DOI: 10.55643/fcaptp.5.64.2025.4953

BASIC PILLARS OF THE INDUSTRIAL-DIGITAL TECHNOLOGICAL ORDER

Volodymyr Mishchenko
D.Sc. in Economics, Professor, Head of the Sector of Digital Economy, Institute of Economics and Forecasting of the NAS of Ukraine, Kyiv, Ukraine;
e-mail: mvi25prof@gmail.com
ORCID: 0000-0002-8565-2686
(Corresponding author)

Ievgen Tishchenko
PhD in Economics, Department of Economics, Finance, and Accounting, Private Higher Education Institution "European University", Kyiv, Ukraine;
ORCID: 0000-0002-1580-4701

Svitlana Mishchenko
D.Sc. in Economics, Professor of the Department of Finance, State University of Trade and Economics, Kyiv, Ukraine;
ORCID: 0000-0002-1840-8579

Svitlana Naumenkova
D.Sc. in Economics, Professor of the Department of Finance, Taras Shevchenko National University of Kyiv, Kyiv, Ukraine;
ORCID: 0000-0001-8582-6044

Received: 13/08/2025
Accepted: 08/10/2025
Published: 31/10/2025

ABSTRACT

The development of an industrial and digital order as a new systemic form of economic organization is an important direction of digital transformation. The purpose of this paper is to substantiate the system of basic pillars of the industrial-digital order, determine their role, functions, relationships, and directions of institutional integration, considering the priorities of national digital development. Based on comparative and functional analysis, a list of basic technological pillars has been defined, and their role in ensuring the structural integrity and systemic sustainability of the new industrial-digital order has been substantiated. The study confirms that the role of these technological pillars implies significant transformation of value creation, employment, collaboration, and institutional interaction. The concept of the support matrix proposed by the authors reveals the architectonics of the industrial-digital order and is of practical importance for the formation of digital policy, regulation, and the construction of a coordinated system of algorithmic, governance, and legal mechanisms. The practical focus of this study is the development of the Technology Support Adaptation Index, which serves as a tool for assessing the readiness of technologies for integration and operational consistency and provides a basis for developing recommendations for institutional transformations during the post-war reconstruction period. The conclusions and recommendations formulated in this study can be used in making political and regulatory decisions, as well as in strategic planning of digital policy aimed at supporting industrial and digital development in Ukraine.

Keywords: industrial-digital order, basic pillars, support matrix, cognitive management, human-machine cooperation, algorithmic coordination, Ukraine

JEL Classification: O33, L86, D85, H83

INTRODUCTION

Digital transformation of the economy is a key factor in shaping a new industrial-digital technological order. Against the backdrop of the development of cognitive algorithms, sensor technologies, cloud infrastructure, platform architectures, and registry systems, there is a need for a scientific understanding of this order as an integral socio-technical system.

In this context, the concept of basic technological pillars acquires key methodological significance as a basic element that forms the functional structure of the system and provides the conditions for its development. These pillars allow us to view the new economic system as an ordered configuration of interactions between human, algorithmic, and sensory agents.

The relevance of this study is due to the need to determine the conceptual basis of the new economic architecture shaped by technological changes in the introduction of digital technologies.

The theoretical basis of the study is the concept of the technological order as a dynamic system of interconnected digital solutions, institutional formats, human-machine cooperation, and regulatory codes that determine the mechanisms of governance, interaction, and implementation of the system of economic relations.

The core of the industrial digital order is the basic digital technologies: AI, IoT, cloud environment, platform architectures, and registry systems that determine its functional and organizational architecture. These components shape a support matrix capable of maintaining systemic integrity and ensuring normative and moral interaction. In this paradigm, there is a transition from human and machine cooperation to a delegated interaction model in which technological entities autonomously coordinate processes through trust protocols, participation interfaces, and intelligent contracts.

Thus, this study aims to substantiate the system of basic pillars of the industrial and digital order, as well as determine their role, functions, relationships, and directions of institutional integration.

LITERATURE REVIEW

The digital transformation of the economy requires a deep theoretical understanding of the methodological principles that determine the logic of studying the basic pillars of the industrial-digital order. Although some aspects of digital economic theory began to emerge in the 1990s, the study of economic orders has been going on for a long time and covers a wide range of approaches. The scientific community pays special attention to developing technologies and innovations that significantly influence the formation of a new economic order, particularly its industrial-digital configuration, in the context of the large-scale digitalization of the economy, the transformation of social institutions, and governance mechanisms.

Perez (2010) presents a conceptual framework for studying the industrial-digital order and describes the stages of technological revolutions, the structure of the technological core, and its impact on markets, institutions, and social systems. North (2005) examined the mechanisms of institutionalization of technological change in the economic environment, while Tylecote (2024) conducted a systematic analysis of the interaction between technological paradigms and social institutions. Tapscott and Williams (2010) conceptualized the digital order as a networked intelligent system that transforms patterns of collaboration, production, and exchange. Castells (2010) defined digital coordination as a new form of socio-economic organization within the framework of network society theory. Schwab (2017) described the industrial-digital order as the integration of physical, digital, and biological systems. Negroponte (1995) was one of the first to introduce the concepts of digital value and digital consumption into scientific circulation. Reinert (2008) provided an in-depth historical and institutional analysis of technological development, and Arthur (2009) argued for the concept of technologies as evolutionary systems that structure the economy.

Kenney and Zysman (2016) and Cusumano, Gawer, and Yoffie (2019) consider the platform economy as an institutional setting of the industrial-digital order; they analyze the governance logics, cooperation mechanisms, and strategic development models of platforms. Srnicek (2016) formulated the concept of platform capitalism as a new form of economic organization, and Acs et al. (2021) proposed a periodization of the evolution of the platform system.

Zuboff (2019) explores human-technology interactions, particularly algorithmic control and delegated subjectivity. Brynjolfsson and McAfee (2014) analyze the impact of digital technologies on employment, productivity, and the transformation of labor relations. Mishchenko et al. (2021) describe the risks of digitalization in the context of social tensions and regulatory coherence.

Energy challenges directly affect the formation of the industrial-digital order (Naumenkova et al., 2023, 2025). Hilty and Aebischer (2015) focus on the energy consumption of IT systems, especially data centers, and the need for energy balance in digital infrastructure.

In scientific research, more and more attention is being paid to digital technologies as key elements of the industrial-digital order. For example, Mittelstadt et al. (2019) consider AI as the cognitive pillar of the digital system, and Narayanan et al. (2016) analyze the role of registry technologies. The development of digital commerce determines the active use of electronic and mobile money (Mishchenko et al., 2022). Steiber and Alänge (2023) describe the transformation of the management architecture of the world's leading companies through the use of digital management models.

Ashkavand et al. (2023) assess the adaptive readiness of technologies for system integration. The issues of forming institutional and regulatory coherence of digital technologies are reflected in the materials of the European Union (EU, 2023), the European Commission (EC, 2023, 2025), the International Organization for Standardization (ISO/IEC, 2022, 2023), and other international organizations.

Despite significant scientific achievements in studying the problems of industrial-digital order formation, a number of questions regarding the role and interaction of its basic pillars remain open, which necessitates further research.

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AIMS AND OBJECTIVES

The purpose of the article is to substantiate the system of basic pillars of the industrial-digital order, determine their role, functions, relationships, and directions of institutional integration, taking into account the priorities of national digital development.

The study aims to explore the features of the functioning of the industrial-digital order's basic pillars for their integration into national development strategies. Based on the stated purpose, the following tasks were formulated:

1. To determine the content and classification features of the industrial-digital order's basic pillars.
2. To describe their main functions and relationships.
3. To assess the level of technological maturity and adaptive readiness of the basic pillars for practical use.
4. To identify the typology of risks associated with the functioning of digital technologies included in the support matrix.
5. To substantiate strategic directions for integrating basic pillars into the national model of industrial and digital development.

The solution to the formulated problems can become the basis for practical recommendations aimed at making regulatory decisions in the digital transformation of the economy.

METHODS

The study is based on exploring and developing modern scientific concepts and approaches related to the digital transformation of the economy and the formation of an industrial-digital order. The methodological basis for the study is an interdisciplinary combination of systemic, functional, and scenario approaches, which allows for a comprehensive analysis of the role that basic technological pillars play in shaping a new order.

The main conceptual provisions that the authors relied on during the research process are as follows:

1. The concept of the industrial-digital order is a socio-technical system that combines cognitive, infrastructural, ethical, and governance components.
2. The theory of basic pillars, according to which key digital technologies are the core of system integration, ensuring the functional coherence and institutional sustainability of the industrial-digital order.
3. An institutional digital transformation theory that focuses on the adaptation of institutions to digitalization challenges.

The concept of the study suggests that the basic pillars of the industrial-digital order are the integrative core of the following digital technologies: AI, the Internet of Things, cloud services, platform architectures, and registry systems. Their systematic use and complex interaction form the structure of the new economic order.

To determine the list of basic technological pillars, their functions, and their role as key agents of the digital economy, a structural-functional approach, system and comparative analysis, generalization, systematization, and interdisciplinary synthesis were used; this made it possible to thoroughly characterize and reveal the potential of the basic pillars in shaping the industrial-digital order.

When constructing the support matrix, a system approach, comparative analysis, expert assessment, classification, and typology were employed, which allowed us to identify functional links between the pillars.

Based on the analysis of domestic and international regulatory documents (IOS, 2013; KMU, 2023; MDTU, 2025), indicators were selected for calculating the Technology Support Adaptation Index (TSAI) of Ukraine's industrial and digital order for practical use. In this case, the principles of functionality, systematicity, and interdisciplinary approach were used. This allowed us to characterize the life cycle of each technology and ensure the reliability of the comparative analysis.

The TSAI calculation methodology involves assessing the basic pillars using seven indicators that take into account the potential for practical implementation, institutionalization degree, resource, infrastructure, and personnel provision, potential for scaling, compliance with social and ethical standards, and socio-economic impact. Following the ISO 16290:2013 requirements (ISO, 2013), indicator values were determined on a scale from 1 to 9, and the adaptation index for each technological pillar (IAO_i) was calculated using the formula:

$$IAO_i = \sum_{k=1}^{7} \frac{I_{ik}}{7}, \quad (1)$$

where I_{ik} is the Technology Support Adaptation Index i (i = 1…5) by indicator k (k = 1, …. 7).

Using a set of specified scientific research methods allowed us to comprehensively describe the process of creating the industrial digital order as a systemic form of economic organization and substantiate recommendations for integrating basic technological pillars into national digital development strategies.

RESULTS

Digital transformation has stimulated the formation of an industrial-digital order in which humans, machine intelligence, infrastructure, and ethical and value guidelines interact within a single system. This order operates as a dynamic environment that integrates technological ecosystems, algorithmic governance models, and information infrastructure based on normative and ethical interactions between people, digital agents, and human-machine systems. During its formation, the structure of productive forces is transformed, the nature of labor changes, new forms of economic subjectivity arise, and interaction scenarios are expanded, defining new forms of socio-economic relations.

In previous technological paradigms, the basic pillars were dominant resources, advanced technologies, institutions, or systemic infrastructure solutions that were characterized by high innovativeness and the ability to spread across industries. They also played a key role in transforming productive forces and production relations.

In the context of digital development, these approaches are changing significantly. The main criteria for identifying technologies as basic pillars are: the ability to intellectualize production, governance, and communication processes; support for integrated human-machine interaction; availability of self-regulation mechanisms; protocol and functional compatibility with other technological modules; institutional flexibility; compliance with regulatory and ethical principles.

The application of these criteria allows us to identify key technologies that provide the basic pillars for the industrial-digital order. According to our hypothesis, such technologies include:

- Artificial intelligence (AI) as a means of cognitive adaptation;
- Internet of Things (IoT) as a mechanism for sensory integration of the physical and digital environment;
- cloud technologies as an infrastructure for mobile computing, storage, and access to data;
- platform architectures as a way of digital cooperation and service modularity;
- registry trust technologies that ensure transparency, legitimation, and compliance with ethical requirements in digital interaction systems.

The selection of these technologies allows us to form a support matrix that reflects their functional interaction and systemic connections within the industrial-digital order.

Thus, under the influence of basic technologies, an industrial-digital order emerges as a new form of systemic economic organization, in which basic technological pillars act as the core of integration, adaptation, and development. Their institutional configuration within the framework of the support matrix opens up prospects for a systemic understanding of post-industrial development in the context of deep human-machine cooperation.

In the formation and evolution of the industrial-digital order, the basic pillars implement cognitive, systemic, network, ethical, and managerial functions, and each technology, through systemic interaction, contributes to their strengthening and simultaneously forms the essential characteristics of the order itself (Table 1).

An analysis of the functions and interrelations of the basic pillars shows that together they form a holistic structure of the industrial-digital order, in which each pillar performs its key function: AI – cognitive, IoT – sensory and communicative, cloud environment – infrastructural, platforms – cooperative, and registry technologies – ethical and legal. This functionality allows us to assert that the combination of technological pillars stimulates the mechanisms of their interaction and creates synergistic effects.

DOI: 10.55643/fcaptp.5.64.2025.4953

Table 1. Characteristics of the main functions of the industrial-digital order's basic pillars.

Pillar / Functions	Intellectual	Systemic	Network	Ethical	Managerial
AI	Cognitive formation of scenarios based on knowledge	Delegation of decision-making	Connecting data, digital subjects, and digital assets	Providing ethical guidance	Defining scenarios for management actions and decision-making
IoT	Autonomous sensory perception of information, local decision making	Interaction of technical objects, distribution of control	Synchronization of devices	Privacy observance	Coordination of interaction between devices
Cloud environment	Adapting computational strategies for data analysis	Institutionalization of rules for the exchange, storage, and management of data	Distributed storage and streaming data processing	Ethical use of personal data, transparency of access	Data flow management
Platform architectures	Combining different types of data on the platform	Defining the rules of integration and interaction on the platform	Merger of market entities and market assets	Protecting the digital rights of participants	Flexible modeling of access rules and interaction mechanisms
Registry trust technologies	Registration of platform participants	Rules of interaction in decentralized systems	Ensuring robust interactions between nodes in distributed transaction networks	Maintaining trust	Access management, rights control

In this context, studying the degree of functional interaction and the density of systemic connections between basic pillars becomes of practical importance. For this purpose, a cross-matrix was formed to identify the nature and intensity of the relationships between the individual pillars of the industrial-digital order (Table 2).

Table 2. Matrix of functional interaction between the basic pillars of the industrial-digital order.

Pillar	AI	IoT	Cloud environment	Platform architectures	Registry technologies
AI	–	Interdependence	Interdependence	Mutual reinforcement of functions	Reproducible function amplification
IoT	Interdependence	–	Mutual reinforcement of functions	Interdependence	Mutual reinforcement of functions
Cloud environment	Interdependence	Mutual reinforcement of functions	–	Mutual reinforcement of functions	Interdependence
Platform architectures	Mutual reinforcement of functions	Interdependence	Mutual reinforcement of functions	–	Mutual reinforcement of functions
Registry technologies	Reproducible function amplification	Mutual reinforcement of functions	Interdependence	Mutual reinforcement of functions	–

An analysis of the functional interactions between the core pillars indicates a high level of systemic synergy, in particular, between AI, platform architectures, and registry technologies. Their combination shows the potential for mutual reinforcement and the formation of complex technological configurations and sustainable systemic effects. Each pillar acts as an autonomous structural unit capable of self-regulation, strategic interaction, scaling, and renewal throughout the entire life cycle.

Assessing the depth of interaction between the basic pillars allows us to determine the level of their technological maturity, functional adaptability, and ability to transform. It also allows identifying the degree of systematicity and the potential for creating new forms of integration through the evolutionary renewal of relations within the digital ecosystem.

A comparative analysis of the technology readiness level of the industrial-digital order's basic pillars, conducted by the Ukrainian National Office for Intellectual Property and Innovations in accordance with the ISO 16290:2013 standard, shows that AI and platform architectures have the highest values of technological maturity, potential for mutual transformation, and the level of systematicity in the structure of the support matrix. Other technologies, given their functional specificity, perform local infrastructure roles and are characterized by limited ability to scale and transform (Table 3).

Table 3. Level of technological maturity and potential for system integration of the basic pillars of the industrial-digital order. *(Source: IOS, 2013; IP OFFICE, 2024)*

Pillar	TRL value	Integration potential	Systematicity level in the matrix	Technology scaling level
AI	8-9	High	High	Global
IoT	8-9	Medium	High	Regional/local
Cloud environment	8-9	Medium	Medium	Regional/local
Platform architectures	8-9	High	High	Global
Registry technologies	7-8	High	Medium	Limited/niche

Within the architectonics of the basic support matrix, these technologies operate as interconnected nodes of a single system, ensuring coordinated work, scalable collaboration, and a balance of ethics and legality.

However, a qualitative assessment of the interaction between technological pillars is not enough for a comprehensive characterization of their role in the structure of the industrial-digital order. The potential for practical implementation, the level of institutionalization, resource availability, compliance with social and ethical standards, and the socio-economic impact must also be considered.

Given this, the calculation of the Technology Support Adaptation Index is proposed, which allows taking these parameters into account in the structure of the industrial-digital order in Ukraine (Table 4).

Table 4. Calculating the Technology Support Adaptation Index of the industrial-digital order for Ukraine (as of January 1, 2025). *(Source: MDTU, 2024; NISS, 2025; SSSU, 2024; UDX Research Group, 2025)*

Indicator / Pillar	AI	IoT	Cloud environment	Platform architectures	Registry technologies
1. Potential for practical implementation	9	8	9	9	4
2. Degree of institutionalization (legal integration)	3	4	5	5	3
3. Resource and infrastructure provision	4	4	4	5	4
4. Staffing	4	4	4	5	4
5. Potential for scaling and integration	9	4	7	8	4
6. Compliance with social and ethical standards	4	4	6	5	4
7. Socio-economic impact	9	7	9	9	6
Average Index value for each technological pillar	6.00	5.00	6.29	6.57	4.14

The results obtained indicate that the adaptation of technological pillars to practical use is asymmetric. Thus, platform architectures and the cloud environment have the highest level of adaptability, 6.57 and 6.29 points, respectively. The TSAI for AI is 6.00, but its dynamics require strengthening regulatory integration and compliance with social and ethical standards.

The relatively low values of the Adaptation Index for IoT (5.00) and registry technologies (4.14) indicate an insufficient level of their institutionalization and limited infrastructure provision. This situation necessitates updating and improving the regulatory framework, strengthening human resources, coordinating institutional interaction, and integrating ethical and legal principles into the practice of using these technologies.

The proposed methodology for calculating TSAI allows for a clear definition of areas of regulatory influence, assessment of technology implementation risks, formation of investment priorities, and monitoring of digital transformation, and, therefore, can be used in strategic planning.

The identified trends in the adaptation of the technological pillars of the industrial digital order are consistent with the dynamics of the Network Readiness Index (NRI) developed by the Portulans Institute. Between 2019 and 2024, the overall

DOI: 10.55643/fcaptp.5.64.2025.4953

value of this index for Ukraine increased from 48.92 to 55.32, indicating a positive evolution of the state's digital capabilities. The development of digital technologies, the increase in the level of human resources, and the improved digital transformation management system made the greatest contribution to this growth (Figure 1).

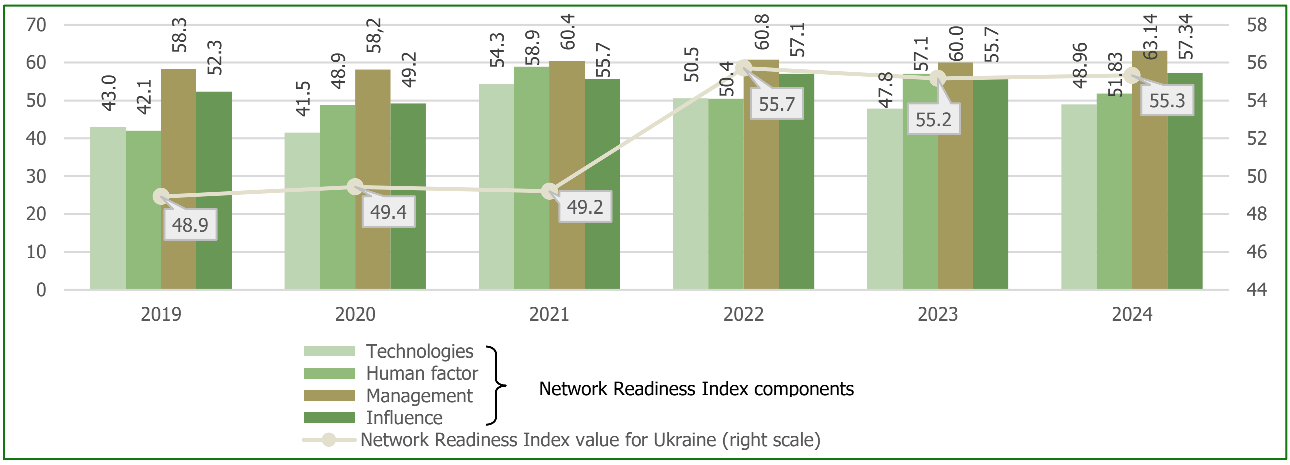

Figure 1. Dynamics of Ukraine's Network Readiness Index components in 2019–2024. *(Source: Portulans Institute, 2024)*

Thus, a comprehensive assessment of the development of basic technologies revealed significant differences both in their ability to integrate and in the level of readiness for practical implementation. This indicates the need for further development of the technologies themselves, strengthening the regulatory framework for their application, and increasing the effectiveness of regulation.

At the same time, one should note that, despite their innovative and transformative role, the basic technological pillars contain a number of internal contradictions and risks that can slow down the development of the industrial-digital order.

Key contradictions include high capital intensity of innovations, which complicates their widespread implementation; rapid technological obsolescence, which reduces the long-term effectiveness of investments; ethical tensions associated with autonomous decisions and algorithmic accountability; digital inequality that increases social fragmentation; and normative uncertainty that creates risks to institutional stability.

These contradictions not only exacerbate social and economic imbalances but also create a new set of risks that require systemic analysis and effective management. In this regard, an improved typology of risks arising during the operation of the industrial digital order's basic pillars is proposed (Table 5).

Table 5. Typology of risks in the functioning of the basic pillars of the industrial-digital order.

Pillar	Regulatory challenges	Socio-ethical risks	Technological risks	System barriers
AI	Lack of ethical standards and tools for algorithmic accountability	Low transparency of algorithms, unclear responsibility for decisions made by AI	Manipulation technologies risk of displacing humans from key processes	Lack of institutions for moral supervision, instability of generative algorithms
IoT	Insufficient level of protocol compatibility, weak regulatory integration	Breach of confidentiality	Vulnerability of devices; lack of unified standards	Technical fragmentation, lack of regulatory coherence
Cloud environment	Low level of access standardization, unclear regulatory boundaries	Risks of data leakage and unauthorized access	High energy dependence	Dependence on suppliers, weak institutional support
Platform architectures	Lack of institutions to regulate the platform economy	Access asymmetry, weak digital rights protection	Concentration of data and power, risks of monopolization	Limited inclusivity, insufficient legal regulation
Registry technologies	Regulatory framework instability; unclear legitimization of transactions	Insufficient digital identity protection, risks of reputational loss	The regulatory framework lags behind the pace of technological development	Lack of trust in digital mechanisms, weak institutional adaptation

The analysis suggests that each pillar presents a specific set of risks that can be categorized into four interrelated categories: regulatory, socio-ethical, technological, and systemic. At the same time, these risks can intertwine and overlap, increasing overall vulnerability.

Thus, AI raises ethical issues related to the opacity of algorithms and the autonomy of decisions, as well as the risks of loss of human control over critical processes. Due to the lack of unified standards, the Internet of Things creates challenges of privacy and technical fragmentation. Cloud environments exhibit high dependency on suppliers and energy resources. Platform architectures lead to the concentration of digital power and limit inclusive access to resources. Registry technologies face regulatory instability and risks of loss of digital identity.

Taken together, these risks not only accumulate but can interact and overlap, creating systemic threats that undermine the integrity of digital ecosystems. This configuration of risks and systemic threats makes it difficult to predict the consequences of their implementation, increases dependence on external factors, and creates the prerequisites for critical situations in which local failures can cause large-scale systemic consequences.

In this regard, managing such risks requires a comprehensive approach using appropriate methods and tools to detect, identify, prevent, or avoid them. Particular attention should be paid to systemic regulation, ensuring digital trust, technological sustainability, and cybersecurity as key conditions for the stable functioning of digital ecosystems.

In this context, state regulation should be based on a balance between technological progress, socio-economic stability, and coherent institutional governance. This approach involves the constant updating of the regulatory framework in accordance with the pace of technological development, the creation of digital ethics institutions, strengthening cybersecurity, and the introduction of inclusive mechanisms aimed at ensuring equal access to technologies for all subjects of digital interaction.

Assessing the functional capacity and interrelations of the basic pillars allows us to determine their systemic impact on macroeconomic indicators and socio-economic dynamics. The systemic integration of these technologies into production and social clusters forms the key features of the modern technological order, and practical implementation contributes to the qualitative renewal of productive forces, ensuring growth in labor productivity, production efficiency, and the population's well-being.

The study allowed us to determine that the basic pillars are capable of creating new economic formats that define the features of their interaction and form the rules for legitimizing actions within the industrial-digital order. Their impact encompasses economic efficiency, regulatory coherence, and socio-ethical stability, and shapes the structure of a digital economy in which: AI creates new forms of productivity; IoT provides sensor coordination and protocol interoperability; cloud services ensure data availability and secure processing; platform architectures create mechanisms for digital cooperation; and registry technologies stabilize the regulatory environment and help strengthen digital trust.

As a result of systemic digital interaction, the influence of the basic pillars on the dynamics of the industrial-digital order becomes macroeconomic (Table 6).

Table 6. Impact of basic pillars on the dynamics of the industrial-digital order.

Pillar	Main functions	Transformation directions	Economic results
AI	System interaction, cognitive moderation, analytics, decision support, scenario management	Formation of behavioral logic of systems based on strategic interaction and self-regulation	▪ acceleration of economic growth; ▪ emergence of new sources and forms of value; ▪ increasing labor productivity; ▪ change in employment structure
IoT	Sensor monitoring, communication, event recording, data collection, transmission, and analytics	Decentralization of control, formation of an adaptive management ecosystem, and analytical autonomy	▪ increasing energy efficiency; ▪ reduced operating expenses; ▪ creation of new employment sectors; ▪ integration into global value chains
Cloud environment	Data storage, computation, integration, and accessibility	Scalable availability, I/O support, business process optimization, data sovereignty assurance	▪ increase in labor productivity; ▪ reducing IT infrastructure costs; ▪ creating new jobs; ▪ support for small and medium businesses
Platform architectures	Coordination of interactions, adaptation of systems, and multi-agent synchronization	Formation of modular ecosystems, intellectualization, and digital cooperation	▪ GDP growth; ▪ scaling production and providing services; ▪ increasing labor productivity; ▪ reducing transaction costs
Registry technologies	Recording and verification of rights and transactions, automation of interaction	DLT implementation, integration with AI, cyber resilience, regulatory compliance, interoperability	▪ GDP growth; ▪ increasing labor productivity; ▪ reducing transaction costs; ▪ formation of digital assets; ▪ increasing fiscal efficiency

DOI: 10.55643/fcaptp.5.64.2025.4953

Production, business models, organizational and management processes, based on cognitive digital platforms and automated decision support systems, are becoming increasingly intellectualized. Resource allocation is carried out using predictive optimization models focused on rationalizing resource use. Exchange transactions are increasingly being replaced by decentralized instruments that provide transparency, adaptability, and technological flexibility for transactions. Consumption is transformed by creating trusted digital identities, verifying requests, and deeply personalizing services. Financing and investing are taking on new forms, in particular through the tokenization of assets, the introduction of digital money, micro-investment models, and crowdfunding mechanisms that ensure inclusiveness and high adaptability of financial flows.

Each technological pillar of the new order not only activates a separate direction of socio-economic transformations, but also interacts with other elements of the support matrix. As a result of their synergy, new mechanisms of interaction are formed, based on the principles of multi-level coordination, intellectual adaptation, and system integration.

Basic technological pillars do not simply transform individual economic functions, but change the fundamental conditions of production, distribution, exchange, consumption, and financing. Each pillar forms a specific direction of influence, determining the logic of interaction between economic agents and resources. Taken together, this contributes to the formation of a new economic system that functions based on intellectual and technical interaction (Table 7).

Table 7. Systemic influence of basic technological pillars on the transformation of economic relations within the industrial-digital order.

Pillar	Production	Resource allocation	Exchange (transactions)	Consumption	Financing
AI	Labor intellectualization, cognitive modeling, and delegation of functions	Algorithmic optimization, demand forecasting	Dynamic pricing, adaptive valuation mechanisms	Service personalization, digital self-service	Cognitive models of financial decision-making
IoT	Sensor control, cyber-physical integration	Contextual resource transfer, crowdsourcing	Autonomous transactions between devices	Real-time consumption personalization	Pay-per-use models, dynamic asset fixation
Cloud environment	Distributed data processing, cooperative work models	Collaborative data sharing, flexible access	Scalable transactions, service integration	Multi-agent maintenance, service adaptation	Flexible access to capital
Platform architectures	Modular organization of processes, new forms of employment	API-oriented distribution, decentralized resource management	Cross-platform interaction, participatory economy	Collaborative consumption, subscription, marketplaces	Asset tokenization, platform financing models
Registry technologies	Automatic process recording	Resource identification, rights legitimation	Decentralized transactions, verification of interactions	Transparency of consumer behavior, protection of consumer rights	Using digital assets

Technological pillars play not only a functional but also an architectural role in the development of the industrial-digital order. Their influence covers all areas of economic activity and ensures the transition from centralized to decentralized models, from linear to adaptive logic, from formal consumption to personalized participation. Such a transformation suggests that basic technological pillars act as agents of intellectualization, coordination, and digital autonomy.

In the context of ensuring and supporting national digital development, integrating technological pillars into a holistic framework of the industrial-digital order is of particular importance. This framework should become the basis for a new concept of economic development focused on innovation, sustainability, and ethical and legal justice.

Given the needs of post-war reconstruction, Ukraine faces the task of forming its own model of industrial-digital order based on national challenges and institutional priorities of technological and socio-economic development.

Strategic directions for integrating basic pillars into the industrial-digital order in Ukraine should include scenarios for institutional transformations that determine the key areas of digital development, appropriate implementation tools, expected results, and mechanisms for achieving the set goals (Table 8).

Table 8. Strategic directions for integrating basic pillars into the industrial and digital order in Ukraine.

Pillar	Scenarios for institutional transformation	Mechanisms for achieving goals	Implementation tools	Expected result
AI	National cognitive platform	Ethical standardization, cross-sectoral integration	DSS models, centers of moral AI	Process adaptation, solution optimization
IoT	State sensor infrastructure	Ensuring interoperability of systems, launching regional test zones, adapting technical regulations	Compatibility standards, telemetry, pilot zones	Autonomization of objects, balance of resources
Cloud environment	Public cloud infrastructure	Formation of public-private clusters, energy modeling, cybersecurity audits	Cloud offices, data centers, online teams	Digital inclusion, flexible employment, and resource saving
Platform architectures	Platform cooperation principles	Development of open standards, institutional support, and adaptation of regulatory norms	Participatory marketplaces, API logic	Scaling entrepreneurship, digital cooperation
Registry technologies	Digital trust infrastructure	Implementation of decentralized registries, legal harmonization, and digital identification	Smart contracts, tokenized models	Institutional trust, fiscal transparency

The integration of basic pillars into Ukraine's industrial-digital order can occur according to various scenarios based on the formation of cognitive, sensory, infrastructural, cooperative, and trust functions. The proposed transformation scenarios involve adapting the institutional configuration of basic pillars to achieve regulatory coherence and ethical compliance. As a result, a holistic system of interaction between technologies, management models, and ethical norms is formed, which allows maintaining structural coherence and systemic manageability in digital transformation processes.

The achievement of set goals is ensured through the use of appropriate mechanisms, among which regulatory harmonization of the legal framework, organizational and managerial coordination, institutional adaptation, as well as ethical and legal standardization, as the basis for trust and legitimacy of digital solutions, play a key role.

Basic technological pillars can coordinate the main directions of transformation and maintain systemic coherence of digital processes. Thanks to their adaptability, scalability, ethical balance, and institutional integration, they become the basis for implementing modern economic policy.

Thus, the industrial-digital order acts as a basis for combining technological renewal, economic efficiency, and institutional sustainability. In the context of post-war restoration in Ukraine, its development should be based on structural consistency of decisions, digital independence, and strategic trust in institutions. The formation of an adaptive national model capable of supporting sustainable economic transformation and ensuring digital sovereignty as a strategic prerequisite for innovative development is a key task.

DISCUSSION

One of the most debated aspects is the justification for the choice of digital technologies capable of playing the role of basic pillars of the industrial-digital order. Some studies give preference to AI technologies, which, according to the authors, play a key role in the structural design of the order (Qin et al., 2024). Siam et al. (2024), studying relevant architectures and communication protocols, focus on the integration of AI and IoT. Ficili et al. (2025) propose a broader set of technologies, including AI, IoT, cloud computing, and distributed ledgers, as the basis for shaping the cognitive environment and enhancing synergies. At the same time, most researchers are inclined to use integrative models for shaping the basic pillars of the industrial-digital order.

Assessing the systemic interaction of the basic pillars remains a subject of interdisciplinary debate. Some researchers consider their action primarily in the technological dimension, which does not correspond to the transformative potential of such pillars (Emako et al., 2022). The fact is that at each stage of the life cycle, the influence of the basic pillars is significantly enhanced, acquiring a non-linear amplification effect. This leads to new macroeconomic outcomes and social effects.

The formation of a regulatory environment that provides conditions for the safe and ethical use of technologies within the industrial-digital order is an important, debatable issue. Implementers, in particular, enterprises, institutions, and users, face regulatory barriers that complicate the integration of technological solutions into economic processes. This highlights

DOI: 10.55643/fcaptp.5.64.2025.4953

the need for flexible regulatory models that can adapt to the dynamics of technological development and meet international requirements, in particular, the EU Recovery and Resilience Facility, AI Act (EC, 2024), and the Guidelines for Providers of General-Purpose AI Models under the AI Act (EC, 2025).

This study examines the impact of basic technological pillars on the formation of the industrial-digital order, and also outlines key systemic connections and scenarios for their interaction. The obtained results deepen the theoretical understanding of shaping a new technological order and contribute to developing a balanced digital transformation policy.

CONCLUSIONS

The system of basic pillars of the industrial-digital order forms the conceptual basis of a new economic model, in which digital technologies play not only a functional, but also a structural and institutional role. Their application ensures the intellectualization of human-machine interaction and is a key factor in shaping a holistic digital environment.

Based on assessing the level of technological maturity, functional focus, and integration capability, five basic pillars were identified that define the essential characteristics and shape the architecture of the industrial digital order: artificial intelligence, the Internet of Things, the cloud environment, platform architectures, and trust registry technologies.

These pillars, in their interaction and interdependence, form the mechanisms of systemic integration, ensuring the coordination and legitimization of actions and facilitating adaptation in the digital environment. The presented support matrix for these technologies allows us to consider the industrial-digital order as a holistic, multi-level socio-technical system.

When a new technological order is established, the basic pillars act as interconnected components, the influence of which is intertwined at different levels of economic organization. With proper regulation and support, they reinforce each other, accelerating the adoption of digital technologies and promoting industrial digital development.

The interconnections between the identified pillars ensure the internal coherence of the industrial-digital system, its flexibility, and resilience to external challenges. The typology of risks associated with the use of digital technologies reveals internal systemic limitations that require normative, ethical, and institutional support.

The integration of basic pillars into Ukraine's industrial and digital model envisages the creation of new nationwide institutions to coordinate technological solutions with strategic priorities, institutional mechanisms, and infrastructure necessary to implement national goals of industrial and digital development.

The results obtained can be used by government bodies, think tanks, and enterprises to formulate technology policies and digital transformation strategies.

Further research may include assessing the impact of digital technologies on governance and economic processes, updating institutional and regulatory frameworks in the platform environment, and developing new forms of interaction between the state, business, and society to ensure effective post-war reconstruction in Ukraine.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

All authors have contributed equally.

FUNDING

The article was prepared as part of the "Formation of structure-forming pillars of military-post-war economic development of Ukraine" project (state registration number 0125U000280).

CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

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Міщенко В., Тіщенко Є., Міщенко С., Науменкова С.

БАЗОВІ ОПОРИ ПРОМИСЛОВО-ЦИФРОВОГО ТЕХНОЛОГІЧНОГО УКЛАДУ

Важливим напрямом цифрової трансформації є формування промислово-цифрового укладу як нової системної форми економічної організації. Метою дослідження є обґрунтування системи базових опор промислово-цифрового укладу, визначення їхньої ролі, функцій, взаємозв'язків і напрямів інституційної інтеграції з урахуванням пріоритетів національного цифрового розвитку. На основі порівняльного та функціонального аналізу визначено перелік базових технологічних опор, обґрунтовано їхню роль у забезпеченні структурної цілісності та системної стабільності нового промислово-цифрового укладу. Результати дослідження підтверджують, що роль цих технологічних опор передбачає суттєву трансформацію процесів створення вартості, зайнятості, кооперації та інституційної взаємодії. Запропонована авторами концепція опорної матриці розкриває архітектоніку промислово-цифрового укладу, має прикладне значення для формування цифрової політики, регулювання та побудови узгодженої системи алгоритмічних, управлінських і правових механізмів. Практичне спрямування має розробка Індексу адаптації базових опор, який слугує інструментом оцінки готовності технологій до інтеграції та операційної узгодженості, а також є основою для розроблення рекомендацій щодо інституційних трансформацій у процесі повоєнного відновлення. Висновки та рекомендації можуть бути використані при ухваленні політичних і регуляторних рішень, а також у стратегічному плануванні цифрової політики, спрямованої на підтримку промислово-цифрового розвитку в Україні.

Ключові слова: промислово-цифровий уклад, базові опори, опорна матриця, когнітивне управління, людино-машинна кооперація, алгоритмічна координація, Україна

JEL Класифікація: O33, L86, D85, H83