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### Abstract

Technoparks play a crucial role in fostering innovation, supporting startups, and facilitating cooperation between science and industry. In this context, logistics serves as a key factor influencing the operational efficiency and sustainability of technoparks. This article examines the role of logistics in improving the efficiency of technoparks by optimizing the movement of materials, information, and technological resources. Particular attention is given to the integration of modern logistics systems, digital platforms, and supply chain management tools that ensure timely delivery, efficient resource allocation, and effective coordination among residents. The study highlights how advanced logistics infrastructure contributes to reducing operational costs, minimizing delays, and enhancing collaboration between stakeholders. Furthermore, the article explores the impact of digital transformation on logistics processes, including the use of automation, data analytics, and smart logistics solutions. The findings demonstrate that effective logistics management strengthens the innovation environment, increases the competitiveness of technoparks, and supports sustainable development. The implementation of integrated logistics strategies is identified as a critical condition for improving overall performance and ensuring the long-term success of technoparks in the modern innovation economy.

**Keywords:** technoparks, logistics management, operational efficiency, supply chain optimization, digital logistics, innovation infrastructure

### Introduction

Technoparks have become essential elements of modern innovation ecosystems, providing favorable conditions for the development of high-tech enterprises, startups, and research institutions. They serve as platforms that facilitate cooperation between science, industry, and business, contributing to the commercialization of research results and the acceleration of technological development. In this environment largely depends on the effective organization and coordination of internal and external processes, among which logistics plays a fundamental role [1].

Logistics in technoparks involves the management of material, information, and technological flows to ensure the uninterrupted functioning of resident companies and supporting infrastructure. Efficient logistics systems enable the timely delivery of equipment, raw materials, and components, as well as the effective distribution of finished products and services. In addition, logistics supports the integration of various participants within the technopark, improving communication, coordination, and resource utilization. With the rapid development of digital technologies and increasing competition in the innovation sector, technoparks face new challenges related to operational efficiency and sustainability. The implementation of modern logistics solutions, including digital platforms, automation, and data-driven management tools, has become a necessary condition for enhancing performance and competitiveness. Effective logistics contributes to reducing operational costs, minimizing delays, and improving the overall productivity of technopark residents.

Therefore, the study of logistics and its impact on the efficiency of technoparks is highly relevant.

Understanding the role of logistics management allows technoparks to optimize their internal processes, strengthen innovation capacity, and ensure sustainable development in the context of the modern innovation economy [2].

In the era of the global knowledge economy, technoparks have emerged as pivotal engines of innovation, bridging the gap between academic research and industrial application. These specialized hubs are designed to foster high-tech entrepreneurship and facilitate the commercialization of cutting-edge technologies. However, the mere concentration of talent and capital within a geographic cluster does not guarantee success. As these ecosystems grow in complexity, the seamless integration of physical and information flows becomes a critical determinant of their overall performance [3].

This is where logistics transcends its traditional definition of transport and warehousing. In the context of a technopark, logistics acts as a strategic “circulatory system”, ensuring that resources – ranging from raw materials for prototyping to shared high-tech equipment and intellectual data – are managed with maximum precision [4]. Despite the clear importance of infrastructure, many technoparks struggle with bottlenecks related to supply chain synchronization and high operational costs, which can stifle the agility of resident startups [5].

The objective of this article is to explore how advanced logistical frameworks can enhance the efficiency of technoparks. By analyzing the synergy between supply chain management and innovation clusters, we seek to demonstrate that optimized logistics is not merely a supportive function, but a fundamental driver of competitive advantage. Through this lens, the

paper examines current challenges and proposes integrated logistical solutions aimed at accelerating the development cycle of high-tech products.

### Methodology

This study employs a mixed-methods approach to analyze the impact of logistics on technopark efficiency, combining a literature review of supply chain management with a comparative analysis of three distinct case studies. Data collection involves semi-structured interviews with industry experts, followed by the development of an integrated logistics efficiency model to evaluate the impact of “smart logistics” on reducing operational overhead.

This study is based on a comprehensive and systematic approach to analyzing the role of logistics in enhancing the efficiency of technoparks. The research applies both qualitative and analytical methods to examine logistics processes, management mechanisms, and their impact on operational performance within technopark environments.

The theoretical foundation of the study is formed through a review and analysis of scientific literature, academic publications, and analytical reports related to logistics management, innovation infrastructure, and technopark operations. This method made it possible to identify key logistics functions, principles, and modern trends influencing the efficiency of technoparks. The comparative analysis method was used to evaluate different logistics models and management approaches applied in innovation ecosystems.

In addition, the system analysis method was applied to examine technoparks as integrated systems consisting of interconnected elements, including logistics infrastructure, resident companies, digital platforms, and supply chains. This approach helped to identify the relationships between logistics processes and overall operational efficiency. The structural analysis method was used to determine the role and position of logistics within the technopark management framework.

The study also employs a logical and analytical method to assess the impact of logistics optimization, digital transformation, and supply chain coordination on technopark performance indicators such as resource utilization, operational speed, and cost efficiency.

The combination of these methods ensures a comprehensive evaluation of logistics management in technoparks and provides a reliable basis for developing practical recommendations aimed at improving their efficiency and sustainability [2].

### Main part: Logistics as a catalyst for technopark performance

Logistics plays a central role in ensuring the efficient functioning and sustainable development of technoparks. As complex innovation systems, technoparks integrate research institutions, startups, manufacturing units, and service providers within a unified infrastructure. The effectiveness of interaction among these elements largely depends on the organization of logistics processes, which coordinate the movement of material, information, and technological flows.

One of the key components of logistics in technoparks is the management of material flows. Resident companies require timely access to equipment, raw

materials, components, and technological tools for research, development, and production activities. Efficient logistics ensures uninterrupted supply, reduces downtime, and support continuous innovation processes. The availability of modern warehouses, transport systems, and distribution centers within or near technoparks significantly improves the speed and reliability of supply operations. As a result, companies can focus on their core activities without delays caused by logistical inefficiencies [6-7].

Information logistics is equally important in technopark environments. Technoparks function as networks of interconnected organizations that exchange data, research results, and technological solutions. Efficient information flow ensures proper coordination between residents, management bodies, suppliers, and external partners. The use of digital logistics platforms enables real-time tracking of resources, monitoring of supply chains, and improved communication among participants. This contributes to faster decision-making, greater transparency, and increased operational efficiency. Another important aspect is the integration of logistics into the overall management system of technoparks [8]. Logistics serves as a connecting element between infrastructure, production, innovation, and commercialization processes. Effective logistics management enables optimal allocation of resources, reduction of operational costs, and improvement of service quality. By optimizing transportation routes, minimizing storage time, and improving inventory management, technoparks can significantly increase their overall productivity.

Digital transformation has further strengthened the role of logistics in technoparks. The introduction of digital technologies such as automation systems, data analytics, cloud platforms, and smart logistics solutions allows technoparks to improve the accuracy and efficiency of logistics operations. Automated inventory management systems help reduce human error and ensure optimal stock levels. Data analytics tools allow managers to forecast demand, optimize supply chains, and identify potential inefficiencies. Digital platforms also facilitate coordination between residents and logistics service providers, improving the overall responsiveness of the system.

Efficient logistics infrastructure also enhances collaboration and innovation within technoparks. When logistics processes function effectively, companies can easily exchange materials, prototypes, and technological components. This accelerates research and development processes and promotes cooperation between different organizations. Logistics supports the creation of an integrated innovation environment where resources and knowledge can be efficiently shared. Furthermore, logistics contributes to reducing operational risks and improving sustainability. Proper planning and coordination of logistics processes help prevent delays, shortages, and disruptions. Optimized logistics systems also reduce transportation costs, energy consumption, and environmental impact. This is particularly important in modern innovation ecosystems, where sustainability and resource efficiency are key priorities [6-7].

The efficiency of technoparks can be significantly improved through the implementation of integrated logistics strategies [9]. These strategies include the development of modern logistics infrastructure, the use of digital technologies, the optimization of supply chain management, and the improvement of coordination mechanisms. A systematic logistics approach allows technoparks to operate more efficiently, support innovation activities, and enhance their competitiveness. In addition, logistics plays an important role in supporting the commercialization of innovations. Technoparks are designed not only to develop new technologies but also to bring them to the market. Efficient logistics ensures the timely delivery of prototypes, products, and technological solutions to customers and partners. This accelerates the commercialization process and increases the economic effectiveness of technoparks. Logistics is a fundamental element of technopark efficiency. It ensures the smooth functioning of operational processes, supports innovation activities, enhances coordination, and contributes to sus-

tainable development. The integration of modern logistics systems and digital technologies creates favorable conditions for improving the performance and competitiveness of technoparks in the modern innovation economy.

The transition from a general conceptual understanding of logistics to its practical application requires a granular analysis of the specific mechanisms that drive value. To understand how logistics transforms from a supporting function into a strategic asset, it is necessary to examine the multifaceted nature of technopark operations [8]. This transformation manifests through several key dimensions: the physical integration of infrastructure, the optimization of resident-specific supply chains, the adoption of cutting-edge digital solutions, and the resulting economic synergies. By deconstructing these elements, we can identify the precise levers that allow a technopark to reduce friction in the innovation cycle and achieve superior performance. The conceptual interconnection of these elements is presented in Fig.

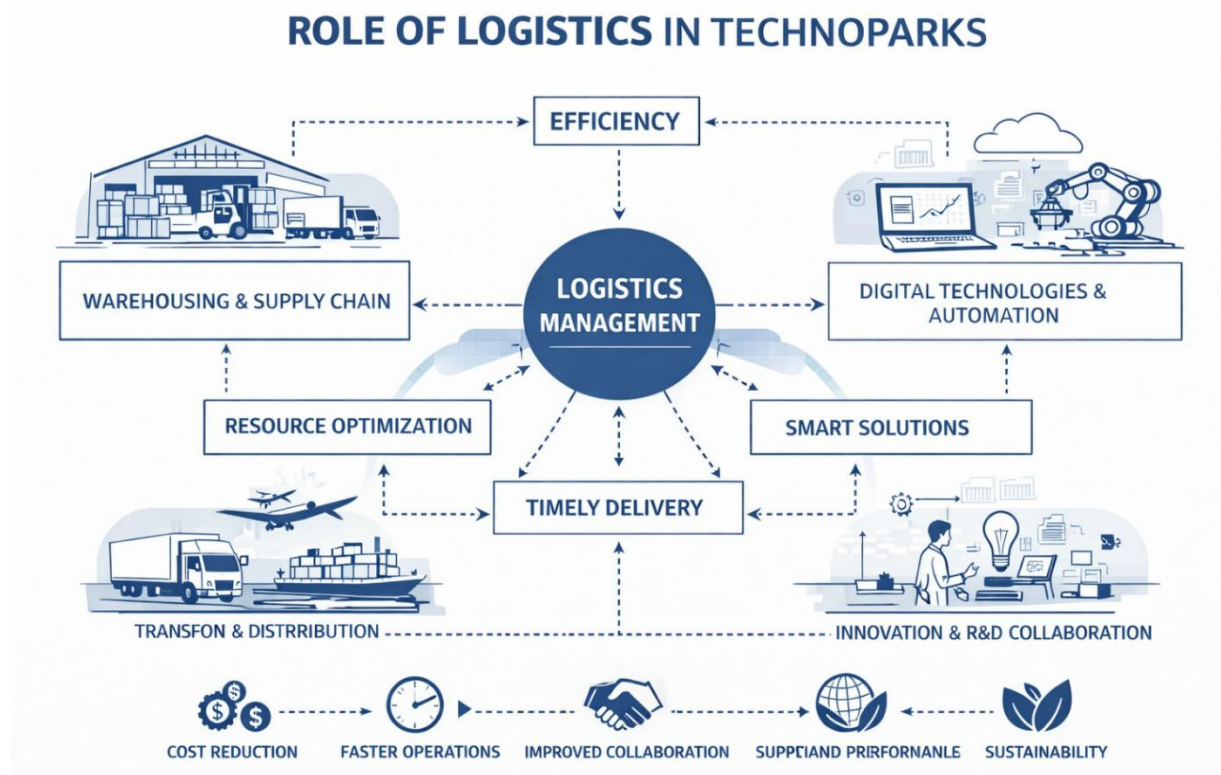


Fig. Conceptual model of logistical value drivers and their impact on technopark efficiency

The following sections detail these pillars of logistical excellence.

### 1. The strategic alignment of physical and innovation infrastructure

The efficiency of a technopark is often judged by the speed at which an idea moves from a laboratory to the market [10-11]. Logistics serves as the fundamental framework that supports this movement. Unlike traditional industrial zones, technopark logistics must handle small-batch, high-value, and time-sensitive shipments.

- **Multimodal connectivity.** Modern technoparks act as “dry ports” for innovation. Proximity to international airports and high-speed rail is not enough, the internal layout must allow for the seamless movement of

specialized equipment and hazardous materials (often used in R&D) without disrupting the work of other residents.

- **Shared resource logistics.** One of the primary value propositions of a technopark is the “shared use center”. Efficient logistics management ensures that expensive machinery (e.g., 3D printers, electron microscopes) is utilized at maximum capacity through precise scheduling and internal transport systems, reducing the capital expenditure for individual startups.

### 2. Optimization of supply chain flows for residents

For a resident company, the technopark is not just a landlord but a partner in the supply chain. The “agile”

nature of startups requires a logistical approach that can scale rapidly [2].

- Inventory management and just-in-time (JIT) delivery. By implementing a centralized warehouse system, a technopark can reduce the “dead space” within individual offices or labs [12]. A unified logistics operator within the park can consolidate orders from multiple residents, gaining leverage with suppliers and reducing delivery costs through “last-mile” optimization within the park territory.

- Reverse logistics and waste management. High-tech manufacturing often produces specific waste streams. A sophisticated logistical system manages the disposal and recycling of electronic components or chemical waste, ensuring compliance with environmental standards – a factor that increasingly impacts the “efficiency index” of modern innovation hubs.

### 3. Digital logistics and the “smart technopark” concept

In the context of Industry 4.0, the “role of logistics” shifts from moving boxes to managing data. The efficiency of a technopark is now inextricably linked to its digital infrastructure [5].

The digital twin approach. By creating a digital twin of the technopark’s logistical flows, management

can predict bottlenecks before they occur. For example, using IoT sensors to monitor the movement of goods and traffic within the park allows for real-time adjustments to loading dock schedules.

Blockchain in intellectual property logistics. While we usually think of logistics as physical, the movement of sensitive technical documentation and prototypes requires “information logistics”. Blockchain technology can be integrated into the park’s logistics platform to track the movement of prototypes, ensuring security and authenticity.

Automated internal logistics. The use of AGVs (Automated Guided Vehicles) and drones for document or small-component delivery within large-scale technoparks reduces human error and minimizes the time scientists spend on administrative “running around”, allowing them to focus on core research.

### 4. Economic impact of logistical synergy

The ultimate metric of efficiency is the reduction of the operational cost-to-revenue ratio. The relationship between lowering operational costs and increasing revenue can be optimized through specific logistics tools that directly impact financial performance. The table outlines key logistics factors, showing how they improve operational efficiency and strengthen the financial stability of the technopark.

Table

Logistics levers for increasing the efficiency of technology park residents

Logistical factor	Impact on efficiency	Economic outcome
Consolidated purchasing	Bulk shipping rates for residents	Lower R&D overheads
Cross-docking systems	Reduced storage time for components	Faster time-to-market
Automated tracking	Full visibility of the supply chain	Higher investor confidence

By centralizing these functions, the technopark creates an “economies of scale” effect that a standalone startup could never achieve. This synergy makes the technopark an attractive ecosystem, directly influencing its occupancy rates and the success rate of its graduates.

### Conclusions

The analysis shows that logistics in a technopark environment is no longer a “back-office” function. It is a strategic tool that minimizes the friction between an idea and its physical realization. Enhancing logistical efficiency directly correlates with the technopark’s ability to attract top-tier residents and accelerate technological breakthroughs.

Logistics plays a decisive role in improving the efficiency, sustainability, and competitiveness of technoparks. As integrated innovation systems, technoparks depend on the effective management of material, information, and technological flows to ensure uninterrupted operation and successful cooperation among resident companies, research institutions, and external partners. Efficient logistics enables the timely supply of resources, optimizes internal processes, and supports the continuous functioning of innovation activities.

The study has shown that well-organized logistics systems contribute to reducing operational costs, minimizing delays, and improving resource utilization. The integration of logistics into the overall management

framework of technoparks enhances coordination, increases operational transparency, and improves decision-making processes. In addition, the implementation of modern digital technologies, including automation, digital platforms, and data analytics, significantly strengthens logistics performance and allows technoparks to respond more effectively to changing operational and market conditions. Furthermore, efficient logistics infrastructure supports collaboration, accelerates innovation processes, and facilitates the commercialization of technological developments. It also contributes to improving environmental sustainability by optimizing transportation and resource consumption.

In conclusion, the development and implementation of integrated and digitally supported logistics strategies are essential for enhancing the operational efficiency and long-term success of technoparks. Effective logistics management creates favorable conditions for innovation, strengthens the competitiveness of technoparks, and supports their strategic role in the modern innovation economy.

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