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IMPROVING TRIPLE BOTTOM LINE PERFORMANCE: A CONCEPTUAL FRAMEWORK ON DIGITALISATION IN CIRCULAR ECONOMY

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ABSTRACT

Organisations today face escalating environmental challenges such as resource depletion, pollution, and waste accumulation that require innovative and systemic solutions. The circular economy (CE) has emerged as a strategic approach to address these issues by maximising resource efficiency and minimising environmental impact. While CE practices offer significant sustainability benefits, their effectiveness can be strengthened when integrated with digital technologies (DTs) that enable data-driven decision-making, operational transparency, and process innovation. Despite this potential, existing research provides limited insight into how digitalisation enhances the relationship between CE practices and sustainability outcomes, as current literature examines isolated CE practices or digital tools but lacks a cohesive framework linking CE implementation, digitalisation, and sustainable performance. To address this gap, this study proposes a conceptual framework connecting CE practices to sustainable performance using the Triple Bottom Line (TBL) perspective, while positioning digitalisation as a moderating factor that amplifies these outcomes, where environmental performance is measured through carbon emission reduction, social performance through alignment with the Social Sustainable Development Goals (SDGs), and financial performance through return on assets (ROA). CE activities are classified using the 9Rs framework, namely Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, and Recycle, across Material, Product, and Waste Management dimensions. The study employs secondary data and content analysis of corporate sustainability reports from manufacturing firms, and the framework posits that digitalisation strengthens CE effectiveness, enabling improved environmental, social, and financial performance, thereby guiding managers in integrating digital tools with CE to enhance data quality, process efficiency, and sustainability outcomes, and informing policymakers to design regulations and incentives that jointly promote CE adoption and digital transformation toward a more resource-efficient industrial ecosystem.

Keywords: *Sustainable firm performance, digitalisation, carbon emission reduction, Social SDGs, waste management*

INTRODUCTION

The global sustainability challenge has grown in recent years, with natural resource extraction recognised as a major driver of climate change, biodiversity loss, and waste generation. According to the United Nations Environment Programme (UNEP), resource extraction alone accounts for 50% of global greenhouse gas emissions, 90% of biodiversity loss and water stress, and 70% of overall waste generation. These findings highlight the fundamental flaws of the linear economy, which operates on a "take-make-dispose" approach that weakens both environmental integrity and economic resilience (Rani et al., 2025a; Zeng et al., 2017). This strategy is becoming incompatible with global sustainability goals, emphasising the need for alternative approaches that can balance environmental and economic sustainability. The circular economy (CE) has developed as a transformational model that solves these deficiencies by focusing on resource efficiency, waste minimisation, and restorative production systems (Korhonen et al., 2018; Rani et al., 2025b). By prolonging product life cycles through reuse, repair, and recycling, CE minimises reliance on

raw materials, alleviates environmental concerns, and fosters economic resilience. Furthermore, CE aligns with the Triple Bottom Line (TBL) framework - commonly termed the 3Ps (Planet, Profit, People), which evaluates sustainability across environmental, economic, and social dimensions.

The first pillar, Planet, emphasises environmental sustainability by minimising ecological harm through reduced emissions, resource efficiency, and waste management. CE practices such as recycling, remanufacturing, and renewable energy use directly address climate change, pollution, and biodiversity loss. Empirical studies show CE adoption can reduce emissions by 30–70% in manufacturing through industrial symbiosis and closed-loop flows, while widespread implementation could cut global resource use by 28% by 2050 (UNEP et al., 2021). The second pillar, People, highlights social equity and well-being. CE supports Sustainable Development Goals (SDGs) by creating green jobs (SDG 8), improving access to goods (SDG 10), reducing pollution (SDG 3), and promoting gender-inclusive supply chains (SDG 5). CE transitions could generate 78 million jobs globally by 2030, and firms adopting CE practices score 35% higher on social performance metrics, underscoring CE's role in advancing socio-economic benefits (Schroeder et al., 2019). The third pillar, Profit, addresses economic sustainability by enhancing long-term competitiveness and financial performance. CE enables higher returns through resource efficiency and waste-to-value strategies, with adopters achieving 8–12% higher ROA (World Economic Forum, 2023). Circular business models reduce costs by up to 40% (Kirchherr et al., 2023) and lower WACC by 1.5–3% as investors reward sustainability. At the macro level, CE could boost EU GDP by 0.9% annually by 2030 and unlock $4.5 trillion in global economic opportunities (OECD, 2024).

CE practices often attract investors who prioritise sustainability, as such practices align with Environmental, Social, and Governance (ESG) criteria, further boosting a firm's market value and investor confidence. Investors increasingly demand transparency and traceability in resource management, highlighting the critical need for digitalisation to enhance the implementation of CE. Digitalisation refers to adopting and integrating digital technologies (DTs) into business processes, systems, and practices to improve efficiency, enhance decision-making, and create value. It involves transforming traditional operations by leveraging technologies such as the Internet of Things (IoT), artificial intelligence (AI), big data analytics, blockchain, cloud computing, and machine learning (Liu et al., 2021). Several studies have found a positive correlation between digitalisation, CE practices, and corporate performance (Bressanelli et al., 2024; Ţurcan et al., 2023). Consequently, digitalisation can act as a moderator in enhancing the relationship between CE practices and firm performance; by providing advanced tools and technologies, digitalisation facilitates more effective implementation of CE strategies.

The impact of CE adoption on corporate sustainable performance has increasingly captured scholarly attention at the micro level. Although prior studies have explored the link between CE practices and sustainability outcomes, this relationship has rarely been examined through the comprehensive perspective of the TBL. Adopting a TBL lens is essential because a TBL perspective offers a more balanced understanding of CE's contributions across environmental, economic, and social dimensions.

Building on this perspective, most existing research has concentrated on environmental and economic outcomes. Evidence from developed economies consistently highlights CE's potential to reduce carbon emissions and minimise waste; however, considerably less is known about how these environmental benefits manifest in tropical and developing regions, where industrial structures, climate conditions, and biodiversity sensitivities differ substantially (Kirchherr et al., 2023). Extending beyond environmental and economic considerations, the social dimension of CE remains the most underexamined. This is particularly evident in developing countries such as Malaysia, where understanding of how CE initiatives contribute to social well-being is still limited. While Malaysia has formally incorporated the UN SDGs into its 11th and 12th Development Plans (2016-2025), there remains a striking paucity of empirical studies examining how CE implementation creates measurable social value through the SDGs. Gonella et al. (2024) notably highlight that less than 15% of recent CE studies systematically examine social outcomes, with developing Asian contexts being particularly underrepresented. However, measuring sustainable performance through the TBL is a topic that still receives little attention in the literature.

Therefore, this study addresses these shortcomings by offering a conceptual framework that combines CE, the TBL framework, and digitalisation to explain sustainable performance in the Malaysian context. Specifically, the framework frames CE as a driver of sustainability across planet, people, and profit, with digitisation acting as a moderator to enhance these benefits through increased efficiency, transparency, and stakeholder involvement. This study makes three contributions. First, it advances CE literature with an integrated framework categorising the 9R principles into three managerial dimensions (Material Management, Product Management, and Waste Management), linked to sustainable firm performance via the TBL perspective. Second, it extends sustainability research by conceptualising digitalisation as a moderator strengthening the CE practices–sustainable firm performance relationship. Third, it provides a theoretical foundation for future research and practical insights for managers, policymakers, and investors promoting circular transitions aligned with the SDGs.

To address the gaps identified in the existing literature, this study aims to propose a conceptual framework for examining the impact of CE practices on sustainable firm performance from a TBL perspective in Malaysian manufacturing firms and to conceptualise the moderating role of digitalisation in strengthening the relationship between CE practices and sustainable firm performance within Malaysian manufacturing firms.

LITERATURE REVIEW

Theoretical Foundation

Natural Resource-Based View Theory

Despite growing recognition of sustainability in business priorities, companies still have difficulty incorporating environmental and social factors into their strategic decisions while maintaining competitiveness. Additional resource-based perspectives generally emphasise economic and financial resources while frequently neglecting the ecological restrictions that influence long-term performance. The Natural Resource-Based View (NRBV) addresses this gap by positing that enterprises can attain sustained competitive advantage through capabilities that include environmental and social considerations in their operations (Hart, 1995). Within the CE framework, the NRBV provides a robust theoretical model that elucidates how companies can transform environmental concerns into business advantages. By adopting CE practices such as resource recovery, product life-cycle extension, closed-loop supply chains, and waste minimisation, companies improve their resource efficiency and resilience, therefore yielding economic advantages while concurrently achieving environmental and social standards (Coppola et al., 2023). These capabilities are not solely compliance-oriented; they are strategic assets that allow firms to balance the TBL dimensions of financial, environmental, and social performance (Osei et al., 2024). From a financial perspective, CE practices based on NRBV enable organisations to minimise expenses, create business models, and penetrate new markets via resource efficiency and value recovery (Kristoffersen et al., 2020). This connection is further supported by empirical evidence, as Rabasedas et al. (2023) have shown that NRBV-driven CE strategies in the agri-food sector enhance both economic and environmental outcomes, particularly when combined with circular reporting.

From the perspective of the environmental dimension, NRBV prioritises capabilities such as pollution prevention, product stewardship, and sustainable development, which are in direct alignment with the principles of CE, which include the reduction of emissions, the conservation of raw materials, and the closure of material cycles (Ntoyanto-Tyatyantsi & Amadi-Echendu, 2024; Sharma et al., 2024). This is in accordance with the findings of Coppola et al. (2023), who discovered that the application of CE in the textile industry is facilitated by dynamic capabilities derived from NRBV, thereby enhancing the environmental performance of firms. Lastly, the social dimension of firm performance is fortified by the development of stakeholder trust and enhanced legitimacy, as firms exhibit proactive responses to societal expectations for responsible resource use and sustainability (Gidage & Bhide, 2024). Empirical studies have increasingly validated that enterprises implementing NRBV-inspired CE strategies attain enhanced sustainability results. Companies that include eco-innovation and resource circularity experience reduced environmental risks, enhanced reputation, improved stakeholder relationships, and increased long-term profitability (Kiefer et al., 2024; Ul-Durar et al., 2023). This evidence emphasises that NRBV offers a solid theoretical basis for connecting CE practices with the multifaceted

performance results represented by the TBL framework. In this context, the adoption of CE can be perceived as both a strategic imperative and a means to achieve sustainable competitive advantage, reinforcing the fundamental assertion of the NRBV that environmental competencies are integral to long-term firm success.

Institutional Theory

Institutional theory elucidates why corporations adopt specific behaviours in response to coercive regulations, normative standards, and mimetic pressures within their sectors. Modern sustainability frameworks increasingly require verifiable evidence of resource circularity, lifecycle accountability, and quantifiable social and environmental outcomes. Digitalisation serves as a strategic response to these challenges by generating the data, traceability, and coordination capabilities essential for implementing and validating CE practices on a large scale, thus enhancing performance across financial, environmental, and social aspects (Mahwish et al., 2024; Yin et al., 2024). Institutional theory offers a comprehensive framework for elucidating why corporations implement CE practices and adopt DTs. Adhering to external demands is both a strategic imperative and a means to bolster credibility, stakeholder trust, and long-term performance results (Chen et al., 2024). In this context, Yin et al. (2024) emphasised that companies encountering heightened regulatory and normative pressures are more inclined to invest in digital capabilities that enhance CE implementation, hence improving organisational performance and legitimacy.

Similarly, Sharma et al. (2023) also discovered that institutional pressures moderate the relationship between digitisation capabilities and ESG performance, indicating that under significant external inspection, DTs more efficiently convert CE practices into quantifiable results. These institutional pressures include coercive, normative, and mimetic pressures that serve as external forces that influence organisational behaviour, necessitating that organisations embrace methods considered legitimate and affecting the efficacy of CE practices and digitalisation capabilities. Coercive pressures arise from formal regulations, laws, and compliance requirements that compel firms to adopt environmentally responsible and resource-efficient practices. Digitalisation improves CE processes through real-time monitoring, traceability, and process optimisation, systematically enhancing resource efficiency, closing material loops, and facilitating sustainable product design in accordance with regulatory standards (Mamudu et al., 2024). Normative and mimetic pressures, arising from societal expectations, professional standards, and competitive conduct, compel enterprises to implement CE practices and DTs to conform to industry norms. Digital instruments, including enterprise resource planning systems and digital platforms, enable transparent sustainability reporting, stakeholder involvement, and benchmarking against industry leaders. These technologies allow companies to replicate excellent practices, bolstering their legitimacy and improving performance in financial, environmental, and social aspects (Lee et al., 2024).

In conclusion, institutional theory offers a comprehensive framework for comprehending how external pressures, coercive, normative, and mimetic, affect the adoption and efficacy of CE activities. Digitalisation serves as a vital enabler, enabling enterprises to implement these practices by improving transparency, traceability, and process efficiency, thus assuring regulatory compliance and alignment with public expectations. By addressing institutional challenges through the incorporation of digital tools and corporate social responsibility initiatives, organisations can enhance their legitimacy, foster stakeholder confidence, and achieve exceptional performance in financial, environmental, and social aspects. This theoretical framework emphasises that the interaction of institutional forces, digitisation, and CE adoption is crucial for attaining sustainable competitive advantage and enduring organisational resilience.

Circular Economy

The 3Rs framework, Reduce, Reuse, Recycle, constitutes the fundamental rationale of CE activities and signifies the initial formal endeavour to organise sustainable resource management (Ghisellini et al., 2016). The 3Rs, originating from environmental policy discussions in the early 2000s, specifically the EU Waste Framework Directive (2008/98/EC), were initially established to reduce waste measures and redirect societal focus from disposal to material recovery and conservation (Directive, 2008). The 3Rs, despite their simplicity, have been crucial in shaping public understanding, industry strategy, and legislative measures aimed at mitigating

the negative environmental impact. The first principle, Reduce, underscores the importance of reducing the generation of waste at the source and the use of virgin resources (Shanmugam et al., 2022). It promotes the development of product designs that prioritise longevity, energy efficiency, and material efficiency. Reuse extends the lifecycle of products and components by promoting their continued use without substantial alteration, thereby delaying their entry into the waste stream. Finally, Recycling entails the recycling of waste materials into new goods, generally necessitating physical or chemical alteration (Lacy et al., 2020). Although recycling is widely adopted among the three, it is frequently considered the least circular in terms of retaining product integrity and embedded value. The 3Rs framework played a crucial role in the transition from the linear take-make-dispose model, however, its effectiveness in the context of intricate industrial systems is now perceived as restricted. Scholars argue that the framework that the paradigm mostly deals with downstream waste management and not with upstream systemic reforms (Ding et al., 2023; Reike et al., 2018).

As the limitations of the traditional 3Rs (Reduce, Reuse, Recycle) framework became increasingly evident in addressing complex sustainability challenges, scholars and practitioners began expanding the model to incorporate additional strategies focused on preventive design, resource recovery, and product longevity. This evolution led to the establishment of the 6Rs framework, commonly comprising Refuse, Reduce, Reuse, Repair, Recycle, and Recover. It represents a more holistic and multi-tiered approach to CE thinking, placing greater emphasis on preventative action and value retention throughout the product lifecycle (Hernández et al., 2019; Nazir & Capocchi, 2024). The inclusion of Refuse introduces a significant upstream strategy by encouraging both consumers and producers to avoid unnecessary resource use altogether, often through redesigning products or rethinking consumption habits (Rani et al., 2026; Skärin et al., 2022). Repair extends product usability and delays disposal, reflecting a move toward circular maintenance models. Recover, meanwhile, expands the end-of-life strategy portfolio by enabling the extraction of energy or materials from waste streams that cannot be recycled, typically through waste-to-energy technologies (Modak, 2020). However, the 6Rs framework still places significant emphasis on downstream actions such as recycling and recovery, which often involve energy-intensive processes. Furthermore, there is still no universally agreed-upon definition of the six R-strategies, with some models substituting Recover with Repurpose or Remanufacture, depending on industrial context and sectoral focus.

The increasing complexity of sustainability challenges and the limitations of earlier R-frameworks (3Rs and 6Rs) led to the development of a more comprehensive and hierarchical model: the 9Rs framework. This framework expands and deepens the conceptual scope of CE by including nine distinct strategies: Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, and Recover (to retain product and material value at different stages of their life cycle) (Potting et al., 2017; Saidani et al., 2019). The 9Rs model was popularised by the Dutch National Institute for Public Health and the Environment (RIVM) and further developed in the academic literature by Potting et al. (2017), who proposed a taxonomy of circular strategies based on product- and system-level decisions and categorised the stages by their common purpose.

The first category comprises "Refuse," "Rethink," and "Reduce," which aim to encourage more sustainable product use and manufacturing. The next category, comprising "Reuse", "Repair", "Refurbish", "Remanufacture", and "Repurpose", extends the lifespan of products and parts. The final two CE practices, "Recycle" and "Recover", make up the third category, which aims to maximise the useful application of materials. While the first category of strategies yields improved resource loops and reduced environmental pressure, the third category of strategies entails lower-value processes because embedded labour, energy, and resource costs are lost. Refuse is the highest level of circularity. The opposite can be said about Recover, which is the furthest away. The distance between these practices and the core of CE principles supports their designation, with Refuse as R0 and Recover as R9.

Empirical research increasingly shows that the adoption of CE produces a diverse array of financial, environmental, and social advantages, positioning it as both a sustainability strategy and a catalyst for competitive advantage and systemic resilience. At the organisational level, CE strategies such as resource optimisation, waste reduction, and design for disassembly are demonstrated to improve

financial performance and operational efficiency. Bertelli et al. (2025) observed that the use of principles in the waste management industry markedly enhances environmental performance, while positively impacting organisational effectiveness through cost reduction and enhanced stakeholder engagement. Similarly, Awan and Sroufe (2022) emphasised that implementing CE practices achieved enhanced cost-efficiency, operational flexibility, and environmental results, which collectively contributed to superior overall firm performance. These findings correspond with Antonioli et al. (2022), who discovered that process-oriented CE innovations stimulate revenue growth in manufacturing firms, especially when bolstered by long-term strategic planning.

Sustainable Firm Performance

Sustainable firm performance has developed as a fundamental measure of organisational success, combining financial resilience, social responsibility, and environmental stewardship. It represents a company's ability to create long-term value while aligning operations with the TBL principles, thereby ensuring competitiveness, stakeholder trust, and contributions to broader sustainability objectives (Rani et al., 2023). To capture the overall value generated by CE adoption, the study proposes three dimensions of sustainable firm performance based on the TBL perspective. Sustainable performance is conceptualised as comprising three interrelated dimensions: Planet, People, and Profit. The environmental dimension (Planet) emphasises a firm's ability to minimise its ecological footprint, here operationalised through carbon emission accounting as an indicator of alignment with global decarbonisation targets. The social dimension (People) is framed by the SDGs, which capture the firm's contributions to inclusive growth, societal well-being, and stakeholder engagement. The economic dimension (Profit) is reflected in financial performance, measured by return on assets (ROA), which signals how CE practices translate into efficiency gains and long-term value creation. Together, these dimensions provide a holistic view of sustainable firm performance and allow this study to theorise how CE adoption drives competitive advantage and contributes to global sustainability agendas.

Environmental Performance (Planet)

Environmental performance reflects a firm's ability to reduce its ecological footprint across operations, production, and supply chains, often assessed through frameworks such as ISO 14031, which track inputs, outputs, and ecological impacts (ISO, 2021). Among these indicators, carbon emission accounting has become the most critical metric, providing a standardised measure of Scope 1, 2, and 3 emissions under the GHG Protocol. Despite regulatory and stakeholder pressures, many firms still face challenges due to fragmented carbon accounting practices and difficulties in translating carbon data into actionable strategies (Diófási-Kovács & Nagy, 2023). The CE offers a practical solution by promoting resource efficiency, reuse, recycling, and product life extension, all of which reduce emissions throughout the product and process life cycles.

Empirical studies demonstrate strong synergies between CE adoption and emission reduction: Wang et al. (2024) found significant emission reductions in Chinese CE demonstration cities, while Dong et al. (2022) showed CE strategies enhance environmental performance and, in turn, business performance. Cross-country studies confirm these outcomes, showing that CE practices reduce CO_2 emissions in European economies. Hailemariam and Erdiaw-Kwasie (2023) concluded that sector-specific cases, such as cement, can achieve up to 70% emission savings. Moreover, firms with stronger carbon performance consistently enjoy higher market valuations, reinforcing the strategic value of emission reduction (Khan et al., 2022). These findings highlight carbon emission accounting as a robust proxy for environmental performance and position CE as not only a sustainability ideal but also a feasible, measurable pathway for firms to achieve low-carbon growth and long-term value creation.

Social Performance (People)

Social performance reflects a firm's ability to manage its social responsibilities, including equity, labour practices, community engagement, and employee well-being. It forms a core element of the TBL and is closely aligned with the United Nations SDGs, which emphasise inclusive growth, human rights, and societal welfare. Among the 17 SDGs, several directly address social outcomes, such as eradicating poverty (SDG 1),

promoting health (SDG 3), ensuring education (SDG 4), achieving gender equality (SDG 5), and fostering decent work (SDG 8). These benchmarks provide internationally recognised standards to evaluate firms' contributions to social sustainability (Rosati & Faria, 2019; van Zanten & van Tulder, 2021). Empirical research highlights that engagement with Social SDGs improves both social and financial outcomes. For instance, Saha et al. (2024) found that firm involvement in SDGs related to employment and gender equality enhances ROA, whereas Beretta et al. (2025) reported that SDG disclosure positively influences ROE in Italian firms. Similarly, Khan et al. (2021) identified eight social goals, ranging from poverty reduction to partnerships, that significantly strengthen sustainable development through corporate practices. However, studies also point to governance gaps and inconsistencies between CSR disclosures and actual social impact (Fahmida, 2025). Overall, Social SDGs serve as a strategic instrument for translating social responsibility into measurable performance outcomes, but further research is required to understand how leadership, stakeholder pressures, and reporting frameworks shape their effectiveness across industries (Weber & ElAlfy, 2024).

Financial Performance (Profit)

Financial performance represents a fundamental measure of corporate success, reflecting a firm's ability to generate economic value while satisfying stakeholder expectations (Coelho et al., 2023). It is commonly assessed using accounting-based metrics such as ROA, return on equity (ROE), and return on investment (ROI), as well as market-based indicators including Tobin's Q and earnings per share (Al-Matari et al., 2014). In recent years, growing attention has been given to how sustainability-oriented strategies, particularly CE practices, influence financial outcomes. CE extends beyond waste management to resource efficiency, product lifespan extension, and closed-loop supply chains, offering both environmental and economic benefits. Empirical findings, however, present mixed results. Some studies report enhanced profitability, cost reductions, and reputational gains (Erdenebulgan, 2020; Wang et al., 2024), while others highlight modest financial benefits due to high eco-innovation costs, despite supportive policies (Sarfraz et al., 2023). More recent evidence links CE practices such as recycling, reverse logistics, and circular innovation with improved ROA and profitability (Mondal et al., 2024; Šapalaitė & Kiaušienė, 2023). Accordingly, this study emphasises financial performance, particularly ROA, as a key outcome variable for assessing the implications of CE adoptions

Digitalisation

Digitalisation refers to the integration of DTs into organisational processes, enabling the transformation of operations, decision-making, and value creation. Recent literature found that digitalisation is increasingly treated as a multidimensional driver of firm performance with measurable effects on financial returns, social outcomes, and carbon reduction, though results vary by technology type and firm capabilities (Bindeeba et al., 2025). The integration of cutting-edge DTs, including AI, big data analytics, the IoT, and blockchain, has been shown to improve stakeholder engagement, foster innovation, and enhance operational efficiency, thereby simultaneously improving multiple performance outcomes (Kristoffersen et al., 2020).

Digitalisation improves environmental management by enabling real-time monitoring, process optimisation, and data-driven control of energy and material flows. A study conducted by Huang et al. (2025) concluded that digital transformation reduces carbon emission intensity in Chinese industrial firms; the impact was greatest in capital- and technology-intensive sectors and in Eastern and Western regions. In addition to that, by improving transparency, accessibility, and inclusivity in business operations, digitalisation enhances a company's ability to address the SDGs. According to the findings of cross-national analyses conducted in the EU-27, nations with greater degrees of digital transformation, like Finland, the Netherlands, and Denmark, show greater progress toward achieving the SDGs, demonstrating how digitalisation fosters social cohesion and fair access to services (Nosratabadi et al., 2023).

Moreover, Abou-foul et al. (2021) conducted a structural equation modelling investigation utilising survey data from 185 manufacturing firms in the United States and Europe. They discovered that the financial performance of firms is directly and positively impacted by both digitalisation and servitisation. Critically, their discoveries indicate that the integration of digital capabilities with service-oriented business practices is essential for achieving superior financial results, as this

profoundly alters the firm's value proposition. Given digital transformation's role in reducing emissions and improving resource efficiency, the CE offers a complementary approach by promoting closed-loop systems that minimise waste and maximise material reuse. Recent scholarship increasingly positions digitalisation as a critical enabler of the CE, linking technological advancements to improved resource efficiency and closed-loop value creation.

HYPOTHESIS DEVELOPMENT

CE and Environmental Performance (Carbon Emission Reduction)

The adoption of CE strategies is widely acknowledged as a transformative method for achieving sustainability across industries. CE focuses on closing material loops, extending product lifecycles, and minimising waste, which directly supports the decarbonisation agenda. Prior research has shown that CE measures such as resource efficiency, recycling, eco-design, and remanufacturing help to reduce greenhouse gas emissions by reducing energy use and material extraction (Harith et al., 2023; Kirchherr et al., 2023). Furthermore, carbon emission reduction has emerged as a significant performance metric, showing companies' compliance with global climate obligations such as the Paris Agreement and the SDGs (Wang et al., 2024). Firms that use CE are expected to demonstrate reductions in their environmental footprint. A recent study indicates that CE adoption enables firms to manage climate-related risks by incorporating low-carbon strategies in core operations and supply chains (Centobelli et al., 2021). In conclusion, the incorporation of CE practices provides businesses with a methodical approach to decouple growth from resource use and to advance global climate commitments. Companies not only improve efficiency and resilience but also contribute to tangible reductions in carbon emissions by integrating circular strategies into their operations. This reinforces the central role of CE as a catalyst for sustainable transformation. Therefore, this study proposes the following hypothesis.

H1: CE practices have a positive impact on environmental performance through carbon emission reduction.

CE and Social Performance (Social SDGs)

In addition to environmental advantages, the implementation of CE principles produces considerable social benefits by transforming production and consumption systems to promote inclusion and equity. CE fosters innovative business models, including resource-sharing platforms, product-service systems, and collaborative consumption, which enhance resource efficiency and catalyse job creation and skill enhancement across many sectors (Murray, Skene, & Haynes, 2017). CE prioritises techniques including waste reduction, product reuse, material recycling, and commodities refurbishment, which enhance environmental sustainability and promote social advantages. CE practices can generate new job possibilities in industries such as recycling, repair, and remanufacturing, therefore fostering decent work and economic growth (SDG 8) (Ortiz-de-Montellano et al., 2023). Furthermore, by facilitating more equitable access to resources and services, CE can contribute to the mitigation of inequalities (SDG 10). Moreover, CE promotes responsible consumption and production patterns (SDG 12) by advocating for sustainable practices across all industries. Research indicates that CE can facilitate the attainment of certain SDGs, notably SDG 6 (Clean Water and Sanitation) and SDG 8 (Decent Work and Economic Growth) (Aborujilah et al., 2023). In conclusion, the implementation of CE principles is expected to yield substantial social benefits by promoting equitable access to resources, inclusive development, and community well-being. CE enables firms to operationalise their social responsibilities in a measurable and impactful manner by aligning corporate strategies with Social SDGs. Consequently, it is proposed that firms that implement CE practices will exhibit improved social performance, indicating tangible contributions to global sustainability objectives and societal welfare.

H2: CE practices have a positive impact on social performance through Social SDGs.

CE and Financial Performance (ROA)

CE practices represent a strategic method for firms to increase economic value while simultaneously addressing environmental and societal issues. CE prioritises resource efficiency, waste minimisation, product lifespan extension, and closed-loop systems, which together enhance operational efficiency and lower production costs. Adopting CE principles enables firms to optimise material utilisation, implement recycling and reuse strategies, and introduce innovative business models such as product-as-a-service, which can create new revenue streams and enhance profitability.

Financial performance is positively correlated with the adoption of CE, as indicated by empirical evidence. For example, Sarfraz et al. (2023) analysed European G7 firms and discovered that CE practices, such as reuse, sharing, repair, and recycling, produce tangible financial benefits by enhancing efficiency and reducing costs. In the same vein, Šapalaitė and Kiaušienė (2023) observed a substantial positive correlation between refuse recycling volumes and ROA, underscoring the enhancement of asset efficiency by circular strategies. Furthermore, Mondal et al. (2024) demonstrated that CE practices, including resource optimisation, circular innovation, and reverse logistics, are substantial predictors of firm profitability through the application of PLS-SEM and fsQCA methodologies. Consequently, it is anticipated that organisations that incorporate CE into their operational and strategic frameworks will achieve enhanced financial outcomes.

H3: CE practices have a positive impact on financial performance through ROA

Moderating Role of Digitalisation Effect between CE and Sustainable Performance Through TBL

Digitalisation is becoming more widely acknowledged as a critical enabler of CE implementation, which improves the capacity of firms to achieve sustainability in the economic, social, and environmental domains. The implementation of advanced DTs, including the IoT, AI, and big data analytics, in the environmental domain (Planet), enables organisations to monitor, optimise, and anticipate energy and material flows. Consequently, this enhances the efficiency of resource utilisation and the reduction of carbon emissions (Huang et al., 2025; Nosratabadi et al., 2023). Digital investment, which involves the allocation of financial and infrastructural resources to digital systems, enhances the ability of firms to integrate CE strategies into production and supply chain operations, thereby facilitating more effective waste reduction, recycling, and circular resource management (Abou-foul et al., 2021). In addition, the translation of digital tools and investments into tangible sustainability outcomes, such as improved operational efficiency, compliance, and reporting accuracy, is facilitated by digital enablers, which include organisational capabilities, governance structures, and skilled personnel (Bressanelli et al., 2024).

In the environmental domain (Planet), digitalisation allows companies to systematically monitor, measure, and optimise energy consumption, material flows, and emissions throughout production and supply chain operations. Real-time tracking and predictive modelling are facilitated by advanced digital tools, including the IoT, big data analytics, and digital twins. This enables organisations to identify inefficiencies, reduce waste, and enhance carbon emission reduction outcomes. In the social domain, digital solutions facilitate inclusive operations, boost transparency in supply chains, and fortify stakeholder interaction, hence augmenting contributions to Social SDGs. In the economic sphere, digitalisation facilitates cost reduction, enhances operational efficiency, and promotes data-driven strategic decision-making, thereby augmenting financial returns. Digitalisation serves as a crucial moderating factor in the relationship between CE practices and sustainable performance by enhancing their influence on environmental, social, and economic outcomes.

H4: Digitalisation positively moderates the relationship between CE practices and environmental performance through carbon emission reduction

H4a: Digitalisation positively moderates the relationship between CE practices and social performance through Social SDGs

H4b: Digitalisation positively moderates the relationship between CE practices and financial performance through ROA

CONCEPTUAL FRAMEWORK

The conceptual framework of this study examines the relationships among CE sustainable firm performance and digitalisation as depicted in Figure 1. CE is the independent variable and is operationalised through the 9Rs, which are categorised into three dimensions: Material Management (Refuse, Reduce), Product Management (Reuse, Repair, Refurbish, Remanufacture, Repurpose), and Waste Management (Recycle, Recover). Sustainable firm performance is the dependent variable, measured using the TBL dimensions: environmental performance, social performance, and financial performance. Environmental performance is captured through carbon emission reduction, social performance is operationalised using Social SDGs, and financial performance is measured using accounting-based indicators, such as ROA. Digitalisation, encompassing DTs, digital investments, and digital enablers, serves as

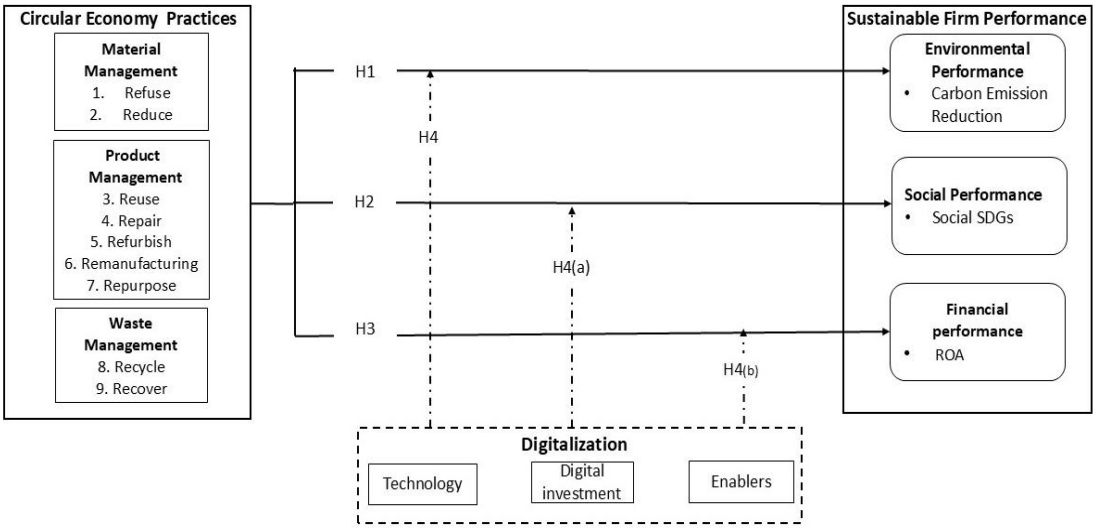


Figure 1 Conceptual framework of the study

a moderating variable that strengthens the relationship between CE practices and sustainable performance.

To further enhance the clarity and readability of the proposed conceptual framework, Table 1 summarises the key constructs, corresponding hypotheses, and proposed measurement approaches. This overview provides a concise reference for understanding the relationships among the study variables and their proposed operationalisation.

METHODOLOGY

This study is conceptual in nature; it delineates a methodological design that can be implemented in future empirical research to substantiate the proposed

Table 2 Summary of constructs, hypotheses, and proposed measurements

Construct Name	Dimensions	Hypothesis Statement	Measurement of Variables
Independent Variable CE Practices	Material Management R1- Refuse R2-Reduce	N/A	Content Analysis Technique (0,1,2,3)
	Product Management R3-Reuse R4-Repair R5-Refurbish R6-Remanufacturing R7-Repurpose		
	Waste Management R8-Recycle R9-Recover		
Dependent Variable Sustainable Firm Performance	Environmental Performance Carbon Emission Reduction	H1	$Corbon\ Intensity = \frac{Scope\ 1 + Scope\ 2 + Scope3}{Net\ Sales}$
	Social Performance Social SDGs	H1	Content analysis (binary coding: 0–1)
	Financial Performance ROA	H3	$ROA = \frac{Net\ Income\ attributable\ to\ shareholders}{Total\ Assets}$
Moderating Variable Digitalisation	Technology	H4, H4a, H4b	Content analysis (binary coding: 0–1)
	Digital Investment		
	Enablers		

framework. The proposed research design employs a quantitative methodology and utilises secondary data to investigate the relationship between sustainable firm performance and CE practices, as moderated by digitalisation. The population of this study is centred on publicly listed manufacturing firms in Malaysia, specifically those operating within the Industrial Products & Services and Consumer Products & Services sectors of Bursa Malaysia. It is suggested that the sample concentrate on companies with a market capitalisation of RM 500 million or more to guarantee data comparability and reporting consistency. Firms that meet this criterion are more likely to have robust disclosure policies, adequate operational and financial resources, and the organisational capability needed to successfully apply and incorporate CE practices into their business plans. The proposed analysis period is from 2016 to 2022, coinciding with the implementation of Bursa Malaysia's enhanced sustainability reporting framework (2015-2016), which considerably increased the quality of ESG disclosure. The firm will be the unit of analysis, and data from annual and sustainability reports will be used to observe the firm over time.

This research advocates the utilisation of secondary data obtained from annual reports, sustainability reports, and the DataStream database. Financial indicators, including ROA, will be obtained from the DataStream database. Environmental performance will be quantified through carbon emission reduction, assessed as carbon emission intensity (Scope 1, Scope 2, and Scope 3 emissions divided by sales), with data sourced from the Refinitiv DataStream database. Non-financial data related to CE practices, social performance (Social SDGs), and digitalisation will be extracted from companies' sustainability reports via content analysis. A content analysis approach is presented to assess sustainability disclosures. The annual and sustainability reports will be carefully assessed using a specified coding manual that describes the coding categories, inclusion criteria, and scoring methodologies for each indicator. This technique improves uniformity, transparency, and comparability between firms and reporting periods.

CE practices will be measured using the 9Rs framework, categorised into three dimensions: material management, product management, and waste management. A weighted content analysis method will be utilised for sustainability reports, in which disclosure elements are categorised on a four-point scale (0–3). A score of 0 signifies no reference to CE practices, 1 offers descriptive assertions, 2 represents measurable objectives or statistics, and 3 suggests evidence of goal attainment relative to previous periods. This approach guarantees a more rigorous and comparable evaluation of CE adoption among firms. Social performance will be assessed through Social SDGs, namely SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-Being), SDG 5 (Gender Equality), SDG 8 (Decent Work and Economic Growth), and SDG 10 (Reduced Inequalities). A binary scale (0–1) will be utilised, with 0 indicating no disclosure or alignment and 1 denoting explicit disclosure or proof of alignment with the specified Social SDGs.

To assure the suggested measures' reliability and validity, the indicators for CE practices, Social SDGs, and digitisation are based on recognised theoretical frameworks and previous research. Content validity is supported through the adoption of the 9R framework (Potting et al., 2017; Rani et al., 2026) and SDG indicators (Hamad et al., 2024), while coding reliability may be enhanced through the use of standardised coding guidelines and pilot testing (Krippendorff, 2004).

The data collected will be analysed using both descriptive and inferential statistical techniques for the proposed study. Descriptive data, including mean, standard deviation, and frequency distribution, will encapsulate the degree of CE adoption, alignment with Social SDGs, digitalisation processes, and performance outcomes among organisations. Inferential statistics, specifically Ordinary Least Squares (OLS) regression, are advised to examine the proposed hypotheses among CE, digitalisation, and sustainable firm performance. OLS regression is offered as the primary analytical technique since it is commonly used to evaluate relationships between independent and dependent variables and is suitable for testing the presented hypotheses involving continuous performance metrics. Prior to the analysis, essential diagnostic tests should be performed to ensure the model's applicability. STATA software is recommended for econometric analysis because of its efficacy in managing panel data, doing regression diagnostics, and implementing fixed- and random-effects models.

CONCLUSION

This study introduces a conceptual framework examining the impact of circular economy (CE) activities on sustainable performance via the Triple Bottom Line (TBL) perspective. Sustainable performance is measured through three proxies: environmental performance (carbon emission reduction), social performance (social Sustainable Development Goals, SDGs), and financial performance (return on assets, ROA). The framework delineates CE into Material Management, Product Management, and Waste Management, with the 9Rs of CE grouped to cover these dimensions. Digitalisation is incorporated as a moderating variable, enhancing the CE practices-sustainable outcomes relationship by optimising processes, improving resource efficiency, and promoting innovation across the value chain, thereby strengthening material, product, and waste management strategies and improving environmental, social, and financial performance. This framework offers a theoretical platform for future empirical validation and practical insights for managers, researchers, and policymakers, showing that CE effectiveness depends on both strategy adoption and digital technology integration, with implications for decision-making, resource optimisation, and policy support aligned with global sustainability agendas such as the SDGs.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

AUTHORS' CONTRIBUTION

Mahwish Rani conceptualised the study, conducted the research, and drafted the manuscript. Fong-Woon Lai provided supervision and guidance in developing the research framework and contributed to the refinement of the manuscript. Muhammad Kashif Shad critically reviewed and edited the manuscript for important intellectual content. All authors read and approved the final version of the manuscript.

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