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Article

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Introduction to the Special Issue “The twin challenge of sustainability and digital transformation”

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The intersection of sustainability, digitalization, and innovation has emerged in recent years as a focal point for academic research and industry practices alike. This special issue showcases a collection of articles that elaborate on these themes from diverse angles, with a particular focus on circular economy principles, blockchain technology, sustainable business models, and the role of legal frameworks. Papers in this issue give an insight into how organizations can incorporate advanced technologies to render business sustainable and at the same time engage stakeholders in transitioning to more circular and eco-efficient business models. This multifaceted approach reflects findings from Prokop, Gerstlberger, and Zapletal (2022), who highlight that sustainability-driven practices can stimulate product innovation while presenting unique challenges that require careful strategic management. Arthur et al. (2024) further illustrate the complex interplay between policy and innovation, revealing how varying levels of government policy stringency, coupled with human capital, influence the effectiveness of circular economy initiatives across OECD countries. Their findings suggest that comprehensive policies, supported by strong human resources, are vital for sustaining eco-innovative progress.

The systematic review ***Digitalisation as a Tool to Enhance Eco-Efficiency Measures: A Systematic Literature Review*** by Sara Majid considers how digitalisation could provide European SMEs with the possibility to be environmentally more sustainable by applying eco-efficiency measures. The review highlights that digitalization is a key enabler for improving eco-efficiency in SMEs, particularly in waste management and energy efficiency. However, SMEs often face challenges due to limited resources and insufficient organizational capacity to fully leverage digital solutions. The study underscores the potential of digital technologies in helping SMEs achieve sustainability goals, such as reducing waste and controlling carbon emissions. It suggests that future research should concentrate on developing and implementing practical, accessible, and affordable digital solutions tailored for SMEs. Additionally, the findings imply that more specific and well-defined policy guidance is necessary to support SMEs in their digital transformation toward eco-efficiency. This study goes in line with Durst and Gerstlberger (2020) illustration of how comprehensive financial support programs and targeted policies play an essential role in enabling SMEs to overcome these constraints and align with sustainability and digitalization goals. In exploring the role of digitalization and sustainability within SMEs, Korsakienė and Raišienė (2022) provide a comprehensive review highlighting key sustainability drivers and challenges that SMEs face. Their analysis aligns with the observations noted in Sarah Majid's systematic review, further emphasizing that limited resources and organizational capacities often hinder SMEs from leveraging eco-efficient solutions, despite their potential for impactful innovation.

The paper ***Blockchain-Based Trustworthy Artificial Intelligence Supported by Stakeholders-In-The-Loop Model*** by Şaban İbrahim Göksal and Maria Claudia Solarte Vasquez proposes the BCTrustAI.SL model, a blockchain-based trustworthy artificial intelligence platform supported by a stakeholders-in-the-loop model to improve trust, compliance with ethics, and other acknowledged issues in AI and blockchains. The key conclusions indicate that integrating blockchain with AI can effectively address trust issues, enhancing the robustness and transparency of AI systems. Sociotechnical frameworks, such as the BCTrustAI.SL model, offer a systematic approach to aligning AI with legal and ethical standards. The stability and decentralization features of blockchain are pivotal in fostering trust and stakeholder engagement, particularly in AI-driven processes. The paper highlights the significant role of human agency within AI systems and emphasizes the importance of stakeholder participation in AI governance. It stresses that future AI development must prioritize ethical considerations and human-centered technological design. This paper contributes to the research by Dohnalová, Dobeš, and Kramoliš (2021) illustrating that the shift towards Industry 4.0 extends beyond technological infrastructure to include workforce adaptability.

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Their analysis of the Czech labor market shows that young professionals need continuous upskilling to meet the demands of these technological advancements, reinforcing the interplay between innovation and sustainable workforce development

The paper ***Industry 4.0 Technologies in Circular Innovation: A Review of Sustainable Value Chain Studies by Turan Azizov*** addresses the role that Industry 4.0 technologies could play in the support of circular value chains, particularly for large corporations. The discussion highlights that advanced technologies, including blockchain, big data, and IoT, play an essential role in enabling value chain circular innovation. The importance of cross-functional collaboration and strong leadership is emphasized as crucial for implementing circular economy practices within organizations. Integrating Industry 4.0 technologies with circular business models can lead to significant positive environmental outcomes, such as improved resource efficiency. Achieving long-term sustainability in value chains will require a holistic approach involving all actors in the ecosystem. Consequently, future research should focus on the practical implications of merging digital technologies with circular economy strategies. Ahmadov, Durst, and Gerstlberger (2023) also underscore that SMEs, in particular, benefit from strategic policy frameworks and collaborative support systems to effectively adopt circular economy practices and overcome structural and resource-related barriers.

In the paper ***Legal Design: A Catalyst for Environmental Social and Governance (ESG) and Sustainable Business Practices by Ebru Metin*** the authors explain how legal design can be applied to increase the effectiveness of ESG frameworks in ensuring corporate compliance and promoting business sustainability. The discussion underscores that legal design enhances the accessibility and comprehensibility of legal approaches, which in turn fosters greater stakeholder engagement. This method employs visual aids, plain language, and human-centered design principles to help organizations navigate complex ESG regulations. Legal design plays a role in promoting transparency, accountability, and long-term sustainability in corporate governance. Additionally, digital transformation has been pivotal in enabling legal frameworks to adapt to evolving ESG standards. The paper advances the idea that legal design serves as a strategic enabler supporting ethical and sustainable business practices. In a similar context, Gyamfi et al. (2024) emphasize that non-financial support systems, such as advisory services and collaborative platforms, are crucial for enhancing innovation within European SMEs. Their research highlights that these non-financial supports play a significant role in fostering SME collaboration, ultimately leading to increased innovative outputs. This connection reinforces the idea that comprehensive support ecosystems—including legal, financial, and operational frameworks—are essential for enabling sustainable business growth and long-term resilience. The importance of strengthening ESG practices is similarly emphasized by Derun, Mysaka, and Skliaruk (2023). Their study underscores the importance of transparent and structured reporting principles that foster corporate compliance and promote sustainable development, aligning with the need for comprehensive frameworks that build stakeholder trust and support ethical governance.

The paper ***Stakeholders' Blockchain Engagement: An Interdependence Theory's Principle of Interaction Framework by Airi Freimuth*** investigates how blockchain technology can enhance stakeholder engagement and contribute to long-term business sustainability through decentralisation, privacy, transparency, and traceability. The key points highlight that blockchain enhances trust, control, and transparency, which can lead to greater customer loyalty and employee satisfaction. Decentralized digital networks powered by blockchain establish secure and reliable environments for stakeholder interactions. The research presents a framework grounded in Interdependence Theory to illustrate how blockchain can drive sustainable stakeholder engagement. Additionally, blockchain is shown to foster ethical business practices and strengthen corporate social responsibility. The paper also highlights blockchain's capacity to remove intermediaries, streamline stakeholder transactions, and support sustainability efforts. This research complements the insights from Pólvora et al. (2021), who highlight the role of multi-stakeholder engagement and policy development in leveraging blockchain for industrial transformation. Their work underscores how coordinated policy strategies can amplify the benefits described in this paper, including trust, transparency, and sustainability, by ensuring that blockchain technology is integrated thoughtfully within industrial and social systems. This integration further solidifies the potential of blockchain to support ethical practices and sustainable growth at both organizational and policy levels.

The paper ***Entrepreneurs and Role Models: Sustainable Context by Ekaterina Demiankova*** explores the influence of role models on entrepreneurs, particularly in shaping their sustainability orientation within entrepreneurial ecosystems. The key takeaways from the paper emphasize the significant role of ERM in promoting sustainable values and practices within entrepreneurship. It suggests that exposure to ERM narratives, whether at an individual or venture level, greatly influences sustainability-focused actions by entrepreneurs. Specifically for the Estonian ecosystem, the paper offers insights into the relationship between role models and sustainable entrepreneurship. It highlights that entrepreneurial ecosystems facilitate role models and support networks that encourage the development of sustainable business models. Successful individuals and ventures serving as role models have been pivotal in inspiring entrepreneurship centered on sustainability. This perspective reinforces the findings of Kozubíková, Dvorský, and others (2020), who explore how social factors, such as influential role models and the communication environment, impact the business landscape for SMEs. Their work demonstrates that positive social influences can foster sustainability-oriented practices and enhance the overall quality of entrepreneurial ecosystems.

The study ***Patterns of Attention Towards Circular-Oriented Innovation: Insights from the Metal Industry*** by **Arseni Kotov** investigates the role of managerial attention in integrating circular economy principles into traditional business models in the energy-intensive metal industry. The main takeaways highlight that managerial cognition plays a crucial role in driving the adoption of circular-oriented innovations (COI) within the metal industry. Both internal and external factors, such as regulatory pressures and market opportunities, influence managerial emphasis on sustainability. The paper expands on the attention-based view (ABV) framework to examine how decision-makers prioritize circular economy strategies. Although technological feasibility exists, the transition to circular adoption faces challenges due to entrenched linear business models. The research offers practical insights for decision-makers to navigate cognitive barriers and effectively implement circular business models. A similar focus on managerial decision-making and the influence of external pressures is highlighted by Ahmadov and Gerstlberger (2024), who explore how stakeholder collaboration and pressure drive the adoption of circular economy practices within SMEs. Their study underscores that effective managerial attention and strategic responses to these pressures are crucial for overcoming barriers and successfully integrating circular models.

The paper ***Smart City Data Commons and EU Competition Law – A Conflict in the Making?*** by **Aleksi Kajander and Thomas Hoffmann** deals with potential conflicts between smart city data commons and EU competition law, especially the governance of non-personal data. The key points from the paper emphasize that treating smart city data as a commons has the potential to empower citizens through self-governance, but this approach may face challenges under EU competition law. The paper examines the tension between open data policies and the protection of non-personal data generated by smart cities, highlighting how this can hinder selective data sharing under EU competition law, particularly with the application of Articles 101 and 102 of the TFEU. It stresses the importance of aligning open data initiatives with citizens' rights to control their data. The paper also discusses potential strategies to reduce these legal conflicts and ensure that smart city data commons align with EU laws. This research adds to the discussion by Důbravová and Bureš (2023) that analyzes how smart city information systems can be designed to effectively share non-personal data, enhancing citizen engagement while navigating regulatory frameworks. Their research supports the idea that aligning data governance strategies with transparency and citizen empowerment is crucial for creating sustainable smart city ecosystems that comply with existing legal standards.

The paper ***Beyond Green or Tech: Cultivating Entrepreneurial Ecosystems for the Twin Transition*** by **Jaime J. Rodríguez Santiago** explores how entrepreneurial ecosystems can support the interconnected goals of digitalisation and sustainability, known as the "twin transition". The study highlights that while digital tools can drive resource efficiency and promote sustainable practices, they also bring challenges such as increased energy consumption and e-waste. It identifies tensions between profit-focused digital business models and sustainability objectives, as well as cultural differences between the rapid pace of digital growth and the slower, mindful approach required for sustainable transformation. The author proposes a framework for developing entrepreneurial ecosystems that align digital and green transitions by fostering a shared vision, building strong support networks, and redefining success metrics to include economic, social, and environmental impacts. This approach emphasizes the need for collaborative efforts among policymakers, entrepreneurs, and support organizations to nurture ecosystems capable of integrating both transitions effectively. Santiago's perspective is extended by Prokop et al. (2023) by examining how environmental policy stringency (EPS) influences green innovation and international cooperation across OECD countries. Their findings reveal that while stringent, market-based policies can stimulate innovation and improve quality of life, their effects on fostering broader international cooperation are more complex. This complements Santiago's focus on cooperative policy approaches, illustrating that while policy can indeed drive local innovation, careful balancing is needed to enhance collaboration on a global scale for comprehensive sustainability outcomes.

The paper ***Growing green processes and sustainable business – mapping company-level motives to initiate sustainable practices based on the wood and metal industries in Estonia*** by **Merle Küttim et al.** explores the motivational factors driving companies to adopt sustainable practices, focusing on Estonia's metal and wood industries. Using qualitative research, the study identifies three distinct mindsets that shape businesses' approaches to sustainability: the "spreadsheet mindset", which is primarily financial and cost-driven; the "mindset of strategic capabilities", which integrates sustainability with innovation and resilience; and the "value-driven mindset", which deeply embeds sustainability in a company's core values and seeks societal impact. These mindsets reflect a spectrum of motivations, ranging from external compliance to intrinsic commitment to sustainability. Building on earlier research by Gerlitz and Prause (2021), which emphasized the role of cultural and creative industries as brokers for sustainable transitions in the Baltic Sea Region, this study examines sustainability motivations at the level of individual companies. Both studies highlight the importance of fostering collaboration and tailoring strategies to support sustainable development. While Gerlitz and Prause focus on cross-sectoral actors, this paper provides insights into the internal dynamics of manufacturing firms, offering a complementary perspective. This typology serves as a tool for companies to self-assess their sustainability approaches and for governments to refine strategies that accelerate the green transition. By aligning company-specific motivations with

broader regional efforts, such as those discussed by Gerlitz and Prause, the findings underscore the need for targeted and collaborative approaches to achieve sustainability goals.

The study ***Blockchain Adoption in Sustainable Supply Chains: An Empirical Investigation by Javad Keypour*** explores the adoption of blockchain technology in sustainable supply chains, putting an emphasis on transparency, traceability, and efficiency improvements. The key takeaways highlight that blockchain adoption improves transparency and traceability within supply chains, aiding compliance with sustainability standards. The research points out significant challenges related to blockchain implementation, such as high costs and the necessity for industry-wide standardization. Blockchain is shown to hold substantial potential for enhancing supply chain efficiency, especially in resource management and waste reduction. The study stresses the importance of stakeholder collaboration for the successful integration of blockchain into supply chains. The author recommends that future research should explore scalable blockchain solutions customized to the unique requirements of sustainable supply chains. Philipp et al. (2021) contribute further to the discourse on sustainable supply chains by examining how digitalization and renewable energy technologies can enhance seaport operations. Their analysis of green and smart seaport practices illustrates that integrating automation and renewable energy into logistics can lead to more eco-efficient and sustainable operations. This reinforces the idea that adopting a blend of digital and energy solutions is pivotal for modernizing supply chains and achieving environmental sustainability.

The paper ***Advancing Circular Economy Models: The Synergistic Role of Service Design and Blockchain Technology in Enhancing Sustainability and Consumer Engagement by Vera Gerasimova*** explores the potential of combining Service Design and Blockchain technology to enhance Circular Economy models, emphasizing both sustainability and consumer engagement. Through case studies focusing on the electronics and food supply chain sectors, the study illustrates how these two approaches together can foster greater transparency, traceability, and user-centric solutions. This integration not only builds trust among stakeholders but also promotes active participation in sustainable practices. In the electronics industry, for example, blockchain-enabled platforms effectively improve lifecycle management, reducing e-waste and encouraging recycling. In the food supply chain context, blockchain provides consumers with verifiable data regarding product origins and environmental impacts, which can guide them toward more sustainable choices. By using Service Design principles, Circular Economy practices become more accessible and appealing, making sustainable actions easier for consumers to adopt. The paper also highlights future opportunities for expanding the use of blockchain through energy-efficient mechanisms and emphasizes the importance of interdisciplinary collaboration to embed these practices widely. It concludes by underlining the need for supportive policy frameworks and ongoing research to leverage emerging technologies for optimal sustainability outcomes. This paper contributes to the study by Meyer, Gerlitz, and Prause (2023) that provides a comprehensive view of how interdisciplinary strategies involving digital technologies can enhance sustainability in urban and port ecosystems. Their conceptualization of smart city and port frameworks reinforces Gerasimova's emphasis on the critical role of collaboration and digital innovation, illustrating that these approaches collectively foster robust ecosystems that support sustainable and resilient infrastructure development.

This collection of articles underscores the complex relationship between sustainability, technology, and strategic management. As demonstrated by Prokop et al. (2024), examining firms' approaches to green innovations in the Central and Eastern European context provides valuable insights into the varied impacts of sustainability-driven strategies, highlighting the importance of tailored, region-specific solutions. Each article in this special issue offers a unique view on how digitalisation, circular economy models, and sustainability work together, showing how businesses and legal frameworks are adapting to environmental challenges. These contributions highlight the growing importance of using technologies like blockchain, artificial intelligence, and Industry 4.0 to support more sustainable business practices. By adopting these technologies, companies can improve how they manage resources, make supply chains more transparent, and foster collaboration across industries and countries. Additionally, legal frameworks and governance play a key role in this shift. Legal design and policies make it easier for companies to follow sustainability guidelines and involve stakeholders, promoting more ethical and responsible behavior. As these articles show, sustainability is not just about technology; it requires coordinated efforts in legal, management, and operational areas. Together, these insights demonstrate how technology, regulation, and circular business models can help industries transition to a more sustainable future.

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