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AI REGULATION AS A DRIVER OF CIRCULAR ENTREPRENEURSHIP IN SOCIETY 5.0: STRATEGIC AND ENGINEERING PERSPECTIVES

DOI: 10.5937/PIM26013C

Abstract:
This paper analyses the role of artificial intelligence (AI) regulation in shaping circular entrepreneurship within the framework of Society 5.0, with a specific focus on the comparative assessment of the European Union and Serbia. The study concentrates on regulatory frameworks as key determinants of innovation capacity, examining how differences in legal approaches influence the development and scalability of AI-driven circular economy solutions. The core contribution of the paper lies in a comparative analysis of the EU's comprehensive regulatory model, particularly the EU AI Act, and Serbia's partially harmonized, but still fragmented regulatory environment. The analysis identifies critical regulatory gaps that may hinder innovation, investment, and scale-up potential in Serbia, especially in the context of circular business models. Findings suggest that while the EU framework provides a structured and risk-based approach that enhances legal certainty and supports innovation, Serbia lacks a unified legal framework for AI, which creates uncertainty for entrepreneurs and limits the development of scalable solutions. The paper argues that targeted regulatory alignment and strategic legal reforms are necessary to enable circular entrepreneurship and foster sustainable innovation in Serbia.

Keywords: *AI Regulation; Circular Economy; Comparative Analysis; EU AI Act; Serbia; Circular Entrepreneurship; Innovation Policy; Regulatory Framework.*

1. Introduction

The global transition toward a sustainable digital economy is increasingly driven by the convergence of artificial intelligence (AI) and the circular economy within the human-centric paradigm of Society 5.0 [7], [19]. In this context, AI technologies optimize resource allocation, improve lifecycle traceability, and enable more efficient circular value

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chains through data-driven decision-making [3], [13]. These developments position AI as a key enabler of "circular intelligence", supporting the transition toward regenerative economic systems [3].

At the same time, AI regulation is evolving from a corrective mechanism into a proactive governance framework aimed at aligning technological development with ethical and societal objectives [2], [11]. The European Union, through the AI Act, has introduced a risk-based regulatory model that balances innovation with the protection of fundamental rights and market stability [1], [2], thereby creating a predictable environment for AI-driven circular solutions.

Existing literature highlights the role of AI in improving efficiency within circular systems, particularly in predictive maintenance, resource optimization, and waste management [3], [13]. In addition, tools such as the Digital Product Passport enhance transparency and traceability across product lifecycles [4], [12].

However, important limitations remain. Research is often fragmented across disciplines, with limited integration of legal, engineering, and management perspectives [14], [15]. Moreover, regulation is frequently viewed as a constraint rather than a driver of innovation [2], [11], while transition economies remain underexplored despite the importance of regulatory capacity for innovation outcomes [9], [10].

1.1. Research Gap

Despite the growing literature on AI and the circular economy, a clear gap remains in understanding their interaction within an integrated regulatory and strategic framework. Existing studies focus either on technical applications or legal aspects, with limited interdisciplinary linkage between regulation, engineering, and management [3], [14].

Furthermore, regulation is predominantly analysed as a restrictive mechanism, while its role as a driver of innovation remains insufficiently explored [2], [11]. There is also a geographical imbalance, with limited attention to transition economies, where regulatory uncertainty directly affects the scalability of circular business models [9], [10].

1.2. Research Aim

The aim of this paper is to analyse how artificial intelligence regulation influences the development of circular entrepreneurship, with a comparative focus on the European Union and Serbia.

1.3. Research Questions

1. How does the EU's risk-based AI regulation support circular innovation through tools such as the Digital Product Passport?
2. How does regulatory divergence between the EU and Serbia affect the scalability of circular business models?

1.4. Research Contribution

This study provides an interdisciplinary perspective on AI regulation as a driver of circular entrepreneurship, linking legal frameworks with technological and managerial dimensions in the context of the digital and green transition.

2. Theoretical Framework

2.1. Artificial Intelligence Regulation

The governance of artificial intelligence has become a key issue in contemporary legal and economic systems, particularly in balancing innovation with the protection of fundamental rights. The European Union has established a leading regulatory model through the AI Act, which introduces a structured, risk-based classification of AI systems according to their societal impact [1], [2]. This approach aims to ensure legal certainty while supporting technological development.

At the international level, frameworks such as the OECD AI Principles emphasize transparency, accountability, and human-centric values as core elements of trustworthy AI systems [2]. These principles highlight that AI governance extends beyond formal compliance to include broader ethical and societal considerations.

Despite these efforts, the implementation of AI systems raises important challenges, including algorithmic bias, limited transparency, and difficulties in assigning responsibility in autonomous decision-making [6]. These issues are particularly significant in high-risk applications, where regulatory oversight is necessary to ensure safety and public trust.

AI regulation also remains globally fragmented. While the European Union applies a comprehensive and centralized approach, other jurisdictions rely on sector-specific models [2], [11]. Such divergence creates barriers for cross-border operations and limits the scalability of AI-driven solutions.

2.2. Circular Economy and Society 5.0

The circular economy is a systemic model focused on minimizing waste and maximizing resource value through reuse, recycling, and regeneration [5]. Within the European context, it is closely linked to the Circular Economy Action Plan and the "Twin Transition", which integrates digital and environmental objectives [12].

Artificial intelligence plays a crucial role in enabling circular systems by improving resource efficiency, optimizing production processes, and supporting data-driven decision-making [3], [13]. For instance, AI applications enhance waste sorting, predictive maintenance, and supply chain optimization, contributing to more sustainable production patterns [3].

A key enabling instrument is the Digital Product Passport, which provides structured data on product composition, lifecycle, and environmental impact [4]. This enhances transparency and traceability across value chains, which are essential for effective circular economy implementation.

These developments align with the concept of Society 5.0, which emphasizes a human-centred approach to digital transformation. In this context, AI functions not only as a technological tool but also as a strategic enabler of sustainable and inclusive economic development [19].

3. AI Regulation as a Driver of Circular Entrepreneurship

3.1. Regulatory Impact on Business Models

The integration of artificial intelligence into circular business models is increasingly shaped by evolving regulatory frameworks, particularly the risk-based approach of the EU AI Act [1], [2]. For firms, compliance is no longer only a legal obligation but a strategic factor influencing innovation and business development [2].

By classifying AI systems into risk categories, regulators provide a structured framework that enables firms to align research and development with established safety and ethical standards [1]. This

reduces uncertainty and supports the deployment of AI-driven solutions within circular economy systems.

At the same time, the operationalization of these technologies depends on the broader regulatory environment. Differences between regulatory models directly affect business strategies, especially in terms of scalability and market entry in cross-border contexts.

3.2. Digital Product Passport and Smart Systems

A key instrument linking AI regulation and circular entrepreneurship is the Digital Product Passport (DPP), designed to improve traceability across value chains. The DPP provides standardized, machine-readable data on product composition, lifecycle, and end-of-life processes [4].

Such regulatory requirements stimulate the development of smart systems capable of processing large datasets to optimize resource recovery [3]. For example, AI-based computer vision systems use DPP data to enhance waste sorting accuracy and reduce material contamination [4].

By enforcing transparency and accountability, regulation creates a technological environment in which AI can improve efficiency and support the functioning of circular systems [7].

4. Comparative Perspective: EU vs Serbia

The regulatory governance of artificial intelligence and the circular economy shows a clear divergence between the European Union and the Serbia. The EU has established a centralized and legally binding framework through the AI Act, based on a risk classification system and mandatory conformity assessments for high-risk applications [1], [2]. This approach provides legal certainty and supports the deployment of advanced circular solutions, including tools such as the Digital Product Passport.

In contrast, Serbia follows a strategy-based approach defined by the *Strategy for the Development of Artificial Intelligence 2020–2025* [8]. Although partial harmonization with EU standards has been achieved, the absence of a comprehensive legal framework creates regulatory uncertainty. This limits the scalability of AI-driven circular business models and reduces attractiveness for investment in innovative solutions.

Table 1: *Comparative Analysis of AI Regulation and Circular Economy (EU vs Serbia)*

No.	*Dimension*	*EU*	*Serbia*
1.	regulatory framework	EU AI Act [1]	AI Strategy 2020–2025 [8]
2.	legal force	binding regulation [2]	non-binding strategy [8]
3.	risk based approach	explicit classification [1]	emerging approach [8]
4.	harmonization level	centralized	partial alignment
5.	circular integration	CEAP 2020 / Twin Transition [12]	sectoral pilot projects [8]
6.	market competitiveness	global standard-setter [1]	sector-specific growth

Source: Author's analysis based on [1], [2], [8], [12]

Institutional maturity shapes scalability, requiring Serbia to align with EU standards, while both regions face shared technical and ethical challenges.

5. Challenges and Strategic Implications

The implementation of AI-driven circular systems is constrained by regulatory fragmentation and the complexity of data governance. For startups and SMEs, conformity assessments required by the EU AI Act represent a significant barrier due to high compliance costs and technical requirements for algorithmic transparency [1], [2].

In addition, the absence of a comprehensive legal framework in countries such as Serbia creates regulatory uncertainty, limiting cross-border scalability and investment in AI-enabled circular solutions [8], [9]. These challenges are further intensified by difficulties in ensuring data integrity within the Digital Product Passport ecosystem, where reliable and secure data exchange is essential for effective resource traceability [4].

From a strategic perspective, AI regulation should be understood not only as a constraint but as a driver of innovation [2]. The integration of legal requirements into the early stages of system design ("compliance-by-design") enables firms to reduce regulatory risks and improve long-term resilience.

By aligning technological development with ethical and regulatory standards, companies can transform compliance into a competitive advantage while maintaining public trust. In this context, the integration

of regulatory foresight with technical capabilities represents a key success factor for circular entrepreneurship in the digital and green transition.

6. Conclusion

This study shows that AI regulation, particularly the EU's risk-based approach, acts both as a constraint and a driver of circular entrepreneurship [1], [2]. A clear divergence between the EU's binding framework and Serbia's strategy-based model directly affects the scalability of AI-driven circular solutions. Integrating legal requirements into system design ("compliance-by-design") enables firms to reduce risks and strengthen competitiveness. In this context, tools such as the Digital Product Passport play a key role in ensuring transparency and supporting circular value chains. Ultimately, the alignment of legal frameworks, technological development, and management strategies is essential for achieving sustainable and competitive growth in the digital and green transition.

Acknowledgement

We are grateful to Prof. Dr. Djerdj Horvat for his cooperation in the research!

REFERENCES

[1] Amir, A.-M. (2025). Between Innovation and Oversight: A Cross-Regional Study of AI Risk Management Frameworks in the EU, U.S., UK, and China. arXiv (Cornell University). https://doi.org/10.48550/arxiv.2503.05773

[2] Walter, Y. (2024). Managing the race to the moon: Global policy and governance in Artificial Intelligence regulation—A contemporary overview and an analysis of socioeconomic consequences. Discover Artificial Intelligence, 4(1). https://doi.org/10.1007/s44163-024-00109-4

[3] Munonye, W. C., et al. (2025). Governing circular intelligence: How AI-driven policy tools can accelerate the circular economy transition. Cleaner and Responsible Consumption, 19, 100324. https://doi.org/10.1016/j.clrc.2025.100324

[4] Badawi, I. (2026). E-Waste, Artificial Intelligence, and The Law: Toward A Circular and Sustainable Digital Economy. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.6012214

[5] Özsoy, T. (2023). The role of artificial intelligence in facilitating the transition to a circular economy. Nişantaşı Üniversitesi Sosyal Bilimler Dergisi, 11(2), 369. https://doi.org/10.52122/nisantasisbd.1345828

[6] Roberts, H., et al. (2022). Artificial intelligence in support of the circular economy: ethical considerations and a path forward. AI & Society, 39(3), 1451. https://doi.org/10.1007/s00146-022-01596-8

[7] Winfield, A., & Jirotka, M. (2018). Ethical governance is essential to building trust in robotics and artificial intelligence systems. Philosophical Transactions of the Royal Society A, 376(2133), 20180085. https://doi.org/10.1098/rsta.2018.0085

[8] Strategy for the Development of Artificial Intelligence in the Serbia for the period 2020–2025.

[9] Dejanović, M., & Kriviņš, A. (2025). Legal and financial regulation of AI in Serbia, Latvia, and the EU. Srpska Politička Misao, 94(6), 167. https://doi.org/10.5937/spm94-59321

[10] Krivokapić, Đ., et al. (2022). Artificial Intelligence Regulation in the Areas of Data Protection, Information Security, and Anti-discrimination in Western Balkan Economies. MIPRO Proceedings. https://doi.org/10.23919/mipro55190.2022.9803678

[11] Chun, J., et al. (2025). Comparative Global AI Regulation: Policy Perspectives from the EU, China, and the US. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.5104429

[12] Hernandez, J. C. R., et al. (2025). Smart Innovation for a Circular Economy: A Systematic Review. Sustainability, 17(13), 5793. https://doi.org/10.3390/su17135793

[13] Raut, S., et al. (2025). Application of artificial intelligence in circular economy: A critical analysis. Sustainable Futures, 9, 100784. https://doi.org/10.1016/j.sftr.2025.100784

[14] Ahrens, F., et al. (2024). Interdisciplinary Transition Innovation, Management, and Engineering (InTIME) Design. Proceedings of the Design Society, 4, 1169. https://doi.org/10.1017/pds.2024.119

[15] Nweke, G. I., & Nweke, O. C. (2024). Harmonising Strategy, Innovation, and Law. Beijing Law Review, 15(1), 200. https://doi.org/10.4236/blr.2024.151013

[16] Bashynska, I., & Prokopenko, O. (2024). Leveraging Artificial Intelligence for Circular Economy. https://doi.org/10.19192/wsfip.sj2.2024.13

[17] Gailhofer, P., et al. (2021). The role of Artificial Intelligence in the European Green Deal.

[18] Madiaga, T., et al. (2024). EU Legislation in Progress.

[19] Đorđević, L., et al. (2023). Entrepreneurship in Society 5.0. Industrija, 51(1), 29. https://doi.org/10.5937/industrija51-45802