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A Sustainable Circular Business Model to Improve the Performance of Small and Medium-sized Enterprises Using Blockchain Technology

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Abstract

The paper analyzed the function of Blockchain Technology (BT) in the Circular Economy (CE) to improve the performance of Small and Medium-sized Enterprises (SMEs). It presents a Sustainable Circular Business (SCB) model that utilizes BT to improve the performance of SMEs. A closed-ended questionnaire survey was conducted to gather cross-sectional data from 275 SMEs. A total of 400 questionnaires were issued, of which 285 were received. The CE method in Circular Supply Chain Management (CSCM) provides both ecological and economic advantages to organizations. The advent of the Industry 4.0 era has brought about a strong focus on technology across all industries. The emergence of BT, a relatively new phenomena, has significant potential for enhancing the processes of SMEs. The findings indicate that BT favors the CE due to its characteristics like exposure, accountability, relationship management, and smart contracting. Also, it has been discovered that adopting environmentally friendly methods had a beneficial connection with both the environmental and economic aspects of SMEs performance. Additionally, it was also seen that the ecological sustainability of the business had a favorable relationship with its economic well-being. Finally, it was discovered that both sustainability and economic capabilities were responsible for enhancing the performance of SMEs.

Keywords: Circular Economy, Sustainable Circular Business Model, Small and Medium-sized Enterprises, Blockchain Technology.

1 Introduction

Conventional economies are structured according to a linear resource paradigm that follows a "take-make-dispose" cycle. Once the consumer has finished using the commodity, they discard it, resulting in a significant amount of the limited resources being squandered. The 21st century has seen the emergence of supply instabilities and increased resource costs due to an economy that operates on a linear structure. This framework has led to financial and fiscal instability in individual firms and global prosperity (He

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& Ortiz, 2021). In recent times, policymakers have been actively engaged in addressing various sustainability challenges within the framework of a CE (Sreenivasu et al., 2022).

Asset constraint has been a fundamental principle in economics, but it has often been accepted without question. The pricing method considers the issue of limited resources. Specifically, a system has to be implemented where the price increases in response to rising demand and greater scarcity (Velenturf & Purnell, 2021). While there were theories of management that focused on the effectiveness of the manufacturing process and advocated for the optimal use of supplies, these theories did not prioritize the concept of resource functionality (Oleksandr et al., 2024).

The manufacturing process maintained a linear approach. This model is sometimes called the linear economy, which involves the sequential production, consumption, and disposal processes. Due to the intrinsically unsustainable character of the linear economy, the problem of limited resources has been addressed very inventively, leading to the idea of the CE. CE is a production method that involves a cyclical approach consisting of producing, using, recovering, recycling, and remanufacturing (RR). The 3Rs (recycle, reduce, and reuse) are often regarded as the core principles of a CE (Barreiro-Gen & Lozano, 2020; Buljubasic, 2020; Aydalga et al., 2020).

The pursuit of sustainability is just one aspect of the current economic and commercial landscape; the relentless drive for profitability is equally crucial for organizations. This binary equation includes several aspects of the notion of CE. The elements included in this context include the recycling of materials, the recovery of energy, the reconstruction of value, the eradication of waste, the decrease of emissions, and the preservation of the earth's resources (Tripathy & Narkulwad, 2022 ; Stevovic et al., 2018; Imam et al., 2022). A comprehensive strategy is required at every production stage to fully execute a CE, including development, design, processes, and assessment. In the field of SCM, the authors in (Zhuang et al., 2023; Shih et al., 2019) have eloquently summarized the notion of the CE. They assert that the CE seeks to enhance resource effectiveness and environmental performance across all levels of SCM.

A CE requires a more extensive and inclusive SCM considering industry, society, and people. The dispersion and variability of components are the fundamental causes of difficulties in identifying, cultivating, and maintaining a consistent CE source. The combination of CE with SCM is sometimes referred to as sustainable SCM. Green SCM techniques include organizations assuming responsibility for the community and the ecology and pursuing economic gains (Halkos & Skouloudis, 2018). The environmentally friendly movement in the SCM promotes the achievement of pollution-free biodiversity for SMEs. The implementation of the green SCM not only decreases the financial impact of ecological problems and improves the effectiveness of industrial processes (Sinaga et al., 2019).

BT is a rapidly growing innovation that is causing significant changes in the industry and opening up new business opportunities (Obeidat et al., 2023). BT utilizes a distributed and "trustless" repository that efficiently handles large-scale transactions and eliminates the need for intermediaries. It also promotes dispersion among the contracting members (Mukherjee & Pradhan, 2021). BT has all the characteristics necessary to facilitate coordination among different components of a SCM to reach a common objective. For example, Maersk, a prominent global logistics company, achieved significant cost savings by collaborating with IBM to use BT to manage its nautical containers. BT can boost the openness and reliability of ethical procedures in the case of CSCM. One key deployment area for BT is tracking potential societal and ecological circumstances that might provide security, wellness, or environmental concerns.

2 Related Works

The research literature evaluations and debates on SCM, such as (Paul et al., 2021), have led to the emergence of sustainability as a prominent topic. The increasing unsustainable development worldwide may be attributed to expansion, consumption, and trade trends. The existing utilization rates will soon deplete more renewable capital unless there is an increase in item manufacturing, refinement, storage, utilization, reuse, and recycling (Wang et al., 2020). An essential factor that might play a role in this shift is the concept of the CE, which has been increasingly proposed as a superior alternative to the prevailing Linear Business Model (LBM). LBM adheres to the idea of acquisition, generation, and disposal.

Various ideas have been created and utilized indiscriminately in the literature on SCM to demonstrate the integration of sustainability ideals into SCM. These concepts include moral SCM, green SCM, environmental SCM, and closed-loop SCM (Mardani et al., 2020). Although these approaches demonstrate different levels of incorporation into sustainable supply chain operations, none have explicitly focused on the core philosophy of CE in SCM, known as closed-loop theory. Several recent articles have discussed the integration of CE in SCM within a particular setting (Batista et al., 2018). While the CE and SCM sustainability analysis may be scattered, some crucial CE concepts are strategically expressed. In contrast, others are rooted in SCM operations, such as design, acquisition, expansion, etc.

The unified application of CE-SCM will decrease the requirement for fresh supplies and enhance the distribution of commodities within SCM networks (Centobelli et al., 2021). However, the information on the integration of CE into SCM varies according to the study on CE (Centobelli et al., 2021). The focus of environmentally friendly growth at SCM was mostly on rehabilitation responses, such as repair, renovation, remanufacturing, and recycling. However, the concept of regeneration was not considered concerning the durability of SCM. Hence, enhancing the existing sustainable practices in SCM for the CSCM framework is essential.

BT is the latest trend in the field of technology. BT is the driving force underlying Bitcoin's virtual cryptocurrency (Baldan & Zen, 2020). Bitcoin is only one use of BT, causing significant changes in company operations, particularly Supply Chain (SC) processes. BT is a decentralized database that stores entries or distributed ledgers of all digital incidents that have occurred and were transmitted among collaborating members of BT. BT is built upon the decentralized ledger technology. As the chain expands, the initial versions and their value are transferred, which differs from how data and numerous versions flow via the Internet. BT captures value by saving transactions in a distributed record protected by visible and accountable recorded distributed data (Shkembi et al., 2023).

Notably, under the distributed ledger system, users can remain incognito in a public network or be accessible in a private network, such as a SCM network. One crucial distinction between public and private networks is their access to the ledger. In an open network, every user has a duplicate of the ledger and verifies transactions autonomously. Conversely, in a secure network, users must get authorization to possess a replica of the ledger and validate transactions (Muralidharan, 2020).

Within the context of BT, an agent initiates a fresh transaction to incorporate it into the BT. The newly initiated transaction is sent to all the members for verification. A fresh transaction is appended as a fresh block when a consensus is reached among the vast majority of the participants or nodes. The permission is contingent upon predefined rules, implemented by a smart contract, and cannot be altered without unanimous agreement from all participants in the network. The smart contract, a prominent aspect of BT, enables agents to carry out a verified transaction without any intermediary.

A smart contract is a software program that establishes rules and regulations for facilitating agreements and interactions between entities. The system automatically verifies whether the contractual conditions are fulfilled and carries out several transactions (Kannengiesser et al., 2021). After adding a fresh block, its data is stored at various nodes using a disintegrating technique. This is done to establish the confidence chain and improve security. Decentralization makes the system impervious to bottlenecks.

Furthermore, BT ensures transparency without inducing any changes in the behavior of the participating agents, therefore fostering increased confidence in the whole network. The primary catalyst for enhancing SCM performance is this. The impact of BT on SCM is ambiguous and requires further study and attention (Taylor et al., 2020). BT efficiently facilitates the design, organization, and strategic planning of SCM and activities.

3 A Sustainable Circular Business Model using Blockchain Technology to Enhance the Performance of SMEs

3.1 Blockchain Technology

The emergence of BT has a significant role in revolutionizing financial, ecological, and organizational performance (Romero et al., 2023). BT uses an incredibly clear system that eliminates fraudulent resource possession, double expenditure, and data manipulation. Additionally, it ensures continuous accessibility of the information. With its decentralized electronic records and associated processes, BT offers a viable solution to the challenges faced in managing global SCM. The persistent need for both domestic and global firms and consumers to achieve sustainability objectives has increased the importance of BT (Kiruthika et al., 2019; Ribalta et al., 2021).

The manufacturing sector is essential for the production of value in the BT, which has the potential to enhance commercial activity significantly. With the advent of the Industry 4.0 era, it is anticipated that by 2024, over 32% of SMEs generating about $6 billion in revenue will have implemented pilot projects connected to SMEs using BT, which now stands at less than 5%. Using the block-based solutions and the decentralized ledger framework of BT will differentiate manufacturing firms in SCM performance, particularly in CE, SMEs, and Industry 4.0. Zhu and Kouhizadeh, (2019) argue that BT may facilitate sustainable production by connecting SMEs and enabling the exchange and trade of waste materials without intermediaries, which can increase profitability by creating value from waste materials (Kouhizadeh et al., 2020).

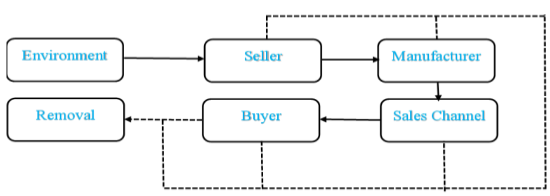
According to Adams et al., monitoring the potential social and ecological variables that might lead to wellness, ecological, and security problems is crucial. It is a key area of application for the BT (Adams et al., 2018; Yesmin et al., 2020). By using BT, it is possible to streamline SCM by reducing the number of layers involved and minimizing time, debris, and transaction costs. BT enables rapid dissemination of all data variations, facilitating rapid implementation of products and processes while minimizing transaction time and human errors. BT guarantees the security and integrity of data, resulting in a reduction in costs associated with intentional and unanticipated data tampering, an increase in SCM risks, and a drop in company dependability. BT also impacts the goods and material paths of the SCM. Various pieces of data may be collected, including the product's location, kind, and the standards used. Buyers may enhance their faith in the product's features by tracking the specific details of the items.

While BT may contribute to the sustainability of the SCM, there is significant uncertainty about its applicability in the SCM environment. Implementing precise object tracking and observation of its subsequent transactions may help minimize revisions, leading to reduced utilization of resources and emission of greenhouse gases. The electric chain is the power solution that employs BT to reduce SCM inefficiency (Padmanabhan et al., 2011). The process of recycling may be enhanced with the use of BT. Saberi et al., (2019) discovered that individuals and enterprises may lack enthusiasm for participating in recycling initiatives (Saberi et al., 2019). In the Nordic region, BT has been used to incentivize individuals by offering digital currencies as rewards in exchange for storing recyclable materials such as cans and plastic bags. Recycle To Coin is a further use of BT that assists individuals in recycling plastic bottles.

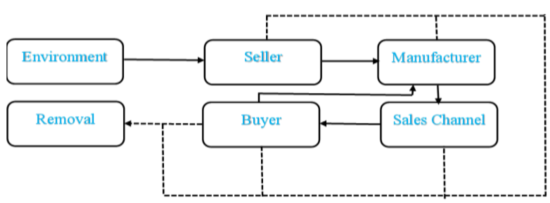
Sustainable design (SD) is a notable example of how businesses may include BT in the SCM's production and maintenance or advertising phases. SD, which prioritizes creating new products while considering environmental requirements, is impacted by a BT in multiple manners. The BT enables efficient information exchange among several stakeholders while gathering and verifying data, controlling the ecological integrity of goods, controlling project timelines for fresh manufacturing processes, and overseeing participation. Verification of the ecological effects of materials used is required in some SD systems, and specific tests must be conducted in other situations. A significant amount of ambiguity about environmental data characterizes these systems. Many simulation techniques have been suggested for sensitivity examination to address the Life Cycle Assessment (LCA) ambiguities. BT's dependability, reliability, and openness may reduce data unpredictability, resulting in enhanced inputs and outcomes for SD and LCA modeling. When the manufacturing process of a product is confirmed to be sustainable in terms of greenhouse gas emissions, ecologically concerned clients may be more inclined to purchase sustainable items.

3.2 Sustainable Circular Business (SCB) Model

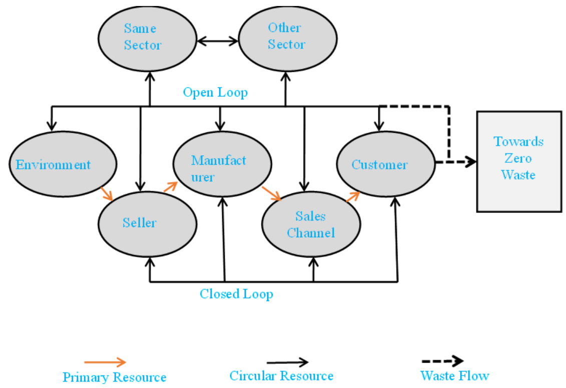
The SCB model incorporates intra and inter-level affiliate firms to maximize the use of commodities or resources. It offers a crucial structure for guiding SCM to enhance the effectiveness and profitability of investments. Additionally, there is a decrease in adverse ecological, neighborhood, and economic consequences.



(a) Linear Model



(b) Closed-loop Model



(c) SCB Model

Figure 1: Various Business Models

As seen in Figure 1, CSCM aims to contribute significantly to developing circular SCs. Figure 1 illustrates a comparison between the CSC (shown in Figure 1c), the standard linear SCM (depicted in Figure 1a), and the closed-loop SCM (shown in Figure 1b). A linear SCM exploits natural resources and seeks to dispose of products, packaging supplies, and trash generated at different points in the SC. Undesirable things are often kept in fields. The closed-loop SC enhances ecological sustainability by facilitating the return of goods and packaging components to the seller in response to their demand. The cost recovery in the closed-loop SC is confined to activities inside the original seller and does not include subsequent SCs. Additionally, extra sales channel members will be involved.

A closed SC generates significant trash due to the limited feasibility of reusing or recycling all rejected products within the same supply chain. A CSC might be used to generate profit from trash by collaborating with comparable or diverse industrial sectors. Ideally, CSC would complete waste elimination since it has been designed to consistently protect and recycle land to improve the economy and ecosystems in which it is applied. CSCs exhibit two distinct forms of resource flow: the primary and the circular movement of resources, as shown in Figure 1c. In both the linear and closed-loop SCM, the primary resource flow is defined by the progressive movement of goods. The circular flow represents the continuous movement and transformation of goods, elements, and energy as they are recycled, saved, reused, corrected, and recycled.

A thorough examination was conducted to assess the effectiveness of the proposed SCB model using a careful study of the instances. The present paper utilizes instances to investigate current trends, comprehensively analyzing specific implementations. Following the literature research, the subsequent step included selecting the firms in the study based on their primary historical background. A particular selection criterion was devised because the case studies pertain to theoretical learning rather than a statistical research methodology.

The key criterion for assessment is the extent to which the operational framework of the organization is linked to loop closure, deceleration, intensification, reduction loops, and decomposition. A survey using a closed-ended questionnaire has been executed to obtain cross-sectional information from 275 SMEs. They were selected to investigate market opportunities using the CE rationale, which involves integrating the SCB model with CSCM to foster sustainable development.

Each selected SME serves as a foundation for understanding the components and operations of CE, regardless of the particular sectors and business models involved. The data analysis mostly centered on semi-structured interviews conducted with the key informants of the SME. The data study included interviews provided by business sustainability. The study restriction has been alleviated by supplementing the interview evidence with written documentation and client databases. Interviewers often requested precise definitions for general remarks. The key informants were picked based on their presence and comprehensive understanding of each client's business plan. The interviews included questions on the characteristics and perspectives of the interviewees, which were in line with the SCB model of their companies. The research specifically examined three aspects: (i) the worth of the business, which includes the social, environmental, and economic advantages it aims to convey; (ii) the creation and dissemination methods that focus on ending the good's lifelong loop; and (iii) the level of interest shown by various stakeholders. The obtained data is assessed qualitatively based on sustainability criteria.

4 Results and Discussion

The research used a survey methodology to gather information about SMEs involved in green SCM activities, particularly those linked to manufacturing. The participants were given questionnaires and a concise explanation of the study's goal. The people who responded, consisting of management personnel from SMEs, were required to possess expertise in BT. A closed-ended questionnaire survey was conducted to gather cross-sectional data from 275 SMEs. A total of 400 questionnaires were issued, of which 285 were received. However, 20 of the returned questions were incomplete or improperly filled out. Therefore, 265 questionnaires were used for the analysis, representing an average response rate of 66.25%. Various business models have been evaluated for comparison as follows:

1. Linear Business (LB) model
2. Closed-Loop Supply Chain (CLB) model
3. Sustainable Circular Business (SCB) model

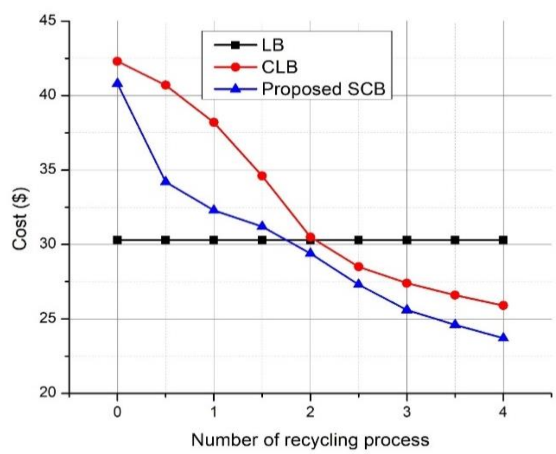


Figure 2: Cost Analysis Versus the Number of Recycling Processes for Various Business Models Using BT

Figure 2 depicts the cost analysis versus the number of recycling processes for various business models using BT. Starting at 30.3 with 0 recycling cycles, LB costs stay constant. CLB costs 42.3, whereas proposed SCB costs 40.8. Recycling is economically beneficial since all business models' costs reduce as recycling frequency increases. At 0.5 recycling cycles, LB remains at 30.3, CLB drops to 40.7, and Proposed SCB drops to 34.2, higher than CLB. After one recycling cycle, LB stays at 30.3, CLB drops to 38.2 and proposed SCB drops to 32.3. LB maintains 30.3, CLB drops to 34.6, and Proposed

SCB drops to 31.2 after 1.5 cycles. LB remains at 30.3, CLB falls to 30.5, and Proposed SCB falls to 29.4 in two cycles. At 2.5 cycles, the LB value stays at 30.3, the CLB value drops to 28.5, and the proposed SCB value drops to 27.3. After three recycling cycles, the LB stays at 30.3, the CLB drops to 27.4, and the proposed SCB drops to 25.6. When 3.5 cycles are completed, LB remains at 30.3, CLB drops to 26.6, and proposed SCB drops to 24.6. After four recycling cycles, LB remains at 30.3. CLB drops further to 25.9, while Proposed SCB drops to 23.7. In general, the proposed SCB always has lower costs than CLB as recycling cycles increase.

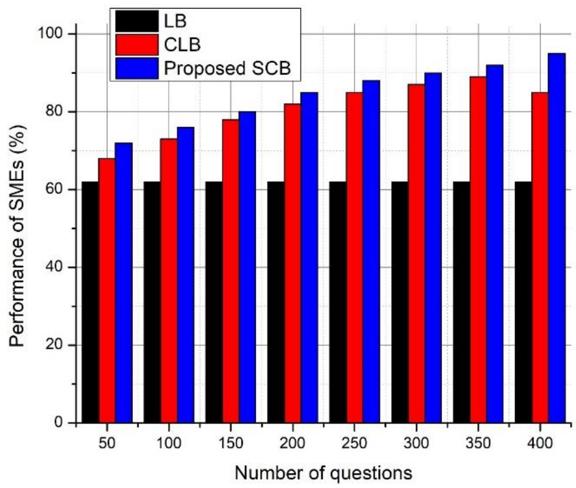


Figure 3: Overall Performance of SMEs (%) Versus the Number of Survey Questions for Different Business Models Using BT

Figure 3 illustrates the overall performance of SMEs (%) versus the number of survey questions for different business models using BT. LB model performance remains 62% independent of question count, demonstrating no improvement with question count. However, the CLB model improves from 68% accuracy with 50 questions to 89% with 350 questions before declining to 85% with 400 questions. The CLB model benefits from more survey questions, but only a limited amount. As suggested, the SCB model performs well at all question counts, from 72% with 50 questions to 95% with 400 questions. This steady ascent trend shows that the SCB model uses survey data to improve SMEs' performance. The SCB model outperforms LB and CLB models at every level, especially at 200 questions (85%) and beyond. Its versatility and use of survey data to improve SME performance are impressive.

5 Conclusion

This paper proposes a Sustainable Circular Business (SCB) paradigm that improves SME performance via BT. A closed-ended questionnaire was used to collect cross-sectional data from 275 SMEs. CSCM incorporates CE into SCM, offering a new and compelling viewpoint on supply chain sustainability. The CE approach in CSCM has benefited SMEs both economically and ecologically. All sectors now prioritize technology due to Industry 4.0. The relatively recent phenomenon of BT has great potential to improve SME operations. The proposed SCB constantly demonstrates reduced expenses and improved performance compared to CLB as the number of recycling phases and survey questions rises. This emphasizes the cost-effectiveness and economic feasibility of the proposed SCB model in using CE and CSCM procedures to decrease costs and improve the performance of SMEs.

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Authors Biography

Dr. Danielle Khalife is currently occupying the position of Dean. Her research focuses on venture capital financing, entrepreneurship, financial modeling, and corporate governance Danielle studied the impact of country governance on the sustainability of the banking sector in emerging economies and analyzes corporate governance effects on bank profits during the pandemic in Gulf Cooperation Council countries. Additionally, Khalife examined psychological and demographic predictors of cryptocurrency investment during crises in the MENA region, studied the influence of investors' sentiments on S&P 500 price levels using deep learning models, and assessed the impact of financial literacy and self-control on individual financial performance during the Lebanese crisis. She leverages quantitative methods to provide insights and potential solutions for navigating complex economic and financial landscapes. In addition to her academic career, Danielle serves as a board member of consulting and trading companies. She got professional certificates in trading from the London Trading Clinic and the London Stock Exchange.

Prof. Dr. Satya Subrahmanyam is a Post Doctoral scholar with dual PhDs, with a diverse career encompassing both academia and management. My professional journey includes teaching graduate students at Ambedkar Open University and managing assignments at prestigious institutions such as Cambridge University and the University of London. I currently serve as the Managing Partner and Trust Member at Vignan Institute of Technology and Management, and as a Professor and Dean (Research) at Holy Spirit University in Kaslik, Lebanon. Previously, I have held significant roles including Professor, Director of the Research Centre, and Director of the Lifelong Learning Centre at the Catholic University in Erbil, Kurdistan Region.

Dr. Assaad Farah joined AUD in 2010, and before assuming the role of Dean, he served as the school's Associate Dean and Director of Accreditation. In addition to his academic responsibilities, Dr. Farah is an executive trainer and consultant, mainly for the United Arab Emirates public sector. His roles also extend to being a Board member of the UNDRR ARISE, a member of the (AACSB) Initial Accreditation Committee, and the Chair of the AACSB International Middle East & North Africa Advisory Council. Before moving to Dubai, Dr. Farah worked in Canada's aeronautical and mobile industry. Dr. Farah's research focuses on knowledge management, strategic human resource management, airline management, and artificial intelligence.