sustainability

Editorial

The Complicated Relationship between Innovation and Sustainability: Opportunities, Threats, Challenges, and Trends

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Since the announcement of the 17 Sustainable Development Goals (SDGs) by the UN in 2015, innovation has been recognized as a crucial tool for achieving these goals by 2030. While innovation has shown its potential to drive progress toward sustainability and accelerate SDG attainment [1], there is an ongoing debate regarding its relationship with sustainability.

On one hand, innovation does not always lead to sustainable outcomes and can sometimes worsen existing problems or create new ones [2]. However, there is also evidence of a positive link between innovation and sustainability.

The challenge of the intricate relationship between innovation and sustainability is closely tied to techno-economic paradigms [3]. Indeed, depending on the paradigm within which innovation operates, its connection with sustainability may be more or less difficult to establish. The prevailing techno-economic paradigm is grounded in a linear industrial and economic system dominated by competitive dynamics, the race for productivity, profitability optimization, the predation of natural resources, and short-term-oriented strategies. In this context, innovation can yield adverse effects on ecological regulations and social dynamics. However, during the past two decades, new paradigms based on sustainability have emerged. These paradigms promote a circular economy, renewable energies, and recycled products, while taking into account the reproductive capacity of the natural ecosystem. For instance, the Industry 5.0 paradigm highlights three leading characteristics for the manufacturing system: human-centricity, sustainability, and resiliency [4]. As another example, the Quintuple Helix innovation model emphasizes the necessary socioecological context of innovation processes [5].

Many companies are embracing sustainability-driven innovation, integrating sustainability criteria into their products, processes, and services. This approach reframes sustainability as a driver of business success rather than just a cost, offering opportunities for enhanced performance and competitive advantages [6].

Moreover, similar to sustainability, innovation for sustainable development is diverse, involving various dimensions including technology, organization, institutions, and society [7]. Effective governance is crucial to managing this complexity and ensuring that innovation aligns with the overarching aim of safeguarding the planet's future.

Therefore, the objective of this Special Issue was to examine the relationship between innovation and sustainability from various angles. The contributions successfully achieve this objective, covering an assortment of topics ranging from logistics and supply chain management to quality and production planning, green productivity, blockchain for sustainable communication, and energy efficiency. These contributions collectively offer a diverse array of insights into the intersection of technology, sustainability, and innovation within various industrial domains.

Contribution 1 provides an in-depth analysis of Logistics 4.0 technologies and proposes a practical methodology for technology selection in business settings. This approach, grounded in multi-criteria decision-making (MCDM) techniques, offers a structured framework within which companies can evaluate and adopt 4.0 technologies to enhance their internal logistics operations. Building upon this foundation, future research could explore broader applications of these technologies and alternative decision-making methodologies, extending the model's scope to encompass a wider range of supply chain activities.

Building upon the theme of technological integration, Contribution 2 underscores the importance of quality management in the era of Industry 4.0, particularly emphasizing the role of zero-defect manufacturing (ZDM) in promoting sustainable production practices. The introduction of a practical tool for assessing and selecting ZDM strategies lays the groundwork for further investigation into the effectiveness of these approaches across various industrial scenarios.

In Contribution 3, the focus shifts to green process innovation (GPI) and green productivity (GP) within the cement and plastic manufacturing industries of Pakistan and India. Through quantitative analysis, the study highlights the significant impacts of GPI and GP on sustainability, with particular emphasis on the moderating role of environmental awareness. These findings underscore the importance of stakeholder education and the promotion of sustainable practices to ensure both environmental conservation and economic viability.

Contribution 4 delves into the realm of sustainability communication within food supply chains, exploring the potential of blockchain technology to enhance traceability and transparency. By proposing a comprehensive framework for blockchain-enabled traceability, the study emphasizes the importance of stakeholder engagement in practical implementation, while also highlighting the substantial promise of blockchain-based solutions in augmenting sustainability communication within these supply chains.

Turning to the realm of production planning and control (PPC), Contribution 5 conducts a bibliometric analysis to identify trends and gaps in sustainable PPC research. The analysis reveals increasing interest in energy-saving production scheduling, circular economy integration, and Industry 4.0 technologies, while also highlighting the need for further attention to social concerns and decision support system development in this domain.

Contribution 6 employs advanced statistical techniques to investigate the relationship between digitalization and supply chain dynamics, confirming the positive impacts on both profitability and sustainability. While digitalization enhances supply chain integration and processes, its influence on profitability varies, underscoring the nuanced nature of this relationship. Nonetheless, digitized processes within the supply chain significantly contribute to sustainability goals, emphasizing the pivotal role of digitalization in driving business success and sustainability.

Finally, Contribution 7 introduces a robust method for monitoring and forecasting energy usage in industrial operations, combining data-driven techniques with physics-based modeling. This approach offers valuable insights into energy flow dynamics, empowering informed decision-making for sustainable energy management practices. Looking ahead, future research avenues may focus on refining modeling techniques and applying them across diverse industrial settings to further enhance energy efficiency and contribute to achieving Sustainable Development Goals (SDGs).

In conclusion, these contributions collectively underscore the intricate relationship between technology, sustainability, and innovation across diverse industrial sectors. From Logistics 4.0 to sustainable production planning and energy management, each study offers valuable insights and methodologies for navigating the complex landscape of modern industrial operations. Moving forward, further research should aim to address gaps in sustainability communication, refine decision-making frameworks, and extend the application of innovative solutions to broader industrial contexts. By embracing these challenges and opportunities, industries can effectively leverage technology to drive sustainable development and achieve long-term success while preserving the planet's future.

Conflicts of Interest: The authors declare no conflicts of interest.

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