

DEVELOPING AN ENHANCED MECHANISM FOR THE COMMERCIALIZATION OF INNOVATIONS IN INDUSTRY 4.0: INSIGHTS FROM URBAN INFRASTRUCTURE SOLUTIONS

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Abstract: The rapid evolution of Industry 4.0 presents significant opportunities for innovation commercialization, yet many organizations and governments struggle to effectively harness these advancements. This study examines the need for a better mechanism for innovation commercialization that addresses the challenges of Industry 4.0. Traditional commercialization models have been important in the past, but they often struggle to keep up with rapid changes in consumer behavior and technology. The research highlights key issues, such as slow responses to market changes, limited geographic reach, inefficient use of resources, disconnected operations among departments, and heavy reliance on existing customer relationships. These problems can hurt competitiveness and growth in today's fast-paced environment. To tackle these challenges, the proposed enhanced mechanism encourages more collaboration among different stakeholders, including businesses, research institutions, government agencies, and industry associations. This collaborative approach aims to create a more flexible ecosystem that supports quick decision-making, adaptable management of intellectual property, and effective use of digital platforms. By adopting this strategy, organizations can better respond to consumer needs and technological advancements, leading to greater success in commercialization. The findings of this study support existing research that emphasizes the importance of adaptability and teamwork in innovation processes. Practical recommendations include building collaborative networks, using digital marketplaces to reach more customers, and implementing flexible compliance strategies to improve innovation efforts. Looking ahead, further research is needed to find best practices for applying this enhanced mechanism across different sectors. Additionally, exploring how digital transformation affects commercialization strategies and ensuring that all stakeholders are included will be crucial for maximizing the effectiveness of this approach. This study contributes valuable insights to the discussion on innovation commercialization and offers practical advice for organizations facing the challenges of today's market.

Keywords: commercialization mechanism; innovation commercialization; Industry 4.0; smart cities; urban infrastructure.

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1. Introduction. The commercialization of innovations is vital for driving economic growth, promoting entrepreneurship, and addressing societal challenges. When organizations invest in research and development, effectively bringing new products and services to market is essential for maximizing returns on these investments. Successful commercialization transforms innovative ideas into market-ready solutions, creating jobs, stimulating local economies, and enhancing the competitive edge of businesses.

However, many organizations face significant challenges in the commercialization process. Barriers such as a lack of collaboration among stakeholders, insufficient understanding of market needs, and ineffective resource allocation can hinder success. These issues highlight the need for strong mechanisms that support the journey from concept to market. Such mechanisms can streamline processes, improve communication between research institutions and industry partners, and provide structured guidance for navigating the complexities of commercialization.

Additionally, effective commercialization mechanisms help organizations identify and protect their intellectual property (IP), ensuring their innovations are safeguarded against competition. By establishing clear strategies for entering the market and engaging customers, organizations can better meet consumer demands and seize emerging opportunities.

As industries evolve and new technologies emerge in an increasingly interconnected global economy, the demand for enhanced commercialization mechanisms becomes more urgent. Organizations must adapt their approaches to innovation commercialization to remain competitive. This article will examine the importance of innovation commercialization, the barriers to its success, and the mechanisms needed to overcome these challenges, ultimately contributing to a more dynamic and sustainable economic landscape.

2. Literature Review.

The commercialization of innovations is increasingly recognized as a critical factor for entrepreneurial success and economic development, particularly within the framework of Industry 4.0. This literature review synthesizes current research findings, highlights key contributions, and identifies unresolved issues related to the commercialization of innovations in urban infrastructure management.

The increasing complexity of this process in Industry 4.0 has garnered significant research interest. For instance, Avimanyu Datta, Debmalya Mukherjee and Len Jessup (Datta et al., 2014) and Kateryna Shevchenko, Liudmyla Saher and Anastasiia Shymoshenko (Shevchenko et al., 2022) emphasize that commercialization encompasses various entrepreneurial activities, including sourcing innovations, market entry strategies, and the protection and deployment of new technologies. It involves transforming research results into marketable products, a process fraught with challenges for companies (Poltoratska et al., 2021).

Commercialization of intellectual property is one of the more extensively researched topics, as industries seek ways to maximize returns on innovations. Intellectual property (IP) protection is essential for safeguarding innovations and facilitating technology transfer in the Industry 4.0 environment (Villafaña-Díaz & Lezama-de la Rosa, 2020; Chandra & Liaqat, 2019). However, local barriers and restrictions on licensing activities can impede IP commercialization efforts (Chandra & Liaqat, 2019). To navigate these challenges, SMEs must develop new strategies that prioritize strategic planning and marketing activities (Villafaña-Díaz & Lezama-de la Rosa, 2020). Additionally, business models play a crucial role in promoting sustainable innovations, particularly in sectors like energy (Sabatini et al., 2021). The intersection of innovation commercialization and internationalization is still in its early stages but shows an upward trend in research development (Bracio & Szarucki, 2019).

Despite the growing body of research, the field remains fragmented across disciplines (Shevchenko et al., 2022). Commercialization acts as an intermediary between scientific development and market value creation (Shevchenko et al., 2022). In Ukraine, for instance, the decline in innovative enterprises highlights significant challenges in innovation commercialization (Shevchenko et al., 2022). A comprehensive approach that considers all stakeholders' interests is necessary to develop effective commercialization strategies.

The intersection of commercialization and technology transfer also requires further exploration. While both processes are related, they should be viewed as distinct within the broader innovation landscape (Plahotnik, 2015). The lack of a comprehensive methodology for implementing commercialization mechanisms poses additional obstacles to fostering an innovative economy in Ukraine (Plahotnik, 2015).

The COVID-19 pandemic has exacerbated existing challenges in commercialization processes (Gregori, 2021). As companies establish new departments focused on Industry 4.0 innovations to remain competitive, there is a pressing need for innovative strategies to accelerate technology commercialization and transfer (Poór & Basl, 2020; Villafaña-Díaz & Lezama-de la Rosa, 2020).

Industry 4.0 technologies have transformative potential across various sectors, particularly in urban infrastructure management. These technologies offer significant opportunities for creating more sustainable, efficient, and resilient cities while advancing progress toward Sustainable Development Goals (Niesheva et al., 2023). The integration of these technologies facilitates the development of innovation ecosystems that empower small and medium-sized enterprises (SMEs) to co-create solutions. As Guilherme Brites Benitez, Néstor Fabián Ayala and Alejandro G. Frank (Benitez et al., 2020) note, this evolution shifts the focus from merely accessing innovation funds to establishing platform-driven structures that foster smart business solutions.

In conclusion, while significant strides have been made in understanding the commercialization of innovations within Industry 4.0, further research is needed to address existing gaps and develop comprehensive frameworks that can guide various types of projects including urban infrastructure projects toward successful market implementation. Future studies should focus on integrating various themes of entrepreneurial activities to advance understanding of innovation commercialization processes.

3. Methodology and research methods

The following study aims to explore the commercialization processes of innovations within the context of Industry 4.0, particularly focusing on urban infrastructure management. The research is grounded in a theoretical framework that integrates insights from innovation theory, technology transfer models, and entrepreneurial frameworks, allowing for a comprehensive examination of the commercialization landscape.

This methodology has both positive and negative aspects. On the positive side, it enables the synthesis of existing literature to identify gaps and trends in the field, thereby enhancing the validity of findings through comprehensive analysis. However, challenges arise from relying solely on secondary data, which may limit the depth of insights compared to primary data collection methods.

Data for this study were collected exclusively from existing online articles, publications, and reports relevant to commercialization of innovations, Industry 4.0 and urban infrastructure. The methods employed include literature review, content analysis and case studies.

The empirical basis for this study includes a wide range of literature focusing on Industry 4.0 technologies, urban infrastructure management, and innovation commercialization processes. Key sources comprise peer-reviewed journals, industry reports, and governmental publications that provide insights into current practices and challenges.

Several limitations were noted in this study:

1. **Access to Data:** The reliance on secondary data sources may lead to gaps in information that could be addressed through primary data collection.
2. **Generalizability:** The findings may not be universally applicable across all sectors or regions due to variations in local contexts and regulatory environments.
3. **Fragmentation:** The existing literature on this topic is fragmented across disciplines, which may affect the coherence of synthesized findings.

By relying on a comprehensive literature review and content analysis approach, the research aims to yield robust findings that contribute valuable insights into the commercialization of innovations in Industry 4.0 within urban infrastructure contexts.

4. Results.

The commercialization of innovations refers to the structured process of transforming new ideas, products, or services into profitable ventures (Andrushkiv & Ratych, 2022). This process goes beyond simple invention; it requires the development of strategic plans for production, marketing, distribution, and scaling, all aimed at delivering value to consumers and ensuring a return on investment (Shevchenko et al., 2022). In the fast-paced technological landscape of today, effective commercialization is essential as it enables organizations to turn creative concepts into tangible products that fulfil market demands, provide competitive advantages, and stimulate economic growth.

Industry 4.0, commonly known as the Fourth Industrial Revolution, represents a significant shift characterized by the integration of advanced digital technologies into manufacturing and other sectors (Tay et al., 2018). This encompasses a wide range of innovations, including the Internet of Things (IoT), artificial intelligence (AI), robotics, big data analytics, and blockchain technology (Patil et al., 2018). The aim of Industry 4.0 is to establish "smart" factories and ecosystems where devices, systems, and individuals interact in real-time to promote highly responsive, efficient, and optimized operations (Karpagavalli, 2019). This revolution signifies the merging of physical and digital realms, leading to self-organizing and adaptable systems capable of continuous improvement.

The interplay between commercialization and Industry 4.0 presents both opportunities and challenges. On one hand, Industry 4.0 technologies foster unprecedented innovations with significant potential across various sectors such as urban infrastructure, healthcare, manufacturing, and logistics. Conversely, these innovations are complex and demand substantial investment, regulatory adjustments, and ecosystem development to successfully reach the market.

The commercialization of Industry 4.0 innovations requires new approaches and mechanisms because traditional models may not adequately address the interconnected, data-driven, and collaborative nature of these technologies. For example, an AI-driven smart city solution depends on data from multiple stakeholders—such as public transportation systems, local governments, telecommunications networks, and end-users—leading to unique challenges related to intellectual property (IP), regulatory compliance, and interoperability.

These challenges can be categorized into several key areas: regulatory and policy barriers; financial constraints and investment risks; interoperability and technical compatibility issues; and limited public-private partnerships. Addressing each of these challenges is crucial for the successful implementation and scaling

of innovative solutions in urban environments. These categories are further illustrated in Table 1, which outlines their specific applications to urban infrastructure.

One major challenge in commercializing Industry 4.0 innovations is navigating the complex regulatory landscape. Regulations often fail to keep pace with technological advancements, creating uncertainties for companies aiming to implement new technologies. Compliance with safety standards, data privacy laws, and environmental regulations can be burdensome and may necessitate significant adjustments to existing business practices (Sabatini et al., 2020). Furthermore, inconsistent regulations across different regions can impede the deployment of solutions that are effective in one area but face legal hurdles in another. Organizations must collaborate with policymakers to advocate for regulatory frameworks that encourage innovation while ensuring public safety. Such collaboration can foster an environment conducive to experimentation and adaptation, facilitating quicker implementation of Industry 4.0 technologies.

Financial constraints also pose a significant barrier to the commercialization of Industry 4.0 innovations. The initial investment needed to adopt advanced technologies—like IoT devices and AI systems—can be considerable, especially for small and medium-sized enterprises (SMEs). Many SMEs find it challenging to secure necessary funding due to limited access to capital markets or venture capital sources.

Table 1. Challenges in the Commercialization of Industry 4.0 Innovations for Urban Infrastructure

Challenge Category	Description
Regulatory and Policy Barriers	The regulatory landscape often fails to keep pace with technological advancements, leading to uncertainties regarding compliance with safety, data privacy, and environmental regulations. Inconsistent regulations across regions can further complicate the deployment of innovative solutions.
Financial Constraints and Investment Risks	High initial costs associated with adopting Industry 4.0 technologies, such as IoT systems and specialized machinery, can be prohibitive, particularly for small and medium-sized enterprises (SMEs). Additionally, uncertainty around return on investment (ROI) complicates funding decisions.
Interoperability and Technical Compatibility Issues	Achieving seamless integration between new technologies and existing legacy systems poses significant challenges. Many urban infrastructure projects rely on a variety of systems that must work together, but the lack of standardized protocols can lead to operational inefficiencies.
Limited Public-Private Partnerships	Effective public-private partnerships (PPPs) are essential for advancing the commercialization of innovations; however, many regions experience insufficient collaboration between public entities and private companies, limiting opportunities for resource sharing and knowledge exchange.
Workforce Skills Gap	The transition to Industry 4.0 requires a workforce skilled in digital systems, automation, and data analysis. A global shortage of qualified personnel hampers the widespread adoption of these technologies, making it difficult for organizations to implement innovative solutions effectively.

Sources: developed by the authors

The uncertainty surrounding return on investment (ROI) is a significant challenge for businesses contemplating investments in new technologies. Companies are required to perform comprehensive cost-benefit analyses to justify their spending; however, accurately predicting ROI can be difficult due to rapidly changing market conditions and technological advancements. To mitigate these financial risks, businesses may need to explore a variety of funding sources, such as government grants or partnerships with larger firms that can provide financial support. Additionally, projects that serve public interests often rely on public funding, which can be limited or diverted to address other urgent needs, particularly in resource-constrained cities.

Interoperability among various technologies is essential for the effective implementation of Industry 4.0 solutions. Many urban infrastructure projects depend on multiple systems that must function together seamlessly, including the integration of legacy systems with new technologies. However, achieving compatibility between different platforms can be a complex process that demands considerable investment in both time and resources. Furthermore, the absence of standardized protocols across devices and systems can result in inefficiencies and increased costs during implementation. Organizations must prioritize the development of solutions that are not only innovative but also compatible with existing infrastructure to prevent disruptions during the transition phase.

Public-private partnerships (PPPs) are vital for facilitating the commercialization of innovations in urban infrastructure. Unfortunately, many regions face limited collaboration between public entities and private

companies. This lack of cooperation can lead to missed opportunities for sharing resources, knowledge, and expertise necessary for successful project execution. Establishing effective PPPs requires a commitment from both parties to align their goals and objectives towards shared outcomes. Governments should create incentives for private sector involvement while ensuring transparency and accountability in these partnerships. By fostering an environment conducive to collaboration between public and private sectors, cities can leverage Industry 4.0 innovations more effectively.

Overall, the commercialization of Industry 4.0 innovations across various sectors, including urban infrastructure, faces significant challenges that must be addressed through strategic planning and collaboration among stakeholders. Regulatory barriers require careful navigation; financial constraints call for innovative funding solutions; interoperability issues necessitate standardized approaches; and limited public-private partnerships demand stronger collaborative frameworks. By proactively tackling these challenges, businesses can improve their ability to successfully commercialize innovative solutions that contribute to building smarter cities and enhancing urban infrastructure management. Future research should focus on identifying best practices for overcoming these barriers while exploring new collaboration models that leverage the strengths of both public and private sectors in the context of Industry 4.0 advancements.

Within the scope of this article, we propose an enhanced mechanism of innovation commercialization that emphasizes collaboration, strategic intellectual property (IP) management, the utilization of digital platforms, agile regulatory compliance, and sustainable financing models as essential strategies to overcome these challenges. The proposed enhanced mechanism for innovation commercialization is designed to address the challenges associated with bringing Industry 4.0 innovations to market. Below is an explanation of each component of the mechanism (see Table 2 for detailed actions):

1. Collaborative Ecosystem Development: This component emphasizes the importance of building partnerships among different groups, such as businesses, universities, government agencies, and industry organizations. By forming "innovation hubs," these groups can share resources and knowledge, which helps speed up the development of new ideas and solutions. Working together in these networks improves problem-solving skills and strengthens the support system needed for successful commercialization.
2. Adaptive Intellectual Property (IP) Strategy: An adaptive IP strategy is important in the fast-changing world of Industry 4.0. This means creating flexible rules to protect new ideas and inventions, including patents, copyrights, and trade secrets. Training on how to manage IP effectively helps organizations protect their innovations while still collaborating with others. This flexibility is crucial for dealing with the unique challenges that come with digital technologies.
3. Utilization of Digital Marketplaces and Platforms: Digital marketplaces provide a great chance for businesses to reach more customers without spending a lot of money upfront. By using platforms like Amazon or specialized industry sites, organizations can effectively showcase their products and services. These platforms also offer tools that help companies analyze customer behavior, which can guide product development and marketing strategies.
4. Agile Regulatory Compliance Framework: Agile regulatory compliance means being able to quickly adjust to changing laws and regulations related to Industry 4.0 technologies. Traditional compliance methods can be slow and may hinder innovation. By adopting flexible compliance strategies, organizations can respond faster to new legal requirements without disrupting their operations. This adaptability encourages them to experiment with new technologies and business models.
5. Sustainable Financing and Funding Models: Sustainable financing models are essential for supporting the commercialization of innovations, especially for small and medium-sized enterprises (SMEs) that may face financial challenges. Organizations should look for various funding options beyond traditional venture capital, such as government grants, public-private partnerships (PPPs), crowdfunding, and impact investments. These diverse funding sources can provide the necessary capital for research and development efforts that align with sustainability goals.
6. Interoperability Standards Development: Interoperability is crucial for successfully implementing Industry 4.0 solutions. Working with standards organizations to create interoperability guidelines ensures that different technologies can work together smoothly. Promoting open-source platforms helps integrate older systems with new technologies, reducing inefficiencies and costs during implementation.
7. Continuous Learning and Adaptation: Continuous learning is key for organizations that want to innovate effectively in a rapidly changing environment. Creating feedback loops allows stakeholders to share lessons learned from commercialization efforts while encouraging ongoing training on new technologies. Regularly assessing how well the commercialization mechanism is working helps organizations make necessary adjustments based on input from stakeholders and changes in the market.

By implementing this enhanced mechanism for innovation commercialization, organizations can effectively tackle the challenges associated with bringing Industry 4.0 innovations to market. The focus on collaboration through ecosystems, adaptive IP strategies, digital platforms, agile compliance models, sustainable financing sources, interoperability standards, and continuous learning creates a comprehensive

approach that promotes innovation and supports economic growth across various sectors impacted by Industry 4.0 advancements.

This collaborative approach not only helps individual businesses succeed but also contributes positively to broader societal goals by addressing complex challenges through shared efforts among diverse stakeholders.

Table 2. Proposed Mechanism for Innovation Commercialization in Industry 4.0

Component	Objective	Actions
1. Collaborative Ecosystem Development	Foster a collaborative environment among stakeholders.	Form partnerships between businesses, universities, government agencies, and industry groups. Create innovation hubs or clusters for networking and sharing resources. Organize workshops and forums to share knowledge.
2. Adaptive Intellectual Property (IP) Strategy	Protect innovations while enabling collaboration.	Develop flexible strategies for intellectual property (IP) protection, including patents, copyrights, trade secrets, and licensing agreements. Offer training for small and medium-sized enterprises (SMEs) on how to manage IP effectively. Set guidelines for sharing IP among partners in collaborative projects.
3. Utilization of Digital Marketplaces and Platforms	Enhance visibility and access to markets.	Use online marketplaces to reach a wider audience. Utilize digital tools to engage customers and analyze data. Encourage participation in online competitions to attract investors.
4. Agile Regulatory Compliance Framework	Streamline compliance processes to keep pace with technology.	Implement flexible compliance models that allow quick adjustments to regulations. Form a regulatory advisory group to provide guidance on compliance issues. Create a centralized platform for sharing updates on regulations.
5. Sustainable Financing and Funding Models	Secure diverse funding sources for innovation projects.	Look for alternative funding sources such as government grants and crowdfunding. Establish public-private partnerships (PPPs) for projects that serve the public interest. Create a funding consortium to support promising innovations.
6. Interoperability Standards Development	Ensure compatibility among various technologies and systems.	Work with standards organizations to create interoperability standards that ensure different technologies can work together smoothly. Promote open-source platforms to help integrate older systems with new technologies. Conduct pilot projects to test how well interoperability solutions work in practice.
7. Continuous Learning and Adaptation	Foster a culture of innovation and responsiveness.	Set up feedback loops to share lessons learned from commercialization efforts. Encourage ongoing training programs focused on new technologies. Regularly evaluate how well the commercialization mechanism is working and make adjustments as needed.

Sources: developed by the authors

5. Discussion

The enhanced mechanism for innovation commercialization is tailored to tackle the specific challenges organizations face in the fast-changing world of Industry 4.0. By encouraging collaboration among businesses, research institutions, government agencies, and industry groups, this mechanism builds a supportive environment that speeds up the creation of new solutions. The flexible approach to intellectual property (IP) allows organizations to protect their inventions while still working together effectively. Additionally, using digital marketplaces helps businesses reach more customers and understand what they want. Overall, this mechanism improves problem-solving skills and supports successful commercialization.

Traditional commercialization models have been the backbone of many industries, relying on methods like face-to-face interactions and localized marketing. While these models have their strengths, they also have significant limitations that highlight the need for a better approach to innovation commercialization.

One major limitation is the slow response to market changes. Traditional models often struggle to adapt quickly to shifts in what consumers want and to new technologies. This slow reaction can lead to missed

opportunities and reduced competitiveness, as businesses may not be able to change direction effectively when the market evolves.

Additionally, many traditional businesses operate in confined geographic areas, which limits their ability to reach a wider audience. This restriction can hinder growth and make it difficult for these businesses to expand beyond their local communities.

Another issue is inefficient resource use. Traditional models may not make the best use of available resources, leading to wasted time and effort in product development and market entry. Sticking to old methods can prevent businesses from optimizing their operations and taking advantage of new opportunities.

Moreover, traditional commercialization often leads to siloed operations, where different departments—like research and development, marketing, and sales—do not work together effectively. This lack of communication can result in poor coordination and missed chances for better performance.

Finally, there is a dependence on established relationships. Traditional models rely heavily on existing customer connections, which may not be enough in a fast-changing market where new competitors can disrupt established players. As consumer needs change, businesses that focus too much on their current customers may find themselves at a disadvantage.

In contrast, the proposed enhanced mechanism emphasizes agility and flexibility. It allows organizations to quickly adapt to market shifts and regulatory changes by using digital platforms and promoting collaboration among stakeholders. This approach enables a faster response to consumer needs and technological advancements, giving organizations a better chance to succeed in a competitive market.

By addressing the limitations of traditional commercialization models—such as slow adaptability, limited reach, inefficient resource use, siloed operations, and reliance on established relationships—the proposed mechanism creates an environment that supports innovation. It encourages collaboration among businesses, research institutions, government agencies, and industry associations, ultimately leading to more effective commercialization of innovations in today's dynamic landscape.

For those involved in urban infrastructure projects, the enhanced mechanism offers many advantages. Collaborative networks can improve resource sharing and knowledge exchange, leading to better project outcomes. The emphasis on adaptive IP strategies ensures that innovations are protected while still allowing for partnerships that can boost project success. Furthermore, using digital marketplaces helps stakeholders reach more people and attract investment more easily. This mechanism encourages a more unified approach to urban infrastructure development, promoting sustainable solutions that address community needs.

Despite its strengths, the enhanced mechanism has limitations that need further investigation. For example, relying on digital platforms may leave out stakeholders who do not have access to technology or lack digital skills. Additionally, while agile regulatory compliance is helpful, it might create inconsistencies in how regulations are enforced across different regions or sectors. Future research should focus on finding best practices for applying this mechanism in various contexts and exploring ways to include all stakeholders in innovation commercialization. This research could help refine the mechanism further and improve its effectiveness across different industries.

This discussion emphasizes the potential benefits of the enhanced mechanism for innovation commercialization while recognizing its limitations and the need for ongoing research to optimize its use in real-world situations.

6. Conclusions.

This study has explored the need for an enhanced mechanism for innovation commercialization in the context of Industry 4.0, highlighting the limitations of traditional commercialization models. Key findings reveal that traditional approaches often struggle with slow responses to market changes, limited geographic reach, inefficient resource utilization, siloed operations, and a heavy reliance on established customer relationships. These challenges can hinder competitiveness and growth in a rapidly evolving marketplace.

In contrast, the proposed enhanced mechanism emphasizes collaboration among businesses, research institutions, government agencies, and industry associations. By fostering a supportive ecosystem that promotes agile practices, adaptive intellectual property strategies, and the use of digital platforms, organizations can better respond to consumer needs and technological advancements. This approach not only enhances problem-solving capabilities but also positions organizations for greater success in a competitive landscape.

The findings of this study align with existing literature on the importance of collaboration and adaptability in innovation processes, confirming that a more integrated approach can lead to improved commercialization outcomes. Recommendations for implementation include developing collaborative networks, utilizing digital marketplaces, and adopting agile regulatory compliance models to enhance innovation efforts. Looking ahead, further research is needed to explore best practices for implementing this enhanced mechanism across diverse contexts and industries. Investigating the impact of digital transformation on commercialization processes and identifying strategies for inclusivity among all stakeholders will be crucial for optimizing this approach. By continuing to refine our understanding of innovation commercialization in the context of Industry 4.0, we can better equip organizations to thrive in an increasingly complex and dynamic environment.

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РОЗРОБКА ВДОСКОНАЛЕННОГО МЕХАНІЗМУ ДЛЯ КОМЕРЦІАЛІЗАЦІЇ ІННОВАЦІЙ В ІНДУСТРІЇ 4.0: ОГЛЯД РІШЕНЬ ДЛЯ МІСЬКОЇ ІНФРАСТРУКТУРИ

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Швидка еволюція Індустрії 4.0 відкриває значні можливості для комерціалізації інновацій, але багато організацій і урядів не здатні ефективно використовувати ці досягнення. У цьому дослідженні розглядається потреба в кращому механізмі комерціалізації інновацій, який би відповідав викликам Індустрії 4.0. Традиційні моделі комерціалізації були актуальними в минулому, але їм часто важко відповідати швидким змінами в поведінці споживачів і технологіях. Дослідження висвітлює їх ключові проблеми, такі як повільна реакція на зміни ринку, обмежене географічне охоплення, неефективне використання ресурсів, роз'єднаність операцій між відділами та сильна залежність від існуючих відносин із клієнтами. Ці проблеми можуть зашкодити конкурентоспроможності та зростанню в сучасному швидкоплинному середовищі. Щоб подолати ці виклики, запропонований авторами розширений механізм заохочує до більшої співпраці між різними зацікавленими сторонами, включаючи підприємства, дослідницькі установи, державні установи та промислові асоціації. Цей спільний підхід спрямований на створення більш гнучкої екосистеми, яка підтримує швидке прийняття рішень, адаптоване управління інтелектуальною власністю та ефективне використання цифрових платформ. Застосовуючи цей механізм, організації зможуть краще реагувати на потреби споживачів і технологічний прогрес, що призведе до більшого успіху в комерціалізації. Результати цього дослідження підтверджують існуючі дослідження, які підкреслюють важливість адаптивності та командної роботи в інноваційних процесах. Практичні рекомендації включають створення мереж для співпраці, використання цифрових ринків для охоплення більшої кількості клієнтів і впровадження гнучких стратегій відповідності для покращення інноваційних зусиль. Заглядаючи вперед, важливо відмітити необхідність подальших досліджень, щоб знайти найкращі практики застосування цього вдосконаленого механізму в різних секторах. Крім того, вивчення того, як цифрова трансформація впливає на стратегії комерціалізації та забезпечення залучення всіх зацікавлених сторін, буде вирішальним для досягнення максимальної ефективності цього підходу. Це дослідження вносить цінну інформацію в дискусію про комерціалізацію інновацій і пропонує практичні поради для організацій, які стикаються з викликами сучасного ринку.

Ключові слова: механізм комерціалізації; комерціалізація інновацій; Індустрія 4.0; розумні міста; міська інфраструктура.