The Circular ERP: System Requirements for Managing Closed-Loop Resource Flows and Product Lifecycles

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ABSTRACT

As industries move towards a circular economy, traditional Enterprise Resource Planning (ERP) systems struggle with a significant information gap during the product usage and end of life stages. To address this architectural limitation, this study highlights the essential system requirements for a Circular ERP (C-ERP) platform tailored for closed-loop resource management. Through a structured conceptual review of 30 high-impact studies retrieved from the Scopus database and a subsequent integrative thematic analysis, the research identifies three core capabilities for Circular ERP which are technological tracking, data interoperability, and organizational readiness. Guided by Dynamic Capabilities Theory, this study proposes an Integrated Circular ERP Architecture driven by closed loop feedback mechanism, Digital Product Passports (DPPs), AI-powered decision intelligence and Data Lakehouse infrastructures where ELT pipelines flow exclusively into the centralized platform. Ultimately, this architecture offers a strategic roadmap for shifting legacy transactional systems into unified coordination platforms across decentralized circular ecosystems while supporting the United Nations Sustainable Development Goals. The main contribution of this study is a theoretically grounded conceptual Circular ERP architecture that integrates fragmented lifecycle data into a unified Lakehouse platform that eliminates data fragmentation across the Beginning-of-Life (BOL), Middle-of-Life (MOL), and End-of-Life (EOL) phases. This framework practically supports manufacturers and policymakers by providing a structured architecture to guide future empirical validation through industrial case studies.

Keywords: Enterprise Resource Planning; Circular Economy; Closed-Loop Resource Flows; Enterprise Architecture

INTRODUCTION

In favour of a circular economy (CE), modern industries face unavoidable pressure and an immediate need to move away from the traditional "take-make-dispose" practices. This shift is critical given that by 2020, global material consumption has reached a staggering 100 billion tonnes due to growing resource demand even as the global circularity rate dropped from 9.1% in 2018 to 8.6% in 2020. Overcoming this challenge requires the implementation of strict regulatory framework enforcement such as the European Green Deal and the Circular Economy Action Plan to ensure resource longevity, asset reuse, and aggressive waste reduction. In response to these regulatory developments, enterprises are forced to undergo comprehensive operational transformation and shift away from legacy management practices.

These industrial overhauls created a system which is known as Enterprise Resources Planning (ERP) systems. The main functions of the traditional ERPs system were originally engineered to support standard, one-way supply chains while also functioning perfectly as an internal system of record. However, the current literature highlights a severe information gap that is built directly into standard enterprise architecture because of their liner design. Even though the systems track Beginning-of-Life (BOL) data effectively during early design and production phases, data visibility is completely broken down once a product reaches its Middle-of-Life (MOL) usage or End-of-Life (EOL) recovery stage. Hence, companies struggle to run efficient reserve logistics, coordinate remanufacturing schedules and satisfy extended producer responsibility mandates without multi-lifecycle and real-time data. These operational challenges become more severe when the static database schemas experience configuration drift especially when organizations try to accommodate an unstructured lifecycle that cannot be processed by the inflexible legacy ERPs system.

This study adopts the lens of Dynamic Capabilities Theory (DCT) to understand how a firm can survive in such an unprecedented, volatile, and unpredictable operational environment and landscape. A firm's survival depends on its ability to systematically reconfigure its asset base, seize emerging opportunities, and environmental changes (Teece et al.,1997). Although researchers have recognized that data loss occurred between lifecycle stages, the literature still lacks a standardized and clear blueprint that explains how an enterprise platform can plan out their dynamic reconfiguration. To address this gap, this study proposes a conceptual framework known as Circular ERP (C-ERP) architecture designed to orchestrate assets across several lifecycles simultaneously. By implementing IoT sensors for real-time asset monitoring, AI for predictive disassembly, Block chain technologies, and Digital Product Passports (DPPs) for unit-level traceability, this architecture enables a decentralized and secure data foundation. This framework not only ensures compliance with EU's Ecodesign for Sustainable Products Regulation (ESPR) but also untangle complex data streams across scattered supply networks.

Through a structured conceptual review of recent and high impact literature, this paper establishes a comprehensive set of system requirements for Circular ERP. Using an integrative thematic analysis, a theoretically grounded architecture was designed to manage closed-loop resources flows by synthesizing structural and architectural barriers across various industries. The main contribution of this study is an integrated architecture that bridges the data gaps between the Beginning-of-Life, Middle-of-Life, and End-of-Life phases. This architecture helps in transforming traditional linear databases into active circular orchestration platforms. By combining AI-driven decision intelligence and Data Lakehouse infrastructures, this architecture provides a conceptual foundation to support autonomous circular ecosystems and inform future empirical research.

LITERATURE REVIEW

Paradigm Shifts in Enterprise Architecture

According to Badillo-Piña & Tejeida-Padilla, 2005; Kurbel, 2008, from the early 1960s the Enterprise Resource Planning System has evolved over multiple decades by moving away from simple and localized inventory calculations functions toward ecosystem wide resource orchestration. During the early stages of this ERP evolution, most enterprises are dependent on Material Requirements Planning (MRP) and updated version Manufacturing Resources Planning (MRP II). With broader business objectives and high-level business goals, the role of MRP and MRP II had successfully aligned day to day manufacturing operations (Blevins, 1994; Kurbel, 2008).

Regardless of the continuous advancement in Information Technology (IT), the core legacy enterprise platforms are conceptually geared towards an industrial model with a "Take-Make-Dispose" linear model that prioritizes forward logistics for efficiency and speed (Chofreh et al., 2017). A foundational flaw in these legacy systems is their reliance on standard relational databases where it forces a material's lifecycle tracking to end completely at the point of sales which makes it impossible to support the regenerative needs of a circular economy (Chofreh et al., 2017). Although early Sustainable ERP frameworks based on the Triple Bottom Line successfully integrated environmental tracking into corporate databases (Chofreh et al., 2017, 2018), current research explained they are insufficient for circular economics. Many organizations used these systems for basic environmental accounting and compliance reporting instead of helping businesses physically recover and reuse materials (Agarwal & Gupta, 2024).

The Theoretical Foundations: Dynamic Capabilities Theory in Circular Systems

To navigate the inherent volatility of closed loop supply, the organizations must develop specific organizational requirements and routines which are extended beyond the static resources management. Based on Dynamic Capabilities Theory (DCT), a firm's competitive advantages depend on its ability to build, integrate, and reconfigure internal and external competences to address the rapid changes in environmental shift (Teece at al., 1997). In a circular economy, these capabilities are essential to mitigate persistent uncertainties such as unpredictable return rates, shifting regulatory mandates, and fluctuating secondary material quality (Guide & Van Wassenhove, 2009). However, traditional ERP systems known as static assets constrain organizational flexibility and fail to support complex data flows of multi-lifecycle operations.

A Circular ERP (C-ERP) system operationalizes Teece's (2007) dynamic capability pillars by translating DCT into a digital architecture. It allows sensing through real-time IoT and telemetry to identify resource recovery opportunities and environmental threats. Second, the system provides seizing by leveraging AI and advanced analytics as a main strategic differentiator by changing complex circular data into sustainable competitive advantages (Davenport & Harris, 2007). Finally, it supports transforming by continuously reconfiguring enterprise supply networks and database schemas. This flexibility is achieved through Digital Product Passports (DPPs) and modern system design where ELT pipelines send data only to the Data Lakehouse which disconnects the data from the main application.

The Cybernetics of Closed-Loop Resource Flows

Organizations must close the severe data gap that occurs between a product's Beginning-of-Life (BOL), Middle-of-Life (MOL) and End-of-Life (EOL) phases. During the initial design phase, data visibility is robust and highly transparent. However, the data tracking completely drops and degrades during the consumer use and recovery phases. The limitation in data visibility during the EOL stages prevents organizations from effectively managing reverse logistic and remanufacturing workflows (Kiritsis et al., 2008; Jayant et al., 2012). Therefore, the implementation of a Closed Loop Product Lifecycle Management (PLM) architecture can bridge this gap by ensuring a continuous information loop from production through the recovery stage (Jun et al., 2007).

Moreover, prior researchers have applied Stafford Beer's Viable System Model (VSM) as a structural guide and a recursive framework to maintain a stable business architecture while managing the non-linear complexity of circular material loops (Tejeida-Padilla et al., 2010; Badillo-Piña & Tejeida-Padilla, 2005). In accordance with Ashby's Law of Requisite Variety, a Circular ERPs must possess an advanced level of internal complexity to successfully manage the extreme volatility of a circular ecosystem. Hence, Circular ERP systems are important for releasing cybernetic feedback loops allowing organization to balance raw material scarcity with erratic consumer product returns (Slassi-Sennou & Elmouhib, 2026; Tejeida-Padilla et al., 2010)

The Digital Nexus of Circular Intelligence

The significant transformation brought by Industry 4.0 had shifted traditional ERP into Circular ERP which had turned a passive and conventional software that functioned as a "record keeper" into an intelligent and active operational manager system (Singh, 2024). The organizations are now able to evaluate whether a used product can be successfully remanufactured by using real-time Internet of Thing (IoT) sensors and data streams whereas previously the products needed to physically arrive at a recycling centre before determining whether they could be remanufactured. (Prakash et al., 2022; Walia et al., 2024). By integrating Artificial Intelligence (AI) into Master Data Management (MDM), it provides organizations to translate this raw sensor data into actionable business intelligence, enabling immediate decision-making, optimized disassembly sequencing, and automated price forecasting for secondary materials. Moreover, block chain and distributed ledger technologies creates an unchangeable "digital trust layer" across fragmented supply chains which supplies a clean Chain of Custody for materials and allows for the sharing of sensitive sustainability data. This digital advancement continues to evolve in line with regulatory pressures like the European Union's Eco design for Sustainable Products Regulation (ESPR) which requires the implementation of Digital Product Passports (DPPs) for strict item-level traceability (Bruno et al., 2026).

The Post Implementation Longevity Gap

Around 60 % of traditional ERP implementations fail to operate as intended and experience multiple configuration problems in the first year. This high failure rate of ERP systems shows there is a high overlooked risk in setting up enterprise systems (Singh, 2024). When organizations try to start using circular models, they have to deal with a complex and dynamic business environment with new environmental rules and unpredictable numbers of products being returned (Govindan & Hasanagic, 2018; Guide & Van Wassenhove, 2009). The organization's operational agility is affected by the external uncertainties and configuration changes in traditional ERP systems. Moreover, enterprise systems need to use a database that can adapt to changes of strict software rules so that they can comply with environmental rules and use advanced AI models to value materials. The new ERP architectures where ELT pipelines flow into centralized Data Lakehouses to separate data models from main application logic allow businesses to keep flexible and maintain their systems easily for circular operations (Bressanelli et al., 2022).

Transition to the Research Gap

A limitation of the existing literature is that previous studies have proposed fragmented frameworks where most of the research focus on standalone tools such as individual corporate carbon footprints or single sensor tracking. This leaves a critical theoretical gap regarding how to blend these isolated features to construct a fully integrated Circular ERP environment. In response to recent calls for integrated frameworks (Mukwenha & Mutanga, 2025), this study synthesizes current literature to construct a comprehensive conceptual framework. .Based on an integrative thematic analysis of system requirements, this study the framework offers a practical and theoretically grounded for organizations in need to implement Circular ERP platforms.

METHODOLOGY

Research Design

This study adopts a conceptual research approach to analyse and integrate existing literature on Circular Enterprise Resource Planning (ERP) platform specifications, enterprise data integration frameworks, and stakeholder alignment. A conceptual synthesis approach is an appropriate method for the study as it provides the necessary analytical flexibility to integrate diverse theories, technical empirical findings, and industrial trends within a field (Snyder, 2019). Unlike quantitative systematic reviews that focus on rigid statistical data extraction and meta-analyses, a structured conceptual review provides a more comprehensive and strategic discussion of the topic that allows a critical examination of prior research and the systematic identification of research gaps (Green et al., 2006; Snyder, 2019).

The conceptual approach selected due to its suitability for mapping out the precise data specifications and organizational adjustments necessary to transition legacy transactional platforms into circular economic models. This method supports the combination of theoretical and empirical studies to provide a comprehensive discussion that contributes to both academic knowledge and managerial practice.

Data Collection and Search Strategy

The data collection process for this study was conducted through the Scopus database due to its extensive indexing of peer-reviewed literature in enterprise systems and sustainable operations. The search strategy selected core literature by using a combination of the keywords "ERP", "Circular Economy" and “System Requirements” across document titles, abstracts, and metadata. The finalized search string utilized for document retrieval was presented as :("circular" OR "sustainable" OR "closed-loop" OR "regenerative") AND ("ERP" OR "enterprise resource planning" OR "resource management" OR "system") AND ("requirements" OR "criteria" OR "specifications" OR "needs") AND ("implementation" OR "adoption" OR "integration" OR "development") AND ("business process" OR "supply chain" OR "operations" OR "management").

To improve the reliability and relevance of the review, several inclusion criteria were applied which include filtering the database results to focus on high-impact academic articles published within the last five years (2021-2026). The selection boundaries were further limited to full-text accessible studies written in the English language. Studies that were duplicated, inaccessible, or unrelated to Circular ERP implementation and sustainable enterprise systems were excluded from the analysis.

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Data Analysis and Thematic Synthesis

After the data retrieval and filtration process, the selected set of literature was analysed using a three stage of integrative thematic analysis approach to identify and organize key findings into a structured framework. The first stage of analysis involved systematic open coding to identify functional capabilities required for managing closed-loop product lifecycles. To maintain alignment with circular supply chain frameworks, these capabilities were grouped according to three core phases which are Beginning-of-Life (BOL) design and procurement, Middle-of-Life (MOL) usage and maintenance telemetry, and End-of-Life (EOL) recovery and recycling algorithms (Kiritsis et al., 2008). Subsequently, the extracted codes were inductively categorized into three higher-level functional domains essential for conceptualizing modern enterprise architecture which are Technological Tracking and Dashboards, Software and Data Interoperability, and Organizational and Ecosystem Readiness.

In the final stage of synthesis, categorized themes were integrated into a unified conceptual framework designed to address the complexity of circular transformations. By explicitly accounting for real-world integration barriers, heterogeneous data ecosystems, and the complexity of multi-stakeholder networks, this structured analysis establishes a highly reliable, logically sound foundation for the subsequent discussion of Circular ERP capabilities.

RESULTS OF THE INTEGRATIVE THEMATIC SYNTHESIS

The finding from integrative thematic synthesis shows that traditional ERP systems are inadequate to support the high level of complexity in circular economy (CE) strategies. Although information flows are well integrated during the design and production (BOL) stages, they become more fragmented as a product moves through use (MOL) and into end-of-life (EOL) scenarios. In order to address this information gap, the literature identifies several technological and functional requirements that should be incorporated into a Circular ERP architecture. These findings are summarized in Table 1 which serves as the objective output of the thematic synthesis.

Table 1: Synthesized System Requirements for a Circular ERP

Key Finding	Description	Supporting Evidence
Domain 1: Technological Tracking & Dashboards		
Advanced Tracking via DPP	Apply Digital Product Passports (DPP) and RFID as strategic assets to provide real-time visibility of product composition and service history.	(Bruno et al., 2026; Christensen et al., 2025; Hörger et al., 2026)
Real-time Monitoring	Provides dashboard to track Key Performance Indicators (KPIs) such as revenue generated from repaired products and environmental performance indicators.	(Cavicchi & Vagnoni, 2022; Diefta et al., 2024)
Domain 2: Software & Data Interoperability		
Lifecycle Phase Integration	Connect the gap between BOL, MOL, and EOL stages through continuous feedback loop that support product improvements and end of life planning.	(Schümmelfeder et al., 2025; Tyagi et al., 2025; Wlazlak & Johansen, 2025)

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Data Interoperability	Seamlessly integrate different information systems through semantic and syntactic integration technologies.	(Bitsch & Braun, 2026; Exalto-Sijbrands & Ravesteijn, 2021; Liu & Wu, 2025)
Circular Strategy Support	Support circular economy initiatives by incorporating functions for remanufacturing, recycling, and reuse including technical assessments of returned products' conditions.	(Hörger et al., 2026; Schümmelfeder et al., 2025; Wlazlak & Johansen, 2025)
Reverse Logistics Management	Integrates modules for the collection, inspection, and tracking of returned products and waste generation.	(Jafarzadeh Ghoushchi et al., 2025; Mollashahi, 2025; Wicaksana et al., 2024)
Intelligent Decision Support	Leverage Artificial Intelligence (AI) and machine learning to improve resource usage, minimize waste, and address supply uncertainties.	(Dhanya et al., 2023; Singhabahu, 2026; Yasser & Khalifa, 2025)
Domain 3: Organizational Readiness & Ecosystem		
Stakeholder Collaboration	Act as a centralized platform to facilitate communication, coordination and information exchange among suppliers, manufacturers, and recyclers.	(Chang et al., 2024; Zhang et al., 2025)
Organizational Readiness	Highlights the necessity of management commitment, staff training, and process adaptation as critical success factors (CSFs).	(Hurtado & Avila-Garzon, 2026; Mahjoubi & Kabbaj, 2025)

According to Table 1, there are three interconnected functional domains that are important for implementing a Circular ERP architecture. The first domain is Technological Tracking and Dashboards which focus on creating digital connection between physical products and information systems through technologies such as Digital Product Passports (DPP) which allows the monitoring of product data throughout the lifecycle. The second domain, Software and Data Interoperability which highlights the need for integrated systems, semantic data exchange, and AI-driven analytics to convert data from different sources into actionable insights for reverse logistics and remanufacturing activities. The last domain is Organizational Readiness and Ecosystem. It emphasizes the role of the stakeholder collaboration and strong strategic leadership to help achieve the successful implementation and operation of Circular ERP systems.

The Integrated Circular ERP Architecture

The Integrated Circular ERP Architecture proposed in this study synthesizes the thematic findings presented in Table 1 into a unified architectural model for Circular ERP integration. Rather than functioning as a technical software prototype, the proposed architecture acts as a conceptual integration framework that redefines the traditional ERP platform from a static transactional database into a dynamic coordination platform capable of supporting closed-loop resource management across decentralized business ecosystems. The architecture is designed to overcome the fragmentation of information flows commonly observed in between Beginning-of-Life (BOL), Middle-of-Life (MOL), and End-of-Life (EOL) lifecycle phases of the product lifecycle within conventional ERP environments. The development of this integrated architecture is supported by four foundational technological components as below

Closed Loop Feedback Mechanism

The architecture is built around a two way digital network that enables continuous information exchange throughout all product lifecycle stages (Schummelfeder et al., 2025; Tyagi et al., 2025). Existing literature suggests that conventional ERP platforms which are primarily designed for linear production models often lack the capability to effectively incorporate End-of-Life (EOL) intelligence into upstream processes. The proposed architecture address this gap by automating feedback flows that transfer information related to disassembly results, defect analysis, material recovery rates, and recycling data directly back into Beginning-of-Life (BOL) design and procurement modules (Diefta et al., 2024; Wlazlak & Johansen, 2025). By enabling the continuous flow of information between lifecycle stages, organizations can continuously refine product architectures, improve material utilization, and support Value-Retention Processes (VRPs) within circular business models (Tyagi et al., 2025).

Implementation of the Digital Product Passport (DPP)

The circular ERP architecture is required to include the DPP as the main mechanism to enable digital identity and product traceability which can improve the transparency of circular networks. The DPP acts as a verifiable digital record that stores important data including material composition, maintenance history, repair records, and regulatory compliance. The implementation of DPP into ERP systems allows organizations to securely share product information in real time with suppliers, logistics providers, remanufacturers, and regulatory authorities (Wicaksana et al., 2024; Zhang et al., 2025). This helps to maintain accurate tracking throughout the lifecycle while ensuring organizations remain compliant with strict global sustainability regulations and reporting standards.

Data Lakehouse Infrastructure and Semantic Interoperability

The success of the feedback loops and the DPP integration depends on a centralized Data Lakehouse Infrastructure that is designed to enable semantic and syntactic interoperability across different enterprise systems. A main barrier to circular IT implementation is the existence of fragmented legacy data silos that isolate core manufacturing execution from reverse logistics. To address these silos, the proposed architecture requires all enterprise data flows to be processed through centralized Extract, Load, and Transform (ELT) pipelines (Liu & Wu, 2025). This approach combines structured transactional data with unstructured circular telemetry to create a unified data environment for enterprise operation. This provides scalable analytics and provides a centralized enterprise source of information for organization operational decision making.

AI-Enabled Decision Intelligence for Circular Operations

The management of circular supply chains is often characterized by uncertainty due to variation in the volumes of product returns, variation in the condition of end-of-life products and fluctuation in the value of recovered materials (Jafarzadeh et al., 2025; Mollashahi, 2025). To overcome these difficulties, the proposed architecture must consist of AI Enabled decision intelligence capabilities which use predictive analytics and machine learning to optimize operational planning and resource allocation. These elements allow the system to predict return flows, schedule disassembly effectively, and improve reverse logistics processes based on data driven decisions (Wicaksana et al., 2024). This approach also expands the role of ERP systems to go beyond traditional transaction processing by transforming operational data into meaningful insight and improving the circular operation.

DISCUSSION

The shift from a linear to a circular enterprise system requires organizations to rethink the way resources and information are managed across the product lifecycle. Although the proposed Integrated Circular ERP

Architecture provides a technological framework for this transition, the successful implementation requires close coordination between IT infrastructure, business strategy, and ecosystem governance.

A theoretical contribution of this study is the clear differences between the proposed Circular ERP (C-ERP) architecture and conventional ERP systems. Traditional ERP systems were designed to support conventional linear business models and function as internal systems of record. The system is unable to provide the flexibility and visibility required to manage complex information flows, reverse logistics operations and life cycle data within circular economy practices (Tseng et al., 2020). These limitations demonstrate the need for an adaptive enterprise architecture that can support closed-loop resource management.

Table 2. Differences between Traditional ERP and Proposed Circular ERP System

	Traditional ERP	Proposed Circular ERP
Primary Objective	Transactional efficiency and linear resource planning.	Dynamic management of closed-loop resource flows throughout the product lifecycle.
Lifecycle Visibility	Visibility primarily limited to the Beginning-of-Life (BOL) stage and ending at the point of sale	Continuous data integration across BOL, MOL, and EOL stages.
Data Architecture	Relational databases architecture designed for linear business processes.	Centralized Lakehouse architecture integrating lifecycle data through ELT pipelines.
Architectural Role	Serves as an internal system of record within a single organization.	Functions as a decentralized ecosystem governance platform supported by verifiable Digital Product Passports (DPPs).

This study adopts Dynamic Capabilities Theory to conceptualize the proposed C-ERP architecture as a platform that supports organization to identify opportunities, seizing value, and reconfiguring capabilities. The integration of Digital Product Passports (DPPs) as part of architectures helps to provide continuous visibility into product conditions throughout the Middle-of-Life (MOL) and End-of-Life (EOL) stages which enhance organizations' ability to identify recovery and value retention opportunities. Besides, the application of AI improves decision intelligence by supporting value-seizing activities through data-driven decision-making for asset recovery, remanufacturing, and the utilization of secondary materials (Kristoffersen et al., 2021). Finally, the architecture enables dynamic reconfiguration by fundamentally transforming enterprise data structures. By ensuring that ELT pipelines flow into a centralized Lakehouse platform, the system eliminates legacy information silos and reporting delays which allows the enterprise to adapt with a volatile circular market.

Bridging the Information Gap and Ecosystem Interoperability

Existing studies indicates that information flow are well establish during the Beginning-of-Life (BOL) design and production phases but it becomes increasingly fragmented during the Middle-of-Life (MOL) and End-of-Life (EOL) phases (Dhanya et al., 2023; Schümmelfeder et al., 2025). The proposed framework addresses this information gap by improving visibility across the entire product lifecycle beyond the point of sale. Through the application of Product-Embedded Information Devices (PEIDs) such as RFID and Digital Product Passports (DPP), the system enables continuous two way information flows throughout the product lifecycle.

The literature also highlighted the absence of standardized data formats remains a barrier to information exchange across decentralized networks environments. For Circular ERP to operate across a wider business ecosystem, the system must support high levels of semantic and syntactic interoperability among diverse stakeholders and information systems. To solve this issue, the proposed architecture combines Web Service

Wrappers and multi-source data fusion flowing into a Lakehouse to integrate seamless data from diverse IT systems (Bitsch & Braun, 2026; Liu & Wu, 2025). This approach enables organizations throughout the value chain to access, share, and coordinate information more effectively.

Strategic Alignment with Global Sustainability Goals (SDGs)

The proposed architecture shows that a Circular ERP system can be used for other purposes than operational management by supporting sustainability and operational performance. The system is capable of improving the demand visibility and reduces resource inefficiencies through the integration of advanced technologies such as AI and predictive analytics. This directly contributes to the United Nations Sustainable Development Goals (SDGs) as below:

- **SDG 9 (Industry, Innovation, and Infrastructure):** Through the promotion of innovative, autonomous, and resilient industrial IT environments.
- **SDG 12 (Responsible Consumption and Production):** By optimizing the use of resources, implementing reverse logistics, and minimizing the generation of waste.
- **SDG 13 (Climate Action):** By utilizing real-time monitoring dashboards to measure, visualize, and actively reduce carbon footprints across the extended value chain.

Managerial Implications and Implementation Challenges

The literature consistently highlights that ERP implementation is often costly, time consuming, and with high historical failure rates frequently cited in enterprise systems. The implementation of Circular ERP systems introduces additional challenges due to important lifecycle information being distributed across multiple stakeholders, including suppliers, customers, remanufacturers, and recyclers (Zhang et al., 2025). As a result, implementing a Circular ERP requires more than a technological upgrade as it involves significant organizational transformation.

To support successful implementation, managers need to ensure strong strategic alignment between circular economy objectives and organizational priorities. Previous studies identify senior management commitment as a key factor in overcoming organizational resistance, securing resources, and facilitating system adoption (Mahjoubi & Kabbaj, 2025). In addition, existing business processes may need to be redesigned to support circular activities such as product return management, disassembly planning and material recovery which are typically not supported by conventional linear ERP systems.

Future Research Directions

While this study presents a conceptual framework for Circular ERP integration, further empirical research is needed to validate its practical feasibility and technical effectiveness. Hence, future research needs to prioritize industrial case studies to evaluate the effectiveness of the proposed architecture in real world settings and its ability to reduce data silos, improve asset recovery, and better integration between reverse logistics and core enterprise systems. In-depth investigations within manufacturing organizations could also provide valuable findings into implementation challenges such as organizational resistance, business process realignment, and the impact of Lakehouse integration on enterprise performance. Based on the study by Yin (2018), the case studies approach would provide empirical evidence regarding the applicability and effectiveness of the proposed architecture in supporting circular business networks.

CONCLUSION

The transition from traditional enterprise systems to a Circular Enterprise Resource Planning represents a paradigm change in how organizations manage information, resources, and value creation across product lifecycles. One of the major drivers behind this evolution is the need to close the information gap that occurs when legacy systems are unable to maintain the visibility of product related data once products enter the market. The proposed C-ERP framework reduces this limitation by supporting continuous data tracking across all stages of the product lifecycle. The integration of advanced technologies such as Digital Product Passports (DPPs), centralized Data Lakehouse infrastructures, and AI-driven analytics allow organizations to establish continuous feedback and data exchange mechanisms. These mechanisms ensure that valuable data generated during product's end-of-life phase is systematically fed back into initial design and operational processes.

Furthermore, the effectiveness of C-ERP not only depends on technological capabilities but also requires collaboration among diverse external stakeholders such as suppliers, consumers, and resource recovery facilities operating within a complex and decentralized ecosystem. The ability to achieve seamless information exchange across networks is very important for supporting circular resource flows and decision making. Additionally, the proposed C-ERP framework also contributes to sustainability objectives SDG 9 (Industry, Innovation and Infrastructure), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) by improving resource efficiency, reverse logistics capabilities, and environmental performance. Practically, this framework benefits for various ecosystem stakeholder including manufacturers, remanufacturers, and policymakers by providing the data transparency necessary to execute extended producer responsibility mandates.

Successful implementation of C-ERP requires more than just a technological readiness and demands huge organizational transformation. Its effectiveness highly depends on strong strategic alignment, stakeholder collaboration, and the redesign of business processes to support circular economy activities. The proposed framework provides a strategic foundation for supporting the transition towards sustainable, data-driven, and resilient enterprise transformation within circular economy environments.

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