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Tokenized Innovation as a Solution for National Innovation System Failures

الابتكار المجزأ كحل لفشل النظام الوطني للابتكار

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Abstract:

This study examines patenting patterns contributing to innovation system failure and proposes a blockchain-based solution to support innovation-related sustainable development goals. Using patent landscape and network analyses, we investigate invention features, assess actor synergy, and identify concerning patenting patterns. The results show patents are more likely to be inactive when granted for non-competitive technologies with low originality scores. Problematic patterns include closed technology transfer, weak collaborative ties, and network disconnects. To address intellectual property rights management limitations, we propose tokenizing the system through blockchain technology. We introduce a blockchain-based rewards system to enable mutually beneficial relationships for IP stakeholders in innovation-oriented activities. This research enhances our understanding of innovation system theory and demonstrates how analyzing patenting patterns can inform policy to achieve innovation-related SDGs.

Keywords: Blockchain Technology; Innovation system failure; Intellectual property rights; National innovation system; Tokenization; SDGs.

Jel Classification Codes: O31, O34, O38, L86.

الملخص:

تتناول هذه الدراسة أنماط براءات الاختراع التي تسهم في فشل نظام الابتكار وتقترح حلاقائما على تقنية البلوكتشين لدعم أهداف التنمية المستدامة المتعلقة بالابتكار. باستخدام تحليلات المشهد البرائي والشبكات. أظهرت النتائج أن براءات الاختراع من المرجح أن تكون غير نشطة عندما تمنح لتقنيات غير تنافسية ذات درجات أصالة منخفضة، ونقترح تحويل النظام إلى رموز من خلال تقنية البلوكتشين في الأنشطة المعنية بالابتكار لتمكين علاقات تعود بالنفع المتبادل لمستثمري الملكية الفكرية في الأنشطة الموجهة نحو الابتكار.

الكلمات المفتاحية: تقنية البلوكتشين؛ فشل نظام الابتكار؛ حقوق الملكية الفكرية؛ نظام الابتكار الوطني؛ التحويل إلى رموز؛ أهداف التنمية المستدامة.

تصنيف JEL : O31، O34، O38، L86.

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1. Introduction:

Innovation is increasingly recognized as a collaborative process, involving a network of diverse actors, including firms, universities, research institutions, and government agencies (Wu et al., 2020). These synergistic relationships are vital for driving technological advancements and economic growth, contributing to the development of new products, industries, and jobs. A well-functioning innovation system is crucial for achieving global sustainable development goals, particularly SDG-9, which focuses on building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation (Fernandes et al., 2022).

The role of intellectual property rights (IPRs) within this system is critical, as they facilitate the transfer of knowledge from universities to the private sector for commercial exploitation. However, current IPR management systems are plagued by significant challenges, including high patent fees, complex legal procedures, and substantial commercial risks (Alnafrah & Bogdanova, 2019). These barriers often lead to innovation system failures, characterized by costly and unproductive patenting patterns that stall technological progress and economic development.

This study argues that these systemic shortcomings contribute to patenting behaviours that undermine national and regional innovation systems, hindering progress toward sustainable development (Cirera & Maloney, 2017). While some solutions have been proposed from legal and technical perspectives (Auriol et al., 2023), a comprehensive approach addressing the root causes of innovation system failures remains absent.

To address these challenges, we propose a blockchain-based solution aimed at revolutionizing the IPR management framework. Blockchain technology, with its decentralized and transparent nature, offers the potential to overcome existing inefficiencies by facilitating more effective collaboration between universities and the private sector. By tokenizing the IPR system, this approach seeks to create a more equitable and efficient platform that incentivizes innovation and aligns closely with sustainable development objectives. Ultimately, this proposed solution not only addresses the immediate shortcomings of the current IPR system but also sets the stage for a more dynamic and resilient innovation ecosystem, essential for achieving long-term sustainable development.
To guide this investigation, the main research question is:
How can a blockchain-based tokenization approach address the limitations of current intellectual property rights management systems, and what benefits does it offer for sustainable development?

2. Literature review:

The assessment of innovation institutions within broader systems has long been recognized as complex and challenging. Scholars have argued that a focus on specific institutional frameworks, particularly those governing innovation, provides clearer insights into their effectiveness (Papageorgiadis & McDonald, 2019). Within national innovation systems, the intellectual property rights (IPRs) system plays a pivotal role in the commercialization of ideas, acting as a crucial

sub-system that organizes the contractual relationships among various actors, including firms, universities, and government agencies (Gargate & Momaya, 2018).

The evolution of the national innovation system perspective, as conceptualized by (Freeman, 1982) emphasizes the importance of interactions between actors and institutions in fostering innovation. Effective innovation outcomes are contingent upon the coherence of policies, institutional arrangements, and the capabilities of these actors (Fagerberg et al., 2009). Within this context, the triple helix model proposed by (Leydesdorff & Etzkowitz, 1998) underscores the synergistic relationships between academia, industry, and government, which are vital for technology transfer and patent licensing. However, the current IPR management system is fraught with inefficiencies that undermine its potential to support innovation. High costs associated with patenting, lengthy processing times, and inadequate search capabilities are significant barriers that hinder the system's effectiveness (Alnafrah, 2019). These issues are further exacerbated by a lack of trust, transparency, and efficiency within the system, leading to a prevalence of inactive or "dead" patents, which reflect unproductive innovation efforts (Park et al., 2023).

Moreover, the literature highlights that collaboration among actors within the innovation system is essential for driving technological diversification and reducing the likelihood of patents becoming inactive. Collaboration facilitates the pooling of diverse expertise and resources, leading to more innovative and competitive technological advancements (Aldieri et al., 2019). Effective collaboration also enhances resource utilization and knowledge sharing, which are crucial for overcoming the challenges of patent inactivity and ensuring that innovations reach the market (Hsieh, 2013).

The shortcomings of the current IPR management system have broader implications for the overall innovation ecosystem. These inefficiencies not only contribute to innovation system failures but also impede progress toward achieving sustainable development goals, particularly in the context of emerging economies. Addressing these challenges requires a comprehensive approach that goes beyond legal and technical fixes to tackle the underlying issues within the system.

3. Data and Methodology:

This study examines patent applications and granted patents from Russian universities between 2010 and 2022. Universities are selected due to their role as intermediaries between research and industry, crucial for national innovation systems. Our primary data source is the Orbit Questel database, encompassing 9323 patent documents. We focus on the top 20 Russian universities to explore diverse innovation patterns and address issues in intellectual property rights (IPRs) management. The methodology involves two key steps:

- **Patent Landscape Analysis:** Identifies invention features such as technological domains, legal status, and collaboration.
- **Network Analysis:** Examines patent joint ownerships to assess collaboration and synergy using parameters like degree centrality, closeness

centrality, betweenness centrality, and network modularity. Key formulas include:

Degree Centrality: $C_D(v_i) = \sum_{j=1}^{n} d(v_i, v_j)$

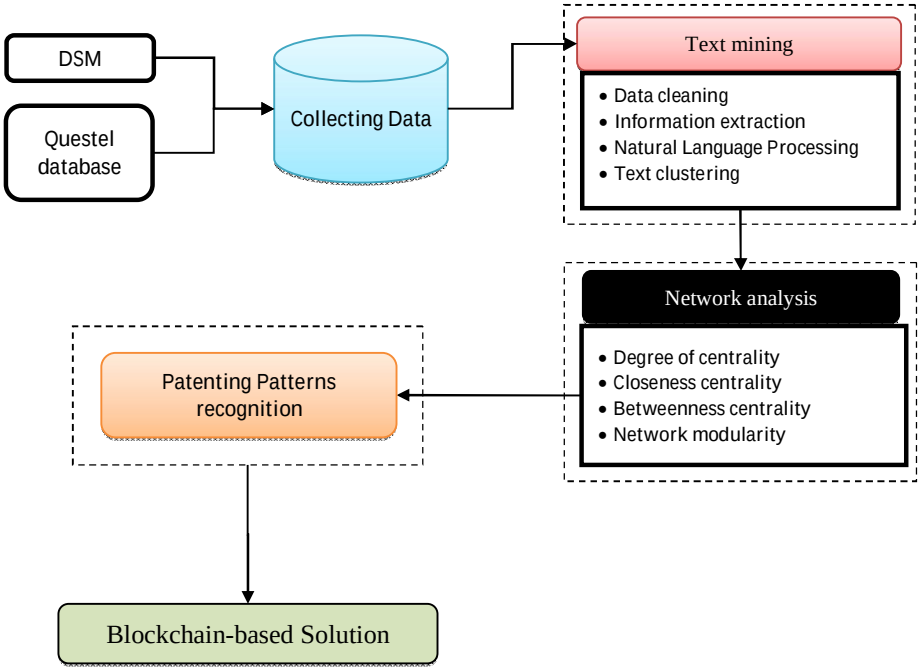
Closeness Centrality: $C_C(v_i) = \frac{N-1}{\sum_{j=1}^{n} d(v_i v_j)}$

Betweenness Centrality: $C_B(v_i) = \sum_{j<k} g_{jk}(v_i)/g_{jk}$

Network Modularity: $M = \frac{1}{2m}\sum_{ij}\left(A_{ij} - \frac{v_i v_j}{2m}\right)\sum_i \delta(c_v, i)\delta(c_j, i)$

Text mining techniques, including data cleaning, information extraction, and text clustering are used to process and analyze patent documents. To address identified issues in the IPRs management system, we propose a blockchain-based solution. Blockchain technology offers a decentralized and secure method for managing transactions, enhancing trust, and improving resource allocation within the innovation system. We analyze the current system to develop a new model, addressing key questions about system actors, stakeholder benefits, and institutional frameworks, as illustrated in Figure 1.

Figure 1. Methodology Workflow (Source: Author)



4. Analysis of the results:

The study analyses 9323 patent documents from Russian universities. Figure 2 shows a growth in patent applications from 2010 to 2022, driven by increased R&D funding and portfolio development. However, a sharp decline from 2015 is attributed to structural changes in federal budget priorities and the 2013-2020 state program, which shifted focus to applied research. The decline

from 2016-2018 correlates with Russia's financial crisis and economic sanctions impacting R&D funding.

Figure 2. Patenting trend (Source: Author)

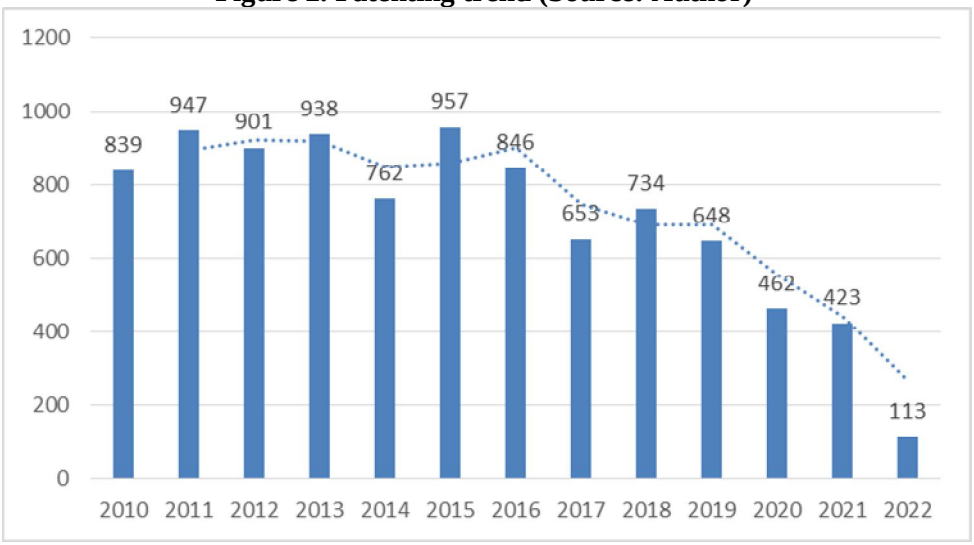


Figure 3 reveals that 75% of patents are dead, indicating either abandonment or obsolescence. Universities with high patent counts, like those with many dead patents, contrast with institutions like ITMO University and Kazan Federal University, which have fewer patents but a higher percentage of active ones. This suggests that a high patent count doesn't necessarily equate to high competition (Maresch et al., 2016). A low originality score, calculated by the percentage of backward citations across diverse technological domains (Eq. 5), is associated with more dead patents (Hall et al., 2001; Squicciarini et al., 2013). Figure 6 shows that most universities have low originality and alive patents, indicating a weak technological profile and high risks (Yun et al., 2021).

Figure 3. Legal analysis results (Source: Author)

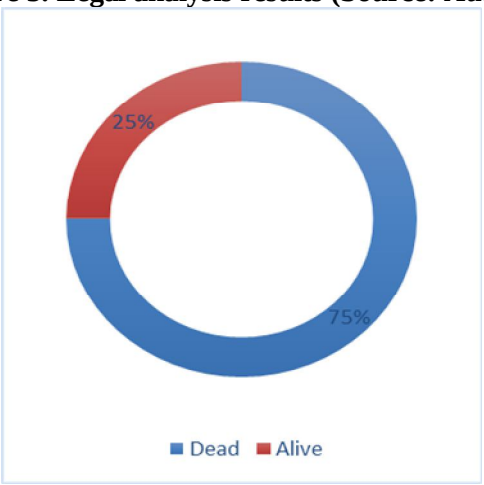


Figure 4 categorizes patents by technology domains, revealing that Russian universities focus on measurement, civil engineering, and electrical machinery, with less emphasis on advanced fields like telecommunications, biotechnology, and nanotechnology. This focus on less cutting-edge technologies contributes to the high proportion of dead patents and low originality.

Figure 4. Technological analysis results (Source: Author)

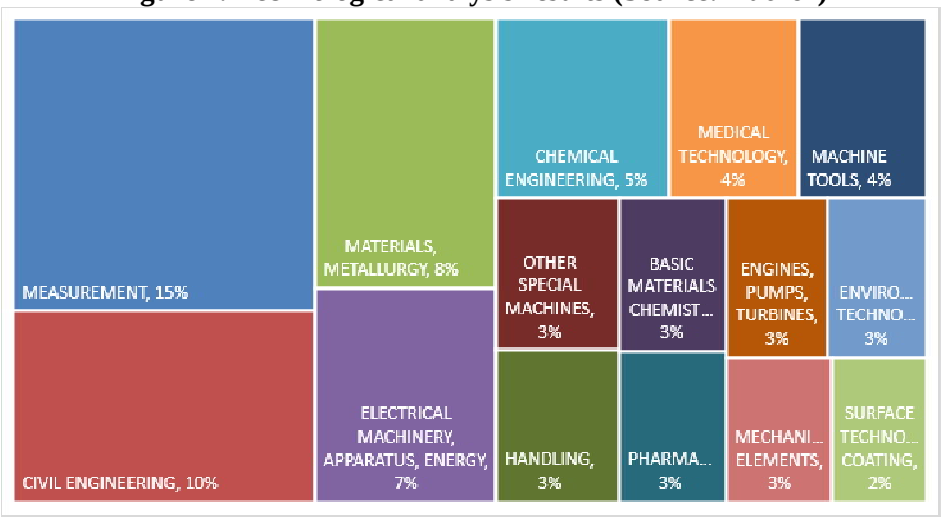


Table 1 shows that the patent network is sparse and uneven, with a mean patent frequency of 25.68 and a mean degree of 1.84 collaborators. A few universities are highly connected, dominating patent filings and collaborations. Network measures of closeness (0.37), betweenness (65.71), and modularity (71.01) suggest moderate connectivity and variation in university roles.

Table 1: Descriptive statistics

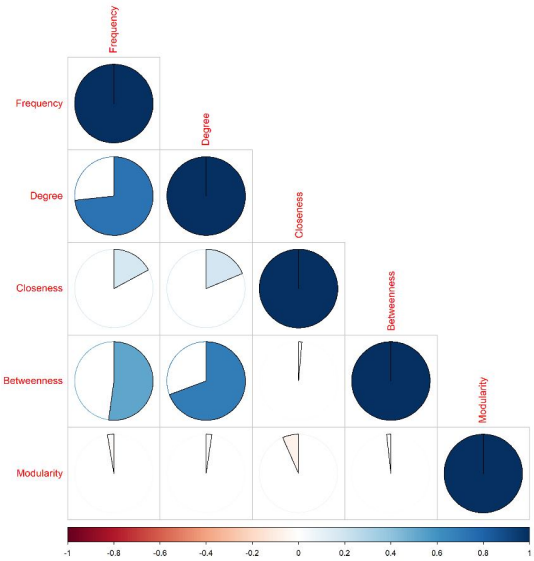
Variable	Obs	Mean	Std	Min	Max
Frequency	580	25.68	154.24	1	2041
Degree	580	1.84	4.40	0	69
Closeness	580	0.37	0.26	0	1
Betweenness	580	65.71	533.48	0	8030.16
Modularity	580	71.01	42.49	0	143

Source: Author's calculations

Figure 5's correlation matrix highlights a strong link between patent frequency and network degree (r = 0.73), indicating that universities with many patents also have broader collaboration networks. Conversely, there is a weak

correlation between closeness and betweenness (r = 0.013), and moderate negative correlations between betweenness and modularity (r = -0.018) and frequency and modularity (r = -0.03). These findings reflect the complex, nuanced nature of university collaborations and their roles in innovation.

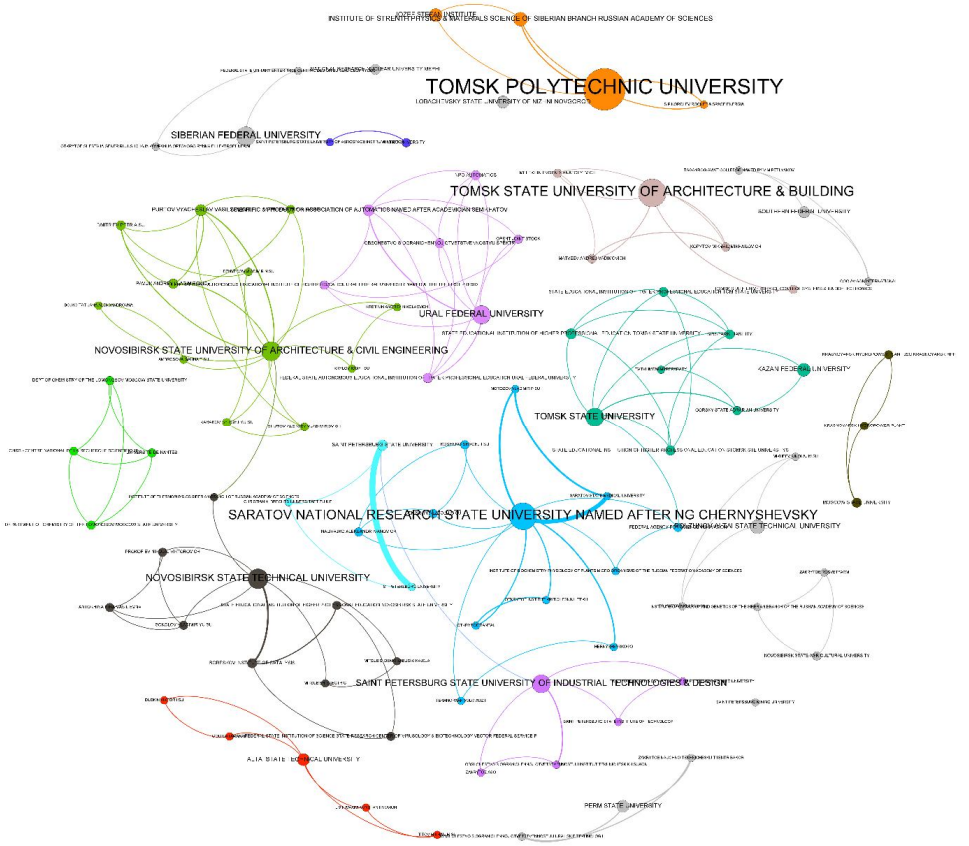
Figure 5. Correlation matrix (Source: Author)



A network analysis of patent joint ownership was performed to assess synergy between universities, private sector entities, and public organizations. Figure 6 reveals that Tomsk University, Novosibirsk State Technical University, and Saratov State University of Architecture and Civil Engineering exhibit high network connectivity.

The analysis indicates that most patents result from collaborations between universities rather than between universities and private sector companies. This pattern suggests that universities often operate independently with limited collaborative synergy among them. Further detailed analysis is needed to uncover specific patenting patterns, focusing on the extent and frequency of collaborations among different actors in the innovation system. Accordingly, it can be argued that the Russian IPRs system exhibits low synergy among key actors in the national innovation system, resulting in ineffective commercialization and frequent failures. We propose that this lack of innovation success is due to weak institutional support and insufficient innovation infrastructure. These deficiencies deter long-term, productive partnerships between inventors and companies, ultimately undermining the system's overall innovativeness.

Figure 6. Network Analysis of Russian Universities' Synergy (Source: Author)



4.1. Blockchain-Based IPRs Management System:

The current IPRs management system is inefficient, failing to address issues like copyright claims, trade secret protection, patent safeguarding, and intellectual property data availability (Glaeser, 2018). Blockchain technology presents a promising solution to these problems by enhancing the functionality of patent management systems (Alnafrah et al., 2019).

Following (Edquist, 2011) perspective on institutional innovation, we propose a national blockchain-based IPRs management platform. This platform aims to revamp the current institutional framework, especially in countries with low innovation rates. It will accelerate the patenting process, foster collaborations, and involve universities, entrepreneurs, independent inventors, and government organizations, thereby promoting national innovation and improving patent quality.

Blockchain operates as a decentralized ledger where transactions are verified through a consensus algorithm and secured by a hash function

(Mougayar, 2016). Each participant uses a public key (IP address) and a private key for anonymous transactions.

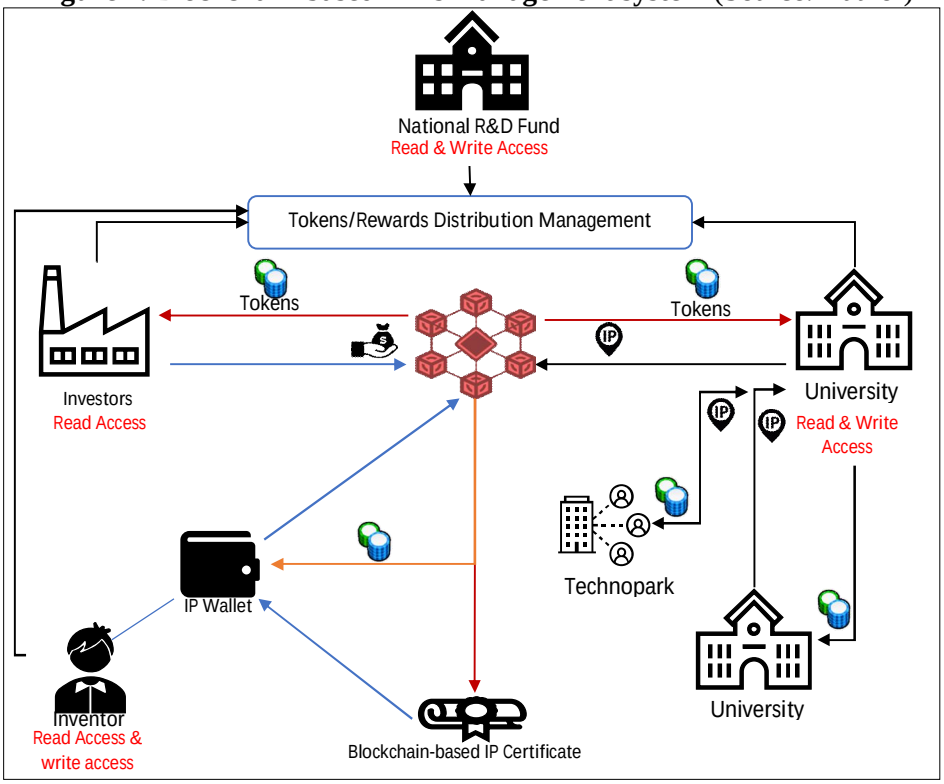
4.1.1. Solution Design:

The proposed blockchain platform will provide immutable proof of ownership and existence of IP, eliminating concerns over intellectual property rights. It will function as a marketplace for knowledge and technology exchange among stakeholders.

In this design, government entities will act as "miners" or full nodes, verifying transactions and receiving rewards. Universities will earn rewards for knowledge sharing and collaborative projects, linked to their IP performance. Over time, these rewards could be tied to R&D funding, incentivizing both universities and private sector actors to engage in joint ventures and align with national goals.

Figure 7 illustrates the blockchain-based IPRs management system mechanism.

Figure 7. Blockchain-based IPRs management system (Source: Author)



We recommend using a public permissioned blockchain for this platform. This type of blockchain offers secure, controlled write access, transparent read access, and faster transaction processing compared to public permissionless blockchains (Goldenfein & Leiter, 2018). Examples like IPCA in UAE and

IPChain in Russia demonstrate the effectiveness of this blockchain type for facilitating complex interactions.

5. Conclusion:

The study investigates patenting patterns within the Russian innovation system, revealing critical issues such as low synergy, high inactive patents, and ineffective collaborations. We propose a national blockchain-based IPRs management platform as a transformative solution. This platform features a comprehensive rewards system, incentivizing patenting and knowledge sharing through a tokenized ecosystem.

The proposed blockchain platform acts as a dynamic marketplace for IP stakeholders—universities, research centers, private firms, and government bodies—to engage in patenting and technology exchange. By implementing a rewards management system supported by a national R&D fund, this platform can enhance commercialization and innovation. Participants use government-issued tokens for transactions, which can be exchanged for IP products or financial resources. Future plans include integrating additional actors such as technoparks and TTOs.

Key policy implications include:

- Invest in Blockchain Platforms: Establish national blockchain-based IPRs platforms to foster collaboration and knowledge sharing.
- Align with Sustainable Development: Support UN Sustainable Development Goal 9 by advancing industry, innovation, and infrastructure.
- Develop Institutional Frameworks: Create standards and regulations for blockchain IPRs platforms to ensure transparency and integration with existing systems.
- Leverage Tokenization: Use tokenization and smart contracts to streamline technology transfer and incentivize commercialization.
- Balance Oversight and Decentralization: Implement a hybrid approach to manage the platform's decentralization while maintaining necessary government oversight.

As the platform expands, consider international linkages to enhance global innovation and technology diffusion. This approach could revolutionize the innovation landscape, promoting more open, collaborative, and sustainable technological development.

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