed strategy to achieve its medium- and long-term goals.

Therefore, we propose research hypothesis H3: Assessing the readiness of industrial integration to implement the strategy of institutional transformations will allow enterprises to identify areas of innovative growth.

3. Research Methodology

To prove our our research hypotheses (H1–H3), we employed a research strategy based on the logical scenario of institutional transformations as part of industrial integration and a methodology for assessing the readiness of industrial systems to implement institutional transformation strategies using modified Shewhart control charts.

3.1. Logical Scenario Sequence of Institutional Transformations within Industrial Integrations

Timely decision making on institutional reforms in a proactive and managed format converts accumulated systemic contradictions into new opportunities. This enables companies and industrial integration to ascend to a qualitatively new level of growth and development. Furthermore, the implementation of institutional changes in relation to the ex-ternal environment creates substantial competitive advantages. Industrial integration, in this context, assumes the role of a leader and exporter of institutional changes in the economy, shaping new "rules of the game", scaling innovative management solutions, and catalyzing the formation of new business models (Figure 2).

Let us elaborate on the scenario presented above.

Stage 1: Prerequisites for institutional transformations arise from the accumulation of systemic contradictions caused by both internal factors that influence companies participating in industrial integration and external factors resulting from the general evolution of the economy and its industries. This accumulation is influenced by various economic, social, environmental, geopolitical, and other factors.

Stage 2: Companies participating in industrial integration respond to these prerequisites for institutional reforms. At a substantive level, this stage involves making business management decisions regarding the execution of institutional reforms or the dismissal of prerequisites as inconsequential.

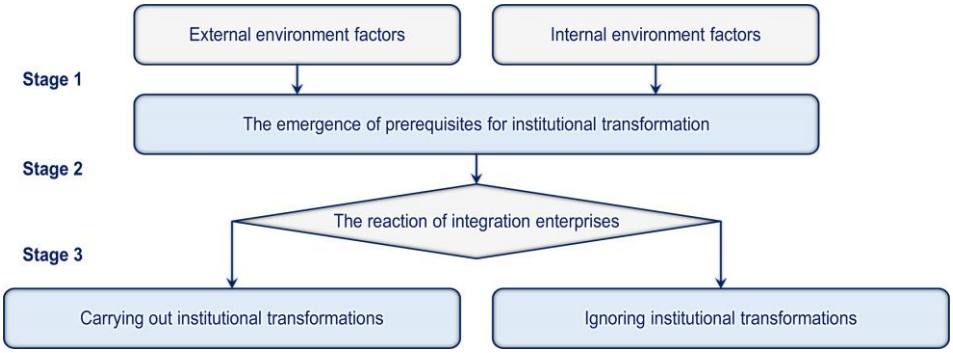

Figure 2. A scenario of institutional transformations as part of industrial integration. Source: Developed by the authors.

Stage 3: Companies start institutional reforms in alignment with quantitative and qualitative changes in the industrial system. The outcomes include a transformation in business characteristics, a shift in the functioning of the industrial system, a move towards the sustainability of the emerging model of integration, and the development of participating businesses. This results in the stabilization of the key integration processes at a higher quality, poised for the next cycle of transformations. The decision to ignore or postpone institutional reforms and maintain the current state must be justified based on the perceived insignificance of the risks associated with growing integration contradictions and imbalances. Failure to address these issues may lead to a decrease in the strategic competitiveness of businesses and a missed opportunity to capitalize on further development prospects.

The structural logic and algorithm of the process dictate that businesses traverse seven phases, incorporating 18 key stages of transformation, as visually depicted in Figures 3–6.

Figure 3. The first phase of the institutional transformation process as part of industrial integration: key stages. Source: Developed by the authors.

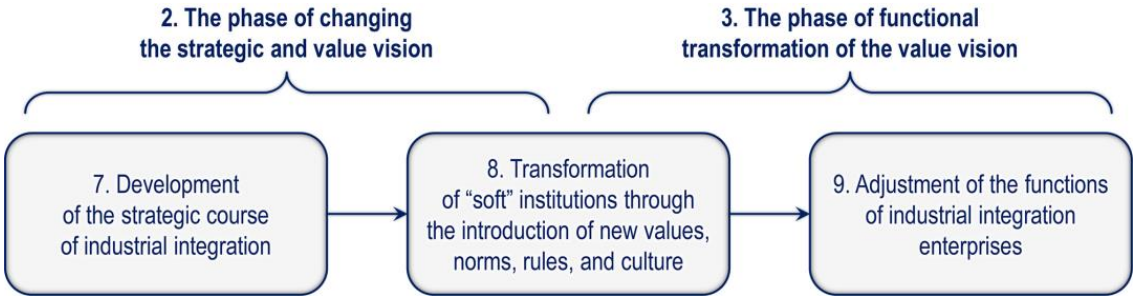

Figure 4. The second and third phases of the institutional transformation process as part of industrial integration: key stages. Source: Developed by the authors.

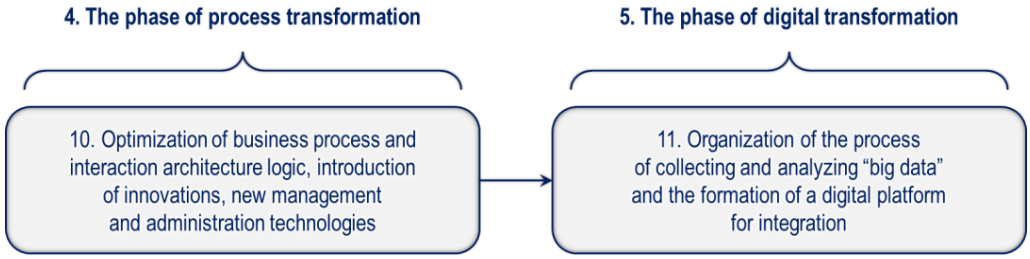

Figure 5. The fourth and fifth phases of the institutional transformation process as part of industrial integration: key stages. Source: Developed by the authors.

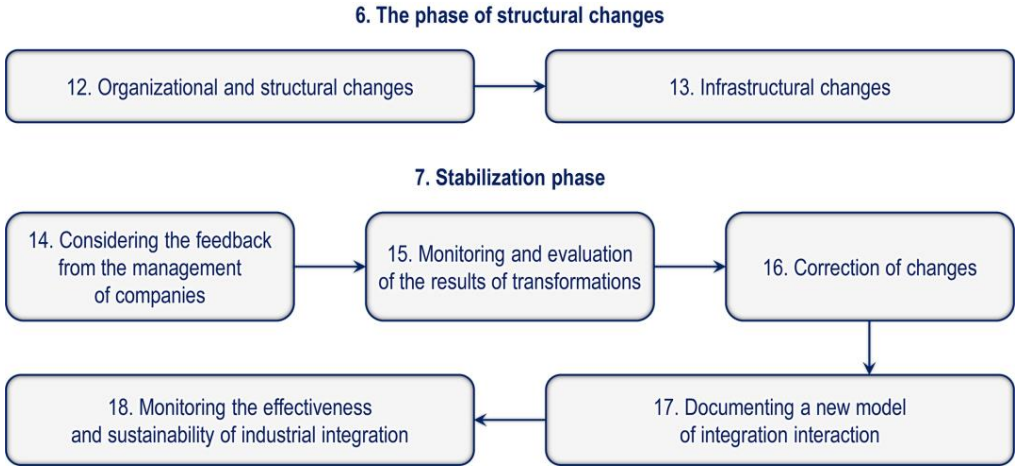

Figure 6. The sixth and seventh phases of the institutional transformation process as part of industrial integration: key stages. Source: Developed by the authors.

The first phase of the transformation process (stages 1–6) encompasses the initiation of industrial integration transformations and the preparation for the implementation of planned changes. Within this phase, the following steps are undertaken: conducting a comprehensive analysis of the market position and internal environment of each company, assessing the existing prerequisites for changes, and determining the overall readiness of the integrated system for transformation. Additionally, a system of long-term goals is developed, along with a modernization and development strategy. Also, a detailed program of activities for institutional transformation is established, specifying the time frame, allocated resources, planned results, and a set of indicators for monitoring the transformation process. A crucial aspect of preparing companies for the transformation process is streamlining integration interactions. This serves as a pivotal factor in promptly and effectively addressing emerging economic and managerial challenges during the transitional stage of development.

The second phase of the transformation process (stages 7 and 8) focuses on adjusting the strategic course of industrial integration. This entails a systematic change to the key strategic vector, encompassing priorities for business development, operating principles, action strategies in the context of integration, management culture, and fundamental corporate institutions. Despite the inherent complexity, labor intensity, length of time, and potential for conflict in the transformation of production values, norms, corporate relations, managerial mentality, established institutions, rules of organizational behavior, and work approaches, these changes must be initiated first or concurrently with other transformational events. In economic practice, companies usually do not pay enough attention to either the process of cultural, institutional, and value transformation, or with preparatory work with their employees. This neglect can provoke resistance to reforms among their staff and can sometimes lead to critical situations within businesses. Studying such examples, P. Drucker astutely observed that "culture eats strategy for breakfast" [52]. McKinsey

estimates that 30 to 40% of practical attempts to deeply transform large commercial companies prove ineffective and incomplete due to widespread resistance, counteraction, and insufficient employee involvement [53].

The third phase of the transformation process (stage 9) centers on adjusting and optimizing the functional content of the management and production activities performed by the industrial integration participants. This involves the elimination of ineffective, redundant, and poorly organized functions from the perspective of industrial integration. Simultaneously, it emphasizes proactive development, continuous streamlining, and the implementation of system-forming, innovative, strategically promising, and integration functions.

The fourth phase of the transformation process (stage 10) entails reengineering the entire system of key business processes within companies involved in integration. This includes processes related to production and technology, R&D, financial and economic activities, information and digital processes, marketing and sales, logistics, and others. During this phase, an updated logical architecture for the interaction of all elements of the organizational and economic model of industrial integration is established. Effective algorithms for implementing management functions, production business processes and procedures, work communications, technical operations, financial relations with counterparties, etc., are developed.

The fifth phase of the transformation process (stage 11) involves the digital and associated technological transformation in industrial integration. Systematic digital and technological modernization enables an increase in the overall efficiency of interactions within the system, enhancement of production processes and communications, and minimization of transaction costs and losses. From an applied standpoint, digital and technological transformation includes the development of a modern digital platform, the establishment of a system for big data collection and in-depth research, and the utilization of innovative tools to enhance the quality of strategic and tactical management.

The sixth phase of the transformation process (stages 12 and 13) in industrial integration focuses on implementing organizational and structural changes. This phase consolidates all substantive transformations and provides a new production and economic architecture for the integration business model. Adhering to principles such as flexibility, simplicity, adaptability, and self-organization is very important for the structural development of industrial integration. These principles ensure that companies can quickly find solutions to cross-functional and interdisciplinary problems characteristic of modern economic and market conditions.

The seventh phase (stages 14–18) marks the culmination of the transformation process for industrial integration. It stabilizes integration in its new state, reduces entropy, and enhances the economic sustainability of businesses. In the final stages of transformation, an assessment of the completed changes is conducted, and monitoring of integration progress is organized. The conclusion of the transformation process involves the institutional formalization of a new system of business processes, management approaches, and other aspects of interaction between businesses.

3.2. Structure of the Institutional Industrial Integration Platform

Additionally, control mechanisms over the most crucial parameters of development are established. The foundation of the strategic management system for transformations within an industrial system is a collection of integrated platforms, with the key ones being:

(1) compliance platform for risk management;
(2) digital platform;
(3) functional platform;
(4) process platform;
(5) human resources platform;
(6) organizational and structural platform;
(7) institutional platform;

(8) infrastructure platform.

Let us delve into their functionalities.

A compliance platform constitutes a system for interconnected analytical, forecasting, and optimization activities, which is designed to identify and mitigate sanctions and regulatory risks. When establishing a compliance platform in an industrial system, it is advisable to adhere to traditional risk management principles, primarily those of diversification, maintaining sustainability, minimizing losses, and flexibility. Problem-oriented management methods are also recommended. The competitive advantage of the compliance platform lies in its high level of integration into the processes of developing, coordinating, and adopting strategic decisions by the management within an integrated system of companies in areas with high business, economic, and political risks. It is also integral to the general processes of managing institutional transformation. A functional platform encompasses a collection of cyclical and system-forming types of management activities that serve as the foundation for the development, organization, and implementation of corporate strategies, programs, and processes for the medium and long term.

A process platform is a set of logically interconnected and coordinated algorithms for performing various types of activities, operations, procedures, and measures aimed at the controlled transformation of industrial integration. A modular construction of a process platform is proposed, enabling the reduction or supplementation of links in the overall process of managing strategic changes within a company depending on its specifics or the characteristics of the external environment. An organizational and structural platform constitutes a framework of economic relations, administrative and managerial interactions, interaction algorithms, and structural elements within companies. These components are integrated into a cohesive system to ensure the implementation of targeted and managed strategic transformations in interactions between businesses.

An institutional platform is a combination of sustainable corporate values, norms, rules, algorithms, informal interaction practices, and management technologies. It dictates the environment, logic, form, and content of both internal and external relationships within industrial integration. The institutional platform is shaped by four key elements:

- individual strategic values grounded in shared values emphasizing the development and continuity of positive changes, production philosophy, digital culture, and a preference for innovative and experimental ideas;
- formal norms, rules, and algorithms governing industrial relations, with the primary objective of providing a meaningful basis for establishing and developing effective institutions of industrial interaction;
- informal practices of horizontal and network interactions that ensure flexibility in work processes, allowing for the mitigation of imperfections in regulations for implementing production procedures. These practices stimulate the development of cross-functional interaction among employees, fostering a dynamic exchange of experience, information, and innovative ideas within the framework of industrial integration;
- technologies for managing and implementing work processes at industrial integration enterprises, delineating general approaches to organizing business processes and performing functions.

The infrastructure supporting the platform comprises software and hardware, digital modules, services, applications, quantitative and qualitative databases, peripheral and network devices, and other elements of information and computer technologies. The functional application and use of the digital platform can be significantly adjusted depending on the nature of production, the level of automation, and the characteristics of the markets in which the company operates.

3.3. The Methodology for Assessing the Readiness of Industrial Systems to Implement Institutional Transformation Strategies

The authors propose a methodology using modified Shewhart control charts [54]. This methodology adopts a two-criteria approach to analyzing finances, production reserves,

human resources, organizational structures, management technologies, corporate institutions, and the staff motivation system. It facilitates the compliance assessment of the company's resources with the requirements of the transformation plan. The methodology stands out for its use of modified Shewhart control charts for indicative monitoring of the industrial system's readiness to achieve strategic goals. Figure 7 outlines the key stages of the methodology.

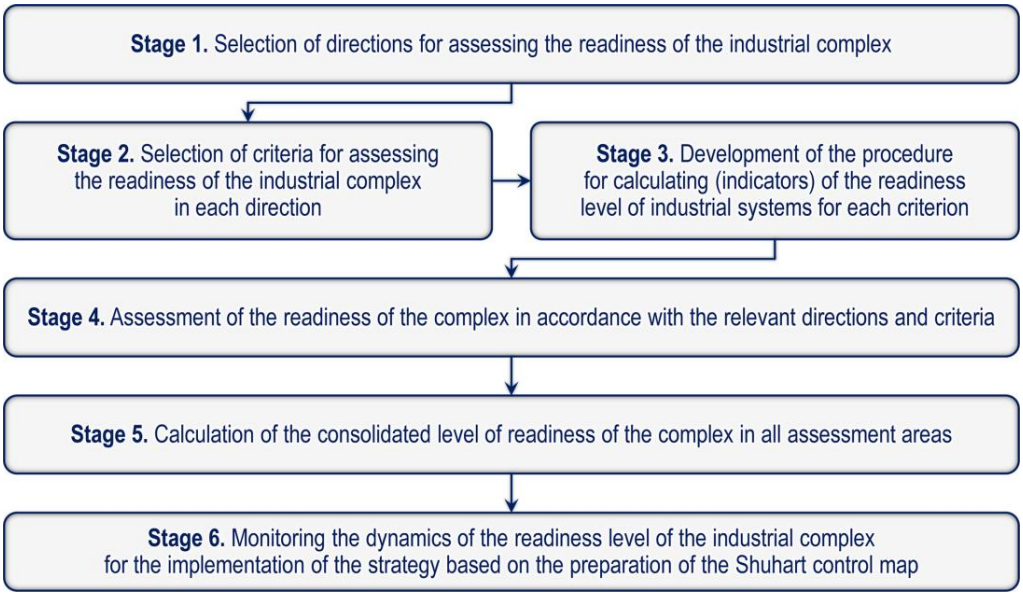

Figure 7. Stages of the methodology for assessing the readiness of industrial systems to implement institutional transformation strategies. Source: Developed by the authors.

It is advisable to assess the readiness of the industrial system to implement the strategy of institutional transformations using the following six indicators:

1. Financial resources and production infrastructure. This aspect enables the evaluation of the actual capabilities of the industrial system to financially support the developed transformation strategy. It also assesses production, infrastructure, transport reserves, and logistics reserves for the implementation of the development program and the production of new items. The study of a company's resource readiness is crucial for the timely identification and mitigation of risks related to the underfunding of strategic plans or programs under sanctions, thus creating the necessary conditions for effective implementation.

2. Human resources. This indicator involves a qualitative and quantitative analysis of the staff within the industrial system to determine the availability of the required number of employees with the necessary qualifications, education, and experience for the implementation of the strategy of institutional transformations.

3. Organizational structures. This indicator assesses the communicativeness and adaptability of the organizational structures of the industrial system. It aims to determine its ability to flexibly respond to challenges in the external and internal environment and quickly adapt business processes during the implementation of a change strategy. Economic practice suggests that industrial companies using adaptive, transparent, and combined organizational structures are more successful in carrying out transformations than those with rigid centralized structures.

4. Methodological tools and management technologies. This aspect evaluates the nature of the management tools used, the progressiveness of administration methods, and the achieved level of speed and quality in making tactical and strategic decisions in the industrial system. Companies with high management readiness for transformations typically employ intelligent methods and digital services to support decision making, introduce key performance indicators for the company's structural divisions, use lean

management technologies and project-based methods of staff management, and maintain a high level of discipline in carrying out development plans and management instructions.

5. Corporate culture and institutions. Assessing a business in this area provides insights into the level of staff loyalty and their involvement in the process of implementing the transformation strategy. This becomes particularly crucial in crisis and sanctions conditions. Many researchers agree that managers and specialists who can become initiators of change play a key role in the successful transformation of a company, along with the introduction of innovations and digital technologies.

6. Staff motivation system. This indicator allows for the assessment of the availability of measures used at the company to motivate staff to implement the change strategy. It enables the identification of additional steps necessary to encourage staff participation in the transformation processes of the industrial system.

The total system of areas and criteria for assessing the readiness of industrial systems to implement transformation strategies is presented in Appendix A.

The values of indicators K1.1, K1.2, K2.1, K2.2, K3.2, K4.1.1, K4.1.4, K4.2.2–K4.2.4, K 5.1, K6.1, and K6.2 are found using calculations or the actual values of the indicators, depending on the applied economic and managerial forms of reporting and monitoring. The values of indicators K3.1, K4.1.2–K4.1.5, and K4.2.1 are found based on expert assessments of the management of the industrial system. The values of indicator K5.2.2 are determined through a sociological survey or an anonymous survey of employees. For each criterion, separate ranges of values L1, L2, and L3 are selected based on expert consultations, analysis of market practices, and other suitable tools. The total levels of readiness of industrial systems for the implementation of transformation strategies were calculated using the following ratio:

$$\text{Kis} = \sum_{n=1}^{T} \text{Kis}/\text{T} \quad (1)$$

where Kis is the total level of readiness of the i-th industrial system to implement the strategy of institutional transformations according to all criteria, %; Kis is the value of the readiness level of the i-th industrial system according to the n-th criterion.

T is the number of evaluation criteria (equal to 12) of the industrial system from the set of criteria K1.1, K1.2 . . . K6.2. The control limits between the high, medium, and low levels of readiness for the implementation of the transformation strategy are found using the following relationships:

$$\text{UCLh}/\text{md} = \sum_{n=1}^{T} \text{L3n}_{\text{Kn}} \quad (2)$$

UCLh/md is the value of the upper control limit separating the ranges of the high (L3) and medium (L2) levels of readiness to implement the strategy of institutional transformations, %.

$$\text{LCLmd}/\text{lw} = \sum_{n=1}^{T} \text{L1n}_{\text{Kn}} \quad (3)$$

LCLmd/lw is the value of the lower control limit separating the ranges of the medium (L2) and low (L1) levels of readiness to implement the strategy of institutional transformations, %.

L1Kn and L3Kn are the ranges of values corresponding to the low and high levels of readiness according to the selected criteria, %.

T is the number of evaluation criteria (equal to 12) of the industrial system from the set of criteria K1.1, K1.2 . . . K6.2.

To further analyze the data obtained and conduct visual monitoring of the level of readiness of industrial systems to implement strategies of institutional transformations, the authors used modified Shewhart control charts. When adapted and modified, this tool can be effectively used to analyze changes in the characteristics of many dynamic systems, processes, and phenomena in the economy.

In the context of our research, the primary objectives for using control charts are as follows:

(1) determining the level of readiness of the industrial system to implement the transformation strategy, which involves categorizing the readiness level as high, medium, or low based on established criteria;
(2) identifying periods of decreased readiness of the industrial system, which is necessary for subsequently pinpointing and rectifying existing problems in the company's development.

Producing a control chart entails establishing control limits, forming a range of optimal (acceptable) values. The values within this range represent the stable situation in the organization where the level of readiness for implementing the strategy should ideally lie. The readiness level of the industrial system is dynamic and changes over time due to various factors, including sanctions. If the level of readiness fluctuates within the range of optimal (acceptable) values, corrective management interventions may not be necessary. However, if the readiness level of the industrial system is consistently low or begins to decline systematically, the company's management must identify the causes of existing problems and implement measures to address them. Failure to do so poses the risk of the company not achieving its long-term goals and planned indicator values.

4. Results

We applied the proposed methodology to assess the readiness levels of industrial systems (IS) from various Russian regions based on the developed criteria. The data for calculations were sourced from corporate websites and regional financial and economic reports. The readiness levels of industrial systems to implement the transformation strategy in 2020 are presented in Table 1.

Table 1. Levels of industrial system readiness to implement the transformation strategy.

Criteria	IS 1	IS 2	IS 3	IS 4	IS 5	IS 6	IS 7	IS 8	IS 9	IS 10	IS 11	IS 12	IS 13	IS 14
K1.1	84%	80%	82%	68%	89%	61%	90%	60%	91%	77%	68%	42%	73%	85%
K1.2	81%	75%	67%	78%	77%	63%	90%	61%	82%	78%	80%	68%	65%	75%
K2.1	85%	82%	83%	80%	81%	79%	92%	83%	85%	79%	73%	77%	75%	82%
K2.2	83%	75%	75%	68%	86%	72%	78%	75%	77%	70%	67%	75%	71%	83%
K3.1	72%	70%	72%	52%	69%	86%	85%	74%	85%	79%	55%	61%	70%	80%
K3.2	82%	81%	64%	39%	73%	82%	87%	68%	67%	55%	45%	51%	63%	84%
K4.1	73%	75%	70%	57%	69%	55%	70%	60%	71%	79%	50%	53%	61%	79%
K4.2	75%	73%	65%	59%	78%	62%	75%	63%	63%	71%	60%	43%	72%	77%
K5.1	64%	72%	70%	48%	69%	76%	75%	65%	70%	72%	45%	55%	71%	69%
K5.2	82%	73%	75%	69%	78%	77%	78%	82%	70%	82%	67%	65%	68%	87%
K6.1	74%	72%	73%	67%	88%	78%	84%	84%	85%	74%	45%	63%	73%	82%
K6.2	86%	88%	83%	78%	90%	88%	86%	81%	90%	83%	72%	72%	70%	88%
Kis (total)	78%	76%	73%	64%	79%	73%	83%	71%	78%	75%	61%	60%	69%	81%

Figure 8 illustrates a system of control charts in key areas for assessing the readiness of industrial systems to implement the transformation strategy. The assessment employed the method of two-criteria analysis and coordinate diagnostics, enabling the determination of the industrial systems' readiness levels by visualizing the resulting assessments within the coordinate system and control limits of the control chart.

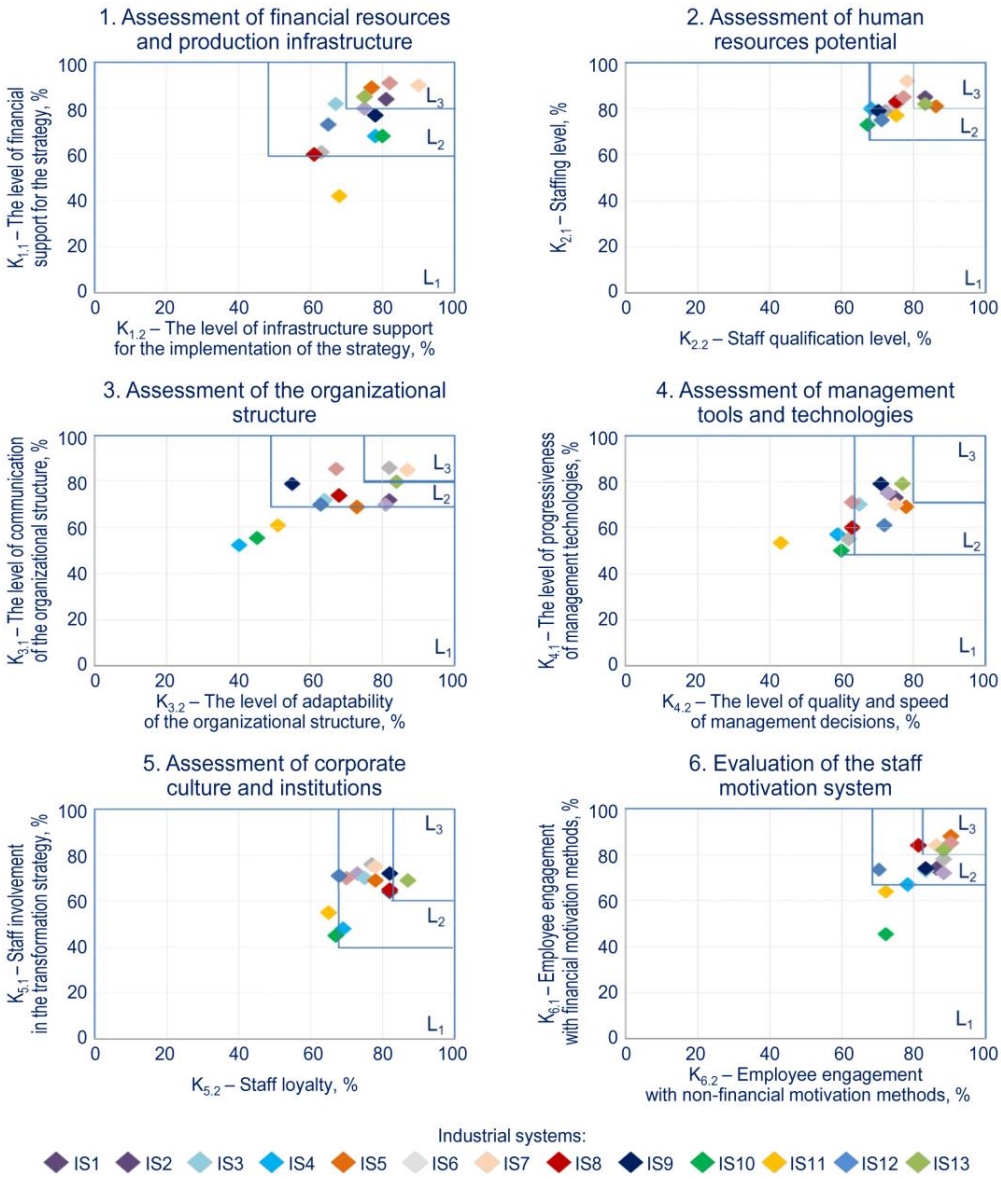

Figure 8. Control charts for assessing the readiness of industrial systems to implement transformation strategies by key areas and criteria. Source: Developed by the authors.

The control charts allow us to draw the following intermediate conclusions:

1. Most of the studied industrial systems possess the necessary resources to finance the transformation strategy and have infrastructure reserves (equipment, facilities, etc.) to optimize business processes and organize the production of new types of items. The exception is IS 12, which exhibits a low level of resource readiness to implement the strategy (55%);
2. In terms of human resources, almost all the industrial systems under study show an average level of readiness to implement the transformation strategy. However, some of them face increased risks due to forced staff reductions. In 2023, noticeable staff reductions occurred at IS 7 (203 people, or 16.1% of the workforce) and IS 8 (99 people, or 46% of the workforce);
3. The industrial systems under study display significant differentiation in terms of the readiness of the organizational structures to implement the strategy of institutional transformations. The most adaptive and communicative organizational structures are

found in IS 6, IS 7, and IS 14. A low level of organizational readiness is noted in IS 4 (46%) and IS 11 (50%).

4. None of the industrial systems studied exhibit a high level of readiness to implement transformation strategies in terms of the methodological tools and management technologies used. This is attributed to the fact that most manufacturing organizations have not fully realized the potential of using flexible management methods, introducing lean production technologies, and utilizing intelligent tools to support management decision making. Some manufacturers face challenges with the shifting of planned project deadlines, the underfunding of digital transformation activities, and the failure to solve other strategically significant problems.
5. Most of the industrial systems under study perform at high and medium levels of readiness to implement strategies based on the state of corporate culture and institutions. The leaders include IS 14, IS 10, IS 7, and IS 6, which are characterized by a high level of staff involvement in the process of institutional reforms as well as staff loyalty. Some industrial systems (such as IS 1) have successfully developed diverse social and management institutions in production, forming an effective innovation-driven culture resistant to external crisis trends.
6. The motivations used in the studied industrial systems incorporate financial and non-financial methods, covering the dominant part of their staff. However, these systems are often not customized. A high level of readiness to implement the change strategy from the perspective of the staff motivation system is observed in IS 5 (89%), IS 7 (85%), IS 14 (85%), and other industrial systems.

The analysis of changes in the levels of corporate readiness for the implementation of transformation strategies is presented in Figure 9.

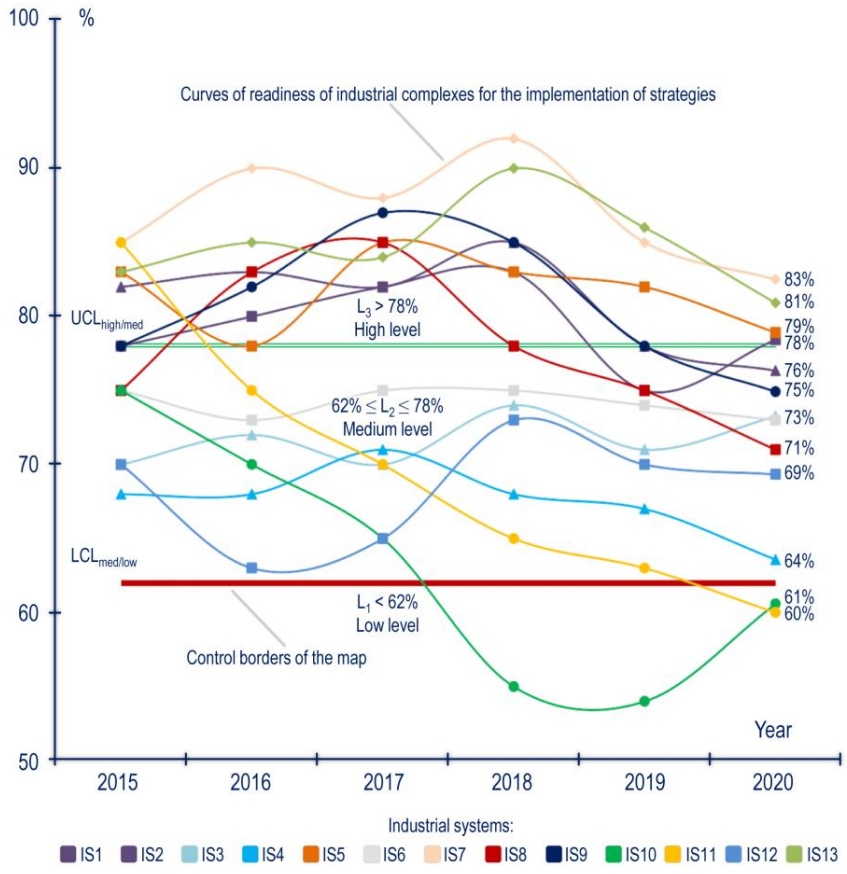

Figure 9. Changes in the levels of corporate readiness for the implementation of institutional transformation strategies. Source: Developed by the authors.

Based on the control chart, the following conclusions can be drawn:

1. During 2023, almost all the industrial systems studied experienced a decline in the level of readiness to implement the transformation strategy. This decline can be attributed to crisis trends in the global and domestic economy and stemming from extensive sanctions. These factors resulted in staff reductions, decreased revenue and profit, sequestration of investments directed towards digitalization and technological upgrades, and a general destabilization across production, technological, financial, and other markets;
2. Based on the changes in the readiness level to implement the transformation strategy, the industrial systems can be categorized into three groups:

- Businesses with high readiness: IS 7, IS 9, IS 14, IS 5, and IS 1 maintained a consistently high level of readiness. These businesses exhibit ongoing development, a sound financial standing, possess highly qualified staff, secure a significant number of government orders, address key sanctions issues, and actively pursue innovation in the digital economy;
- Businesses with medium readiness: IS 2, IS 10, IS 13, IS 3, IS 4, IS 8, and IS 6 demonstrated an average level of readiness. They are implementing strategic measures for production upgrading and digital transformation, house a substantial number of qualified staff, participate in cluster structures, and engage in innovative projects;
- Businesses with low readiness: IS 12 and IS 11 belong to this group.

3. To enhance the readiness level of industrial systems for strategy implementation and transformations, the following recommendations are suggested: creation of financial and material reserves, optimization of development project budgets, improvement of key staff skills, implementation of import substitution measures, enhancement of organizational structure flexibility, and the adoption of updated management methods. The advent of a digital economy amid a deteriorating international economic situation necessitates large-scale and dynamic reforms in the manufacturing sector.

The methodology for assessing the readiness of the industrial system to implement a strategy of institutional transformations enables the exploration of the company's potential for profound changes. It also facilitates the timely identification of resource problems and organizational and management risks that hinder the company's transformation and the achievement of long-term development goals.

5. Discussion

The validation of the methodology for assessing the readiness of enterprises to implement the strategy of institutional transformation confirmed the authors' hypothesis. In the context of challenges, the strategy for enterprises' development becomes industrial integration, i.e., collaboration of enterprises, which allows for the synergistic integration of potentials and the distribution of the risks of innovation implementation. However, most researchers study integration models in the context of sustainable development and a circular economy [55–58]. Y. Chen and Z. Sun consider industrial integration as a new interactive form of cooperation in the global environment of the knowledge economy to produce products and process innovations [59].

The strategy for the institutional transformation of industrial systems has a special significance in the digital economy as a system of economic interaction and determinant of organization. The strategic priority is the extensive use of ICT and the analysis of big data in the processes of production, distribution, and consumption. The automation and digitalization of cyclical and routine business processes is one of the key features of institutional transformation processes in industrial systems and enterprises.

The tendency of enterprises towards systematic digitalization is also confirmed by the research of K. Nordström [60]. She believes that "everything that can be digitized will be digitized". The authors agree with S. Ruutu et al. [61] that the reduction in the level of discreteness in the implementation of business processes and production functions of

industrial systems is provided by the possibility of their integration based on digital platforms and services. These results prompt new research questions and offer opportunities for further studies. The reasonability of the platform-modular approach is determined by the high rate of development of the digital economy, which determines a steady trend of industrial complexes' transition to the platform type of functioning and development.

More specifically, our findings are consistent with the conclusions of V. Kvint [62], who stated that the strategy for the institutional transformation of the industrial systems digital economy is a set of goals, plans, principles, and instruments, which determines the logic and parameters of the managed change of the functioning model. We also confirm the findings of Z. Zhu et al. [63], who stated that the strategy of institutional transformation in the digital economy is a logical sequence of stages of targeted and harmonized changes in the basic structure and interconnections of the industrial systems.

The results of our research can be useful for industrial enterprises, research institutes, educational organizations, and authorities, namely to:

- improve the efficiency of strategic management;
- intensify innovation and integration processes;
- accelerate digital transformation;
- implement modern business models for enterprise development;
- train administrative personnel for the industrial sectors.

Future research directions may also be highlighted. Institutional transformation will be a very relevant, multidisciplinary area for future research given the recent developments of digital technologies. In order to gain a deeper understanding of what makes digital growth strategies successful, the following questions need to be answered: How can we measure the maturity level of industrial systems and their digital readiness? What is the impact of digital transformation on performance? How can digital resources facilitate institutional transformation? What are the possible networking capabilities and how can industrial systems develop them? How can the self-organization and self-management in institutional ecosystems be ensured? [22,41–43].

Developing tools for monitoring changes in industrial systems at macro-, meso-, and microlevels can support the processes of strategizing institutional changes in industrial systems and obtain new knowledge about the regularities, weaknesses, and opportunities for the transformation of industrial enterprises. It seems promising to use genetic algorithms in the methodology of institutional transformation strategizing. We hope that our discussion and research agenda will stimulate future research on institutional transformation.

6. Conclusions

Our study is one of the first to investigate the institutional transformation of industrial integrations in the digital economy, focused on the accelerated and proactive managerial, technological, and innovative transformation of enterprises. The digital platform ensures the efficient performance of the full cycle of management objectives for the transformation of industrial enterprises as well as a high level of coordination through the creation of a unified informational and digital environment. This study confirms the importance of systems thinking in understanding the readiness of industrial enterprises to institutional transformations. The methodology differentiates itself by using modified Shewhart control charts. The analysis highlights the necessity for integrated strategies that will allow industrial enterprises to make financial and material reserves, optimize costs, increase the flexibility of management systems and organizational structures, and develop new competencies.

The experience of Russian regions in the institutional transformation of industrial systems can be applied, for example, in the countries of the Eurasian Economic Union (EAEU). The key objectives of this organization are to increase industry integration and economic competitiveness for its member states. The member states of the EAEU include Armenia, Belarus, Kazakhstan, Kyrgyzstan, and Russia. The possibility of assessing the institutional integration of Kazakhstan and the EAEU based on a single methodology for the economic efficiency of individual enterprises is explored by E. Nurekenova [64].

A. Babkin et al. studied the best practices in the digital institutional transformation of Kazakhstan's industrial enterprises [65]. An approach for estimating the potential effect from the strengthening of comparative advantages in manufacturing industries due to the intensification of industrial cooperation is described in the research of V.A. Salnikov [66]. This approach is based on estimating the interrelation of comparative advantages in the final and intermediate commodities of the industry and empirically defining the labor productivity gap between the enterprises with growing and decreasing staff.

The methodology for assessing the readiness of industrial systems to implement institutional transformation strategies can be helpful in developing China's regional economic integration strategy. China has rapidly developed a sophisticated regionalism strategy in East Asia. This strategy aims to promote synergistic growth among different regions, achieving balanced and sustainable economic development of industrial systems [67,68]. Within industrial integrations in China, SMEs could play an important role in terms of fulfilling so-called "secondary" functions. We agree with the authors [69] stating that "the importance of SMEs for industrial value chains, understanding SMEs' barriers and respective enablers is vital". Enablers related to overcoming barriers to integration adoption include the following: digital policy, digital skills and culture, and technology.

Nevertheless, our study has several limitations that could be addressed in future research.

Specifically, the collection of initial data is a process that requires resource intensification due to the limited access to primary information on the activities of industrial systems and their further validation. This paper selected 14 industrial systems as the research sample. Expanding the geographical scope to include all regions in the Russian Federation could yield additional research findings.

This research contributes to a deeper understanding of the institutional transformations of industrial integrations in the digital age.

Author Contributions: Methodology, T.T., N.S. and A.B.; software, T.T.; validation, N.S., S.P. and T.G.; resources, A.B.; data curation, T.G., N.S. and T.T.; writing—original draft, A.B., T.T., N.S., T.G. and S.P.; writing—review and editing, T.T., N.S. and T.G. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: The datasets are available online upon request.

Conflicts of Interest: We have no conflicts of interest to disclose. We confirm that this work is original and has not been published elsewhere, nor is it currently under consideration for publication elsewhere. We confirm that all authors have approved the manuscript for submission.

Appendix A

Table A1. Assessment criteria for the readiness of the industrial systems to the implementation of the strategy of institutional transformation.

Assessed Resources	Assessment Criteria	The Procedure for Estimation of Readiness of the Industrial Systems According to the Relevant Criterion		Assessment of the Industrial Systems' Readiness Level in Accordance with the Corresponding Criterion		
				L_1—Low	**L_2—Medium**	**L_3—High**
1. Financial resources and production infrastructure	$K_{1.1}$—The level of financial support for the strategy relative to target budget	$K_{1.1} = (K_{1.1.1}/K_{1.1.2}) \times 100\%$, where: $K_{1.1.1}$—financial resources provided for the implementation of the strategy, $K_{1.1.2}$—the target budget of the strategy		$K_{1.1} \leq 60\%$	$60\% < K_{1.1} \leq 80\%$	$K_{1.1} > 80\%$
	$K_{1.2}$—The level of infrastructural support of the strategy's implementation in relation to the demand	$K_{1.2} = K_{1.2.1} \times N_{1.2.1} + K_{1.2.2} \times N_{1.2.2} + K_{1.2.3} \times N_{1.2.3} + K_{1.2.4} \times N_{1.2.4} + K_{1.2.5} \times N_{1.2.5}$, where:		$K_{1.2} \leq 50\%$	$50\% < K_{1.2} \leq 70\%$	$K_{1.2} > 70\%$
		$K_{1.2.1}$—Necessary equipment availability for production program implementation, % demand	Weighing coefficient			
			$N_{1.2.1} = 0.3$			
		$K_{1.2.2}$—Production space availability, % demand	$N_{1.2.2} = 0.25$			
		$K_{1.2.3}$—Warehouse space availability, %	$N_{1.2.3} = 0.2$			
		$K_{1.2.4}$—Land site availability, %	$N_{1.2.4} = 0.15$			
		$K_{1.2.5}$—Transport facilities availability, %	$N_{1.2.5} = 0.1$			
2. Human resources	$K_{2.1}$—Staffing level	$K_{2.1} = (K_{2.1.1}/K_{2.1.2}) \times 100\%$, where: $K_{2.1.1}$—Number of positions on staff member list for the review period, units; $K_{2.1.2}$—Total number of positions on staff member list of the industrial complex, persons		$K_{2.1} \leq 70\%$	$70\% < K_{2.1} \leq 85\%$	$K_{2.1} > 85\%$

Table A1. *Cont.*

Assessed Resources	Assessment Criteria	The Procedure for Estimation of Readiness of the Industrial Systems According to the Relevant Criterion		Assessment of the Industrial Systems' Readiness Level in Accordance with the Corresponding Criterion		
				L_1—Low	**L_2—Medium**	**L_3—High**
2. Human resources	$K_{2.2}$—Personnel skill level	$K_{2.2} = K_{2.2.1} \times N_{2 \cdot 2 \cdot 1} + K_{2 \cdot 2 \cdot 2} \times N_{2 \cdot 2 \cdot 2} + K_{2 \cdot 2 \cdot 3} \times N_{2 \cdot 2 \cdot 3} + K_{2 \cdot 2 \cdot 4} \times N_{2 \cdot 2 \cdot 4} + K_{1 \cdot 2 \cdot 5} \times N_{1 \cdot 2 \cdot 5}$, where:		$K_{2.2} \leq 70\%$	$70\% < K_{2.2} \leq 85\%$	$K_{2.2} > 85\%$
		$K_{2.2.1}$—Higher education rate among personnel, %	Weighing coefficient $N_{2.2.1} = 0.15$			
		$K_{2.2.2}$—Advanced training over the past 3-year rate among personnel, %	$N_{2.2.2} = 0.1$			
		$K_{2.2.3}$—More than 5 years of professional experience rate among personnel, %	$N_{2.2.3} = 0.15$			
		$K_{2.2.4}$—Usage of specialized software to solve work issues rate among personnel, %	$N_{2.2.4} = 0.2$			
		$K_{2.2.5}$—Usage of advanced production technology rate among personnel, %	$N_{2.2.5} = 0.4$			
3. Organizational structures	$K_{3.1}$—Communicativeness level of the organizational infrastructure	$K_{3.2} = (K_{3.1.1} + K_{3.1.2} + K_{3.1.3})/3$, where:		$K_{3.1} \leq 70\%$	$70\% < K_{3.1} \leq 80\%$	$K_{3.1} > 80\%$
		$K_{3.2.1}$—Level of information interaction between industrial systems personnel during horizontal communications, %				
		$K_{3.2.2}$—Level of information interaction between industrial systems personnel during vertical communications, %				
		$K_{3.2.3}$—Level of information interaction between industrial systems personnel and external contractors, %				
	$K_{3.2}$—Adaptability level of the organizational infrastructure	$K_{3.2} = (K_{3.2.1} + K_{3.2.2} + K_{3.2.3})/3$, where:		$K_{3.2} \leq 50\%$	$50\% < K_{3.2} \leq 70\%$	$K_{3.2} > 70\%$
		$K_{3.2.1}$—Presence of digitalization departments (formalized department—100%, informal department—50%, no department—0%).				
		$K_{3.2.2}$—Presence of innovation and R&D departments (formalized department—100%, informal department—50%, no department—0%)				
		$K_{3.2.3}$—Presence of project teams for cross-functional tasks (for most tasks—100%, for individual tasks—50%, no teams—0%).				

Table A1. *Cont.*

Assessed Resources	Assessment Criteria	The Procedure for Estimation of Readiness of the Industrial Systems According to the Relevant Criterion		Assessment of the Industrial Systems' Readiness Level in Accordance with the Corresponding Criterion		
				L_1—Low	L_2—Medium	L_3—High
4. Methodical toolset and management technologies	$K_{4.1}$—Level of advanced management techniques	$K_{4.1} = K_{4.1.1} \times N_{4.1.1} + K_{4.1.2} \times N_{4.1.2} + K_{4.1.3} \times N_{4.1.3} + K_{4.1.4} \times N_{4.1.4} + K_{4.1.5} \times N_{4.1.5}$, where:		$K_{4.1} \leq 50\%$	$50\% < K_{4.1} \leq 70\%$	$K_{4.1} > 70\%$
		$K_{4.1.1}$—Industrial complex strategic objectives with achievement plans (programs) in place, %	Weighing coefficient $N_{4.1.1} = 0.2$			
		$K_{4.1.2}$—Level of usage of flexible (project) management methods, %	$N_{4.1.2} = 0.2$			
		$K_{4.1.3}$—Level of usage of lean management and production technologies, %	$N_{4.1.3} = 0.2$			
		$K_{4.1.4}$—Industrial system departments with established key performance indicators (KPI), %	$N_{4.1.4} = 0.15$			
		$K_{4.1.5}$—Digital technologies implementation level for management decision making, %	$N_{4.1.5} = 0.25$			
	$K_{4.2}$—Quality and speed level of management decision making	$K_{4.2} = K_{4.2.1} \times N_{4.2.1} + K_{4.2.2} \times N_{4.2.2} + K_{4.2.3} \times N_{4.2.3} + K_{4.2.4} \times N_{4.2.4}$, where:		$K_{4.2} \leq 65\%$	$65\% < K_{4.2} \leq 80\%$	$K_{4.2} > 80\%$
		$K_{4.2.1}$—Timely management decisions, %	Weighing coefficient $N_{4.2.1} = 0.3$			
		$K_{4.2.2}$—Strategic plan milestones of the industrial complex implemented in accordance with the established deadlines, % per year	$N_{4.1.2} = 0.25$			
		$K_{4.2.3}$—Strategic plan milestones of the industrial systems implemented in accordance with the established budgets, % per year	$N_{4.1.3} = 0.25$			
		$K_{4.2.4}$—Field assignments from the management of the industrial systems implemented in accordance with the established deadlines and budgets, % per year	$N_{4.1.4} = 0.2$			

Table A1. *Cont.*

Assessed Resources	Assessment Criteria	The Procedure for Estimation of Readiness of the Industrial Systems According to the Relevant Criterion	Assessment of the Industrial Systems' Readiness Level in Accordance with the Corresponding Criterion		
			L_1—Low	**L_2—Medium**	**L_3—High**
5. Corporate culture and institutions	$K_{5.1}$—Personnel involvement in the transformation strategy	$K_{5.1.} = (K_{5.1.1} + K_{5.1.2} + K_{5.1.3} + K_{5.1.4})/4$, where:	$K_{5.1} \leq 40\%$	$40\% < K_{5.1} \leq 60\%$	$K_{5.1} > 60\%$
		$K_{5.1.1}$—Personnel to be involved in implementation of the institutional transformation strategy, %			
		$K_{5.1.2}$—Personnel to present new initiatives, ideas, and projects on the regular basis, %			
		$K_{5.1.3}$—Personnel to participate in pilot projects, managerial and production experiments, %			
		$K_{5.1.4}$—Personnel to participate in mentorship and experience transfer programs, %			
	$K_{5.2}$—Personnel loyalty	$K_{5.2.} = (K_{5.2.1} + K_{5.2.2} + K_{5.2.3} + K_{5.2.4})/4$, where:	$K_{5.2} \leq 70\%$	$70\% < K_{5.2} \leq 85\%$	$K_{5.2} > 85\%$
		$K_{5.2.1}$—Personnel supporting the idea of institutional transformations at the industrial systems			
		$K_{5.2.2}$—Personnel satisfied with the human resources policy of the industrial systems, %			
		$K_{5.2.3}$—Personnel satisfied with internal norms and guidelines of the enterprise performance, %			
		$K_{5.2.4}$—Customer-oriented employees in departments, interacting with external contractors, %			
6. Employee incentive program	$K_{6.1}$—Coverage of employees by financial methods incentives	$K_{6.1} = (K_{6.1.1}/K_{6.1.2}) \times 100\%$, where: $K_{6.1.1}$—Personnel with financial bonuses for successful implementation of transformation strategy, units $K_{6.1.2}$—Average number of the industrial systems personnel, units	$K_{6.1} \leq 70\%$	$70\% < K_{6.1} \leq 85\%$	$K_{6.1} > 85\%$
	$K_{6.2}$—Non-financial motivation methods	$K_{6.2} = (K_{6.2.1}/K_{6.2.2}) \times 100\%$, where: $K_{6.2.1}$—Personnel with non-financial motivation for successful implementation of transformation strategy, units $K_{6.2.2}$—Average number of the industrial systems personnel, units	$K_{6.2} \leq 70\%$	$70\% < K_{6.2} \leq 85\%$	$K_{6.2} > 85\%$

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