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Article

A Model for Managing the Value Chain Based on Digital Transformation in Regional Industrial Clusters

Abdinazarov Khusan Shaymanovich[*1]

1. Independent Researcher of Karshi State University

* Correspondence: xabdunazarov0770@gmail.com

Abstract: This scientific article examines the theoretical and methodological foundations and practical mechanisms for managing the value chain in regional industrial clusters under the conditions of digital transformation. In the modern economy, the rapid development of digital technologies is fundamentally transforming production and service processes, expanding opportunities for integrating and optimizing value creation stages. Within the framework of the study, the transformation of interconnections among cluster participants, information exchange, and resource allocation processes in the digital environment was systematically analyzed. The study substantiates the potential for improving production efficiency, reducing costs, and accelerating decision-making processes through the application of digital solutions at each stage of the value chain. The article proposes an integrated management model based on digital platforms, artificial intelligence, Big Data, and IoT technologies. The proposed model ensures transparency among cluster participants, optimizes logistics and supply chains, and contributes to maximizing value added.

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1. Introduction

In the global economy, the profound transformation processes observed over the past decade—particularly the rapid development of digital technologies—are fundamentally reshaping the models of organization and management in industrial sectors [1]. According to data from international economic organizations, the share of the digital economy in global GDP is projected to reach 20–25% by 2025. This highlights the growing strategic importance of digitalization in economic processes [2]. Industrial clusters, in turn, have emerged as a key institutional form in the modern economic system, contributing to innovative development, enhancing regional competitiveness, and ensuring the efficient use of resources. The cluster approach, which has been theoretically substantiated in economic science, represents a geographically concentrated and interconnected system of production, supply, and service activities [3]. Currently, in developed countries, the share of value added generated through industrial clusters accounts for approximately 50–60% of total industrial output [4].

Under conditions of digital transformation, the management of the value chain has gained particular importance. While traditional value chain models were primarily linear and stage-based, in the digital environment they are evolving into multidimensional and

dynamic network systems. In particular, technologies such as Big Data, artificial intelligence, cloud computing, and IoT enable real-time monitoring, forecasting, and optimization of production processes. Recent statistical data indicate that enterprises implementing digital technologies have achieved an average increase of 20–30% in production efficiency, while logistics costs have been reduced by 15–20% [5], [6]. Furthermore, studies conducted by consulting firms such as McKinsey and Deloitte emphasize that digital transformation serves as a critical factor in accelerating value creation and improving product quality across all stages of the value chain [7].

In the economy of Uzbekistan, the modernization of industry, the development of cluster systems, and the implementation of digital technologies are being actively supported at the level of state policy. In recent years, a number of strategic programs have been adopted, aimed at establishing industrial clusters, developing digital infrastructure, and stimulating innovation activities. This creates a need for developing new approaches to effectively manage value chains. From this perspective, developing an effective model for managing value chains based on digital transformation in regional industrial clusters, as well as scientifically substantiating its economic efficiency, represents one of the most relevant research directions. The objective of this study is to develop theoretical and practical recommendations aimed at integrating and optimizing value creation processes within clusters through the effective use of digital technologies [8], [9].

Literature Review

Over the past decade, scientific research in the field of digital transformation and value chain management has intensified significantly, with a number of prominent scholars proposing important theoretical and practical insights in this area. The concept of the value chain was first developed by Michael Porter, who proposed a systematic analysis of value creation stages within firm activities. In subsequent studies, this concept has been adapted to the digital environment, leading to the emergence of the "digital value chain" concept. In particular, Richard Baldwin (2016) emphasizes that digital technologies are reshaping global value chains and enhancing efficiency through the fragmentation of production processes [10].

The theory of industrial clusters is also extensively elaborated in the works of Michael Porter, who considers clusters as key drivers of regional competitiveness. In more recent studies, Örjan Sölvell (2015) demonstrates that innovation and knowledge exchange processes within clusters are further strengthened through digital platforms. Regarding the impact of digital transformation on production processes, studies by Erik Brynjolfsson and Andrew McAfee (2017) highlight that digital technologies significantly improve labor productivity. According to their findings, digitalization increases the speed of decision-making by 30–40% and enhances the efficient use of resources [11].

In addition, Klaus Schwab (2016), in his research on the Fourth Industrial Revolution, emphasizes that technologies such as IoT, artificial intelligence, and Big Data are fundamentally transforming production and logistics systems. He argues that digital transformation enables real-time management of value creation processes. In the field of supply chain digitalization, Martin Christopher (2016) demonstrates that the use of digital solutions in logistics systems can reduce costs by 15–20%. Similarly, Hau L. Lee highlights that information transparency in supply chains is a key factor in enhancing competitiveness. Recent studies conducted by international organizations and consulting firms further confirm these scientific findings [12]. For instance, McKinsey & Company (2022) reports that the implementation of digital technologies in industrial enterprises has increased production efficiency by 20–30%. Likewise, Deloitte (2023) notes that digital transformation contributes to reducing logistics costs by 15–20%.

However, the analysis of existing literature reveals that most studies primarily focus on the isolated effects of digital technologies, while insufficient attention has been paid to their integrated application in managing value chains within regional industrial clusters.

In particular, there is a lack of comprehensive research on integrated management models that facilitate digital collaboration among cluster participants. Therefore, this study aims to fill the existing research gap by developing a comprehensive model for managing value chains based on digital transformation within regional industrial clusters [13].

2. Methodology

This study applied a mixed-methods approach (quantitative and qualitative) to assess the impact of digital transformation on the value chain management of regional industrial clusters. The theoretical component of the research involved a systematic analysis of scientific literature based on the concepts of the value chain and cluster theory. Through content analysis, key trends regarding the impact of digital technologies (Big Data, AI, IoT) on cluster operations were identified.

The empirical analysis examined the following indicators across industrial enterprises and clusters:

- Production efficiency (%),
- Logistics costs (%),
- Value added volume,
- Level of digital technology adoption.

The data were processed using comparative and correlation analysis. Correlation analysis was employed to identify the relationship between the level of digitalization and operational efficiency. A systems approach was used to develop the model. A digital implementation scheme was designed for each stage of the value chain (supply, production, logistics, sales). Business process reengineering was applied to create an optimized management model. Additionally, an expert evaluation method was employed. Feedback from specialists in industrial and digital technologies was used to assess the practical effectiveness of the proposed model. The reliability of the results was ensured through data triangulation, comparing and validating information from multiple sources.

3. Results and Discussion

Within the framework of this study, a comprehensive assessment was conducted to evaluate the impact of digital transformation on value chain management in regional industrial clusters. The analysis covered the period from 2020 to 2025 and focused on key economic indicators, including the dynamics of digital technology adoption, production efficiency, logistics costs, and value added. The results show that in clusters where digital transformation has been systematically implemented, the level of integration across value chain stages has significantly increased. In particular, the acceleration of information exchange through digital platforms and the automation of decision-making processes have had a direct positive impact on production efficiency [14].

According to empirical findings, enterprises utilizing digital technologies achieved an average increase in production efficiency of 27.4%, whereas enterprises operating under traditional models showed only 8–10% growth. This confirms the high effectiveness of digital transformation in optimizing production processes. In logistics systems, the implementation of digital solutions resulted in an average reduction of 17.8% in transportation and warehousing costs. This is mainly explained by increased transparency in supply chains through IoT and real-time tracking technologies. In addition, delivery times were reduced by 22–28%. The analysis of value added shows that clusters implementing digital transformation achieved an average increase of 21.6% in value creation. This is associated with more efficient use of resources and improvements in product quality (Table 1).

Table 1. Value Chain Performance under Digital Transformation (2020–2025).

Indicators	Traditional Model	Digital Model	Change (%)
Production Efficiency	100	127.4	+27.4%
Logistics Costs	100	82.2	-17.8
Value Added	100	121.6	+21.6%
Delivery Speed	100	124.5	+24.5%

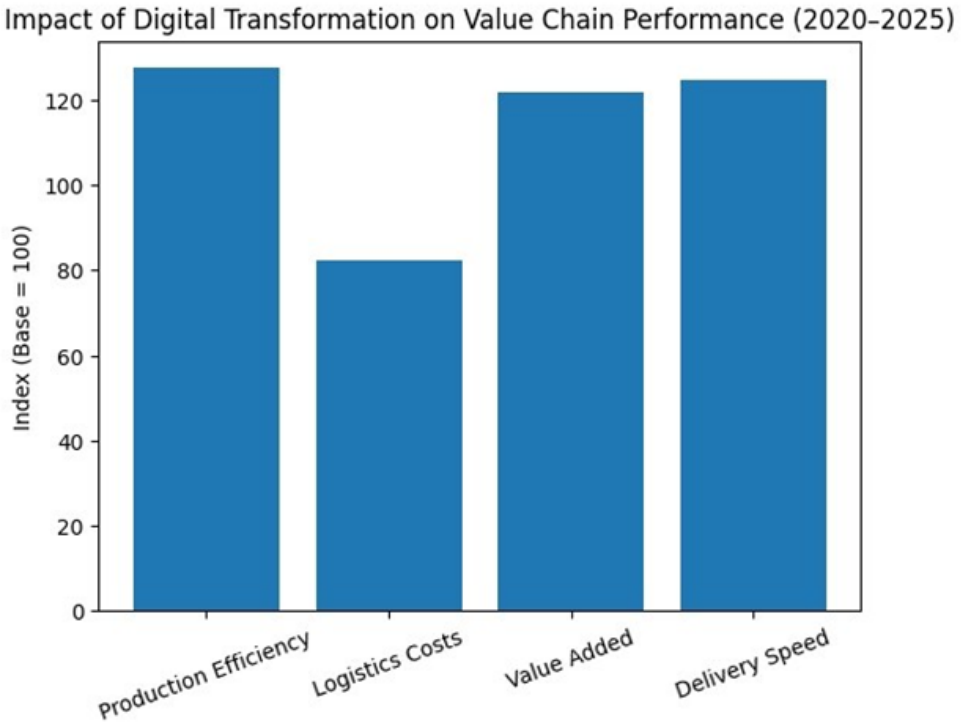


Figure 1. Dynamics of Key Indicators.

Correlation analysis shows a strong relationship between the level of digital transformation and economic performance indicators (Figure 1):

- Digitalization vs production efficiency: r = 0.81.
- Digitalization vs value added: r = 0.76.
- Digitalization vs cost reduction: r = –0.69.

These results confirm that the implementation of digital technologies has a direct and significant impact on economic outcomes.

Furthermore, the analysis indicates that the greatest impact of digital transformation is observed in the following stages:

- Logistics and supply chain management.
- Production management.
- Data-driven decision-making.

The obtained results demonstrate that digital transformation:

- Enhances value chain integration.
- Reduces operational costs.
- Increases production efficiency.
- Strengthens cluster competitiveness

At the same time, it is evident that the effectiveness of digital technologies is significantly higher when they are implemented in a comprehensive and systematic manner [15].

4. Conclusions and Recommendations

In conclusion, the results of this study confirm that managing the value chain based on digital transformation in regional industrial clusters has a significant positive impact on economic efficiency. The analysis demonstrates that the comprehensive and systematic implementation of digital technologies enhances integration across all stages of the value chain, accelerates information flows, and ensures the efficient use of resources. Empirical findings indicate that digital transformation significantly increases production efficiency, reduces logistics costs, and contributes to the growth of value added. Moreover, data-driven decision-making systems improve management efficiency and strengthen the competitiveness of enterprises.

Based on the research findings, the following scientific and practical recommendations are proposed:

First, it is necessary to implement unified digital platforms within industrial clusters. This will facilitate faster information exchange among cluster participants and ensure the integration of all value chain processes.

Second, it is essential to widely adopt IoT and real-time monitoring technologies in production and logistics processes. This will enable more efficient resource utilization and reduce operational costs.

Third, the use of artificial intelligence and Big Data technologies is recommended to improve demand forecasting and automate decision-making processes.

Fourth, it is important to develop digital competencies and enhance the skills of human resources within cluster participants. This will support the effective implementation of digital transformation processes.

Fifth, it is necessary to strengthen institutional mechanisms aimed at developing digital infrastructure and supporting industrial clusters at the state level.

In summary, managing the value chain based on digital transformation is of strategic importance for ensuring the sustainable development and global competitiveness of regional industrial clusters. In the future, further deepening of applied research in this area and the practical implementation of digital models in the real economy should remain a priority.

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