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INTEGRATING CIRCULAR ECONOMY AND REVERSE LOGISTICS INTO THE QUALITY MANAGEMENT SYSTEMS: EVIDENCE FROM POLISH SMEs

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Abstract: This article examines how circular economy (CE) and reverse logistics (RL) practices can be integrated into quality management systems (QMS) in SMEs. Although CE and RL are key components of sustainability, their linkage with formal quality frameworks remains insufficiently explored. This exploratory study proposes an original integration model, investigates the current level of alignment, and identifies organizational barriers. Based on survey data from 37 Polish enterprises, the paper verifies research hypotheses regarding the synergy between circularity and quality management. The findings offer practical insights for practitioners seeking to enhance process reliability through a combined application of circular and quality approaches

Keywords: circular economy; reverse logistics; quality management systems; process integration; operational improvement

1. INTRODUCTION

In response to escalating environmental challenges and tightening regulatory requirements, firms increasingly pursue solutions that enhance operational performance while reducing environmental impacts. In this context, the circular economy (CE) and reverse logistics (RL) have become central components of sustainability-oriented business strategies. CE focuses on extending product life cycles, reducing resource consumption, and maximizing value recovery, whereas RL refers to the backward flow of materials, products, and waste aimed at reuse, recovery, or environmentally sound disposal.

Many organizations simultaneously operate formal quality management systems (QMS), notably those based on ISO 9001, which support process standardization, operational reliability, and customer satisfaction. Although CE and RL are conceptually aligned with the continuous improvement logic embedded in quality management, their integration into established QMS frameworks remains limited in practice. Moreover, existing studies provide relatively few in-depth examinations of how sustainability-oriented practices can be systematically combined with traditional quality management, particularly in the context of Polish enterprises.

Accordingly, this study investigates the extent to which CE and RL practices are integrated into QMS in Polish enterprises and identifies the key barriers and benefits associated with such integration. In this study, integration is understood as the formal incorporation of CE and RL practices into quality management procedures, documentation, performance indicators, and continuous improvement mechanisms. The theoretical contribution of this work lies in the development of an original integration framework (presented in Section 2.4) that bridges CE, RL, and QMS—domains often treated in isolation. By identifying specific 'integration nodes' within the SME sector, this study demonstrates how formal quality structures can stabilize and standardize circular practices, thus filling a gap in systemic process alignment. The article is structured as follows: the first part provides a literature review and the proposed conceptual model, followed by the research methodology, a discussion of the results, and finally, conclusions.

2. THEORETICAL FRAMEWORK FOR INTEGRATING CIRCULAR ECONOMY AND REVERSE LOGISTICS INTO QUALITY MANAGEMENT SYSTEMS

2.1. Circular Economy: Principles

The circular economy (CE) has emerged as a response to global challenges related to resource scarcity and excessive waste generation. The literature emphasizes that its core objective is to preserve the value of products, components, and materials within economic systems for as long as possible (Dańko et al., 2021; Jaworski and Grochowska, 2017; Murray et al., 2017;Parlament Europejski, 2023). This concept encompasses both technical and organizational measures, including product design for disassembly, life cycle extension, and the development of business models based on resource sharing.

Contemporary approaches to CE highlight its systemic and process-oriented nature, which necessitates the analysis of material flows across the entire product life cycle (Kirchherr et al., 2017). From a quality management perspective, particular attention is paid to waste elimination, process control, and the monitoring of material nonconformities, all of which are closely aligned with the philosophy of continuous improvement. The literature also indicates that the implementation of CE practices often requires inter-organizational collaboration, especially in the areas of material recovery and reuse (Jaworski and Grochowska, 2017). This, in turn, creates a foundation for integrating circular practices with the requirements of formal quality management systems, which promote a process-based approach and structured management of relationships with business partners.

2.2. Reverse Logistics in the Context of Product Recovery and Quality Control Processes

Reverse logistics (RL) is commonly defined in the literature as the process of planning, implementing, and controlling the flow of materials from points of consumption to locations of recovery, repair, or disposal (Che Hassan and Osman, 2025; Rogers and Tibben-Lembke, 1998; Sadowski, 2008). In contemporary supply chain configurations, the role of RL extends beyond a purely supportive function and increasingly constitutes a critical element in the design of closed-loop supply chains, as well as in the monitoring of product quality and durability.

Empirical studies indicate that reverse logistics generates valuable feedback related to product defects, return frequencies, and the underlying causes of customer complaints,

thereby enabling the identification of nonconformity sources and the improvement of operational processes (Govindan et al., 2015). This function is particularly relevant in the context of integration with quality management systems, which rely on systematic data analysis, process documentation, and risk-based decision-making. The reverse logistics literature also emphasizes the growing use of digital technologies, such as material tracking systems, automated return identification, and big data analytics, which significantly enhance RL efficiency and improve the quality of information used in managerial decision processes (Krstić et al., 2022). Consequently, reverse logistics can be viewed not only as a mechanism for resource recovery but also as a critical source of data supporting quality management systems.

2.3. Quality Management Systems as a Tool for Integrating Environmental and Process-Oriented Practices

Quality management systems (QMS), such as ISO 9001, Total Quality Management (TQM), and Six Sigma, provide structured frameworks for the standardization, monitoring, and continuous improvement of organizational processes. The literature emphasizes that their primary function is to ensure the coherence of organizational activities, identify process-related risks, and support continuous improvement (Porter, 2010). Empirical and review-based studies further demonstrate that QMS frameworks create a formal foundation for integrating environmental objectives into operational decision-making by embedding sustainability considerations within routine managerial practices (Siva et al., 2016; Wiengarten and Pagell, 2012)

From the perspective of integrating circular economy (CE) and reverse logistics (RL) practices with quality management systems, several QMS principles are particularly important:

- a process-oriented approach that enables the formal incorporation of return and recovery activities into process maps;
- customer orientation, including complaint handling and the analysis of return causes;
- data- and evidence-based analysis, allowing for the assessment of the effectiveness of recovery-related activities;
- risk management, which may encompass risks related to waste generation, product returns, and material consumption;
- internal audits and management reviews, which facilitate the systematic evaluation of circular practice implementation.

Prior research confirms that such principles closely align with environmental management system (EMS) requirements, particularly when QMS and EMS are integrated into a unified management structure (José Tarí and Molina-Azorín, 2010) This integration enhances organizational capability to monitor environmental impacts systematically while maintaining consistency with quality objectives.

The literature also indicates that integrating quality management systems with environmental practices contributes to cost reduction, reputational improvement, and enhanced organizational resilience (Kwiecień, 2018). More recent empirical evidence suggests that QMS maturity positively influences environmental innovation and sustainability performance by strengthening data-driven control, cross-functional coordination, and continuous improvement mechanisms (Zhao et al., 2023) At the same time, scholars emphasize that fully exploiting the potential of such synergies requires

embedding environmental considerations within core quality management processes rather than treating them as a separate organizational domain (Siva et al., 2016).

2.4. Integrating Circular Economy and Reverse Logistics with Quality Management Systems

Although the literature on the circular economy (CE) and reverse logistics (RL) is extensive, and quality management systems (QMS) are well established within management research, relatively few studies explicitly examine their joint functioning within a unified organizational model. Nevertheless, the conceptual discussion of these three domains makes it possible to identify several key areas in which practices characteristic of CE and RL can be aligned with the formal requirements of quality management systems.

These areas provide the basis for developing an integrated, process-oriented approach that supports both environmental objectives and quality-related goals. Accordingly, Table 1 presents the principal rationales for integrating CE and RL practices with quality management systems, derived from the literature review and the conceptual characteristics of both domains.

Table 1.
Key Rationales for Integrating Circular Economy, Reverse Logistics, and Quality Management Systems

Integration Rationale	Description
Product life cycle monitoring and identification of nonconformities	Circular economy and reverse logistics processes provide feedback data (e.g., reasons for returns, material quality) that support QMS tools such as Pareto analysis and FMEA.
Standardization of environmental and recovery-related activities	QMS enable the formal documentation, control, and auditing of CE/RL activities, ensuring consistency and compliance.
Reduction of waste, losses, and production defects	CE objectives are aligned with quality objectives, particularly with respect to eliminating material losses and improving process efficiency.
Collaboration with suppliers and customers	CE and RL require extended cooperation across the value chain; QMS support this through supplier evaluation, complaint handling, and structured communication.
Management of knowledge on products and processes	RL activities generate valuable information on product defects, durability, and process weaknesses, strengthening continuous improvement initiatives within QMS.

Source: authors' own elaboration based on a literature review.

The rationales presented in Table 1 indicate that quality management systems can function as an integrative platform that enables the alignment of environmental and recovery-related activities with traditionally defined quality management processes. To further illustrate the relationships among the analyzed domains, the following figure presents a proposed model for integrating circular economy and reverse logistics practices with quality management systems. The diagram depicts the flows of data, information, and activities between key elements and highlights the cyclical nature of the relationships among them.

The proposed model facilitates a clearer understanding of the mechanisms through which circular economy (CE) initiatives and reverse logistics (RL) processes can supply quality management systems (QMS) with information essential for process improvement. First, CE and RL generate substantial volumes of operational data related to product quality,

durability, and patterns of use. When appropriately processed and analyzed, these data constitute valuable inputs for corrective and preventive actions within QMS.

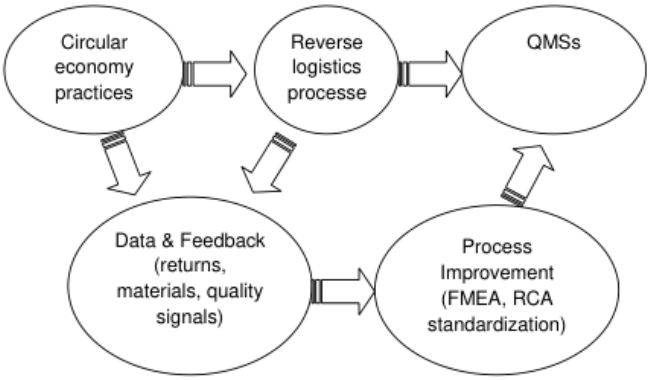

Fig. 1. A Proposed Model of Integrating Circular Economy and Reverse Logistics Practices with Quality Management Systems

Source: authors' own elaboration

Second, the formal documentation and auditing requirements characteristic of quality management systems support the standardization of environmental initiatives, which are often implemented in an ad hoc manner within organizations. Assigning such initiatives the status of system-monitored processes enhances their repeatability, transparency, and effectiveness. Third, integration with quality-related objectives – such as waste reduction, defect minimization, and resource-use optimization – highlights the natural convergence of the two approaches. Both CE and QMS promote waste elimination, process improvement, and enhanced operational efficiency.

Fourth, reverse logistics activities require ongoing collaboration with suppliers, customers, and external partners, which corresponds closely with QMS requirements concerning relationship management. The standardization of these activities enables improved control over the quality of secondary raw materials, recovery processes, and information flows. Finally, reverse logistics – by generating detailed data on return causes, product defects, and operational issues –provides organizations with a valuable knowledge base that can be leveraged in continuous improvement initiatives. Incorporating such data into quality analyses facilitates more effective identification of the root causes of nonconformities and supports the prevention of their recurrence.

Taken together, these elements suggest that integrating CE and RL with quality management systems represents not merely a theoretical alignment, but a practical process management model grounded in the synergy of environmental, quality, and operational objectives. At the same time, further empirical research is needed to examine the real-world implementation of such integration at the firm level and to assess its impact on organizational performance.

3. RESEARCH METHODOLOGY

The objective of the study was to examine the extent to which circular economy (CE) and reverse logistics (RL) practices are integrated with quality management systems (QMS)

in Polish enterprises, as well as to identify the associated benefits and limitations. The study forms part of a broader research project on the implementation of circular solutions in firms; however, this article focuses specifically on the relationships between CE and RL practices and organizational and quality-related processes.

The study was conducted among 37 small and medium-sized enterprises (SMEs) operating in Poland. All surveyed firms operated a formal quality management system (typically ISO 9001), which was a prerequisite for participation. While the sample size is relatively small, it is considered adequate for the exploratory and descriptive nature of this research, aiming to identify emerging trends and qualitative patterns in a niche area of process integration. Based on the literature review, two research hypotheses were formulated to guide the analysis:

H1: There is a positive relationship between the formalization of QMS procedures and the structured implementation of reverse logistics activities.

H2: Organizational and knowledge-based barriers (lack of procedures and expertise) are more significant inhibitors of CE-QMS integration than purely technical constraints.

Due to the exploratory character of the study, these hypotheses are verified through descriptive statistical analysis and trend identification rather than large-scale probabilistic testing.

Data were collected using a standardized questionnaire comprising a firm profile section and thematic blocks related to CE practices, reverse logistics activities, perceived outcomes, and implementation barriers. To ensure the reliability and robustness of the research tool, the questionnaire underwent a formal evaluation process for content validity. This involved a review by two independent academic experts specialized in quality management and circular economy, followed by a pilot study with two SMEs to verify the clarity of the questions and the technical feasibility of the survey. Based on their feedback, minor adjustments were made to the terminology to better reflect the operational reality of Polish enterprises. The analysis focused on survey items relevant to circular and recovery-related practices in the context of organizational processes, material flow monitoring, and quality management.

The collected data were analyzed using descriptive statistics and thematic coding of open-ended responses. This mixed-methods approach enabled the identification of both the overall level of CE and RL implementation and the organizational conditions influencing their integration with quality management systems. The study is subject to limitations related to the SME-focused sample and partial data availability for certain operational indicators; however, these constraints suggest directions for future research rather than undermining the study's contribution.

In the empirical part of this study, the degree of CE/RL-QMS integration is captured through a multi-dimensional analysis of survey items. Integration is reflected in four key operational areas: (1) the formalization of recovery processes within system documentation, (2) the alignment of circular practices with standardized quality procedures (e.g., sorting and refurbishing standards), (3) the use of specific performance indicators (KPIs) that link environmental goals with quality monitoring, and (4) the systematic use of reverse logistics data in corrective and preventive actions. Collectively, these items measure how deeply circular and recovery-oriented activities are embedded into the formal structures of the quality management system, rather than being treated as isolated initiatives.

4. FINDINGS

The analysis of the empirical material was conducted with reference to the five areas constituting the rationales for integrating circular economy (CE) and reverse logistics (RL) practices with quality management systems (QMS), as presented in Table 1. This structure enabled a direct linkage between the empirical findings and the theoretical framework, as well as an assessment of the extent to which circular and recovery-related practices can support the improvement of organizational processes. The aggregated results are presented in Figure 2.

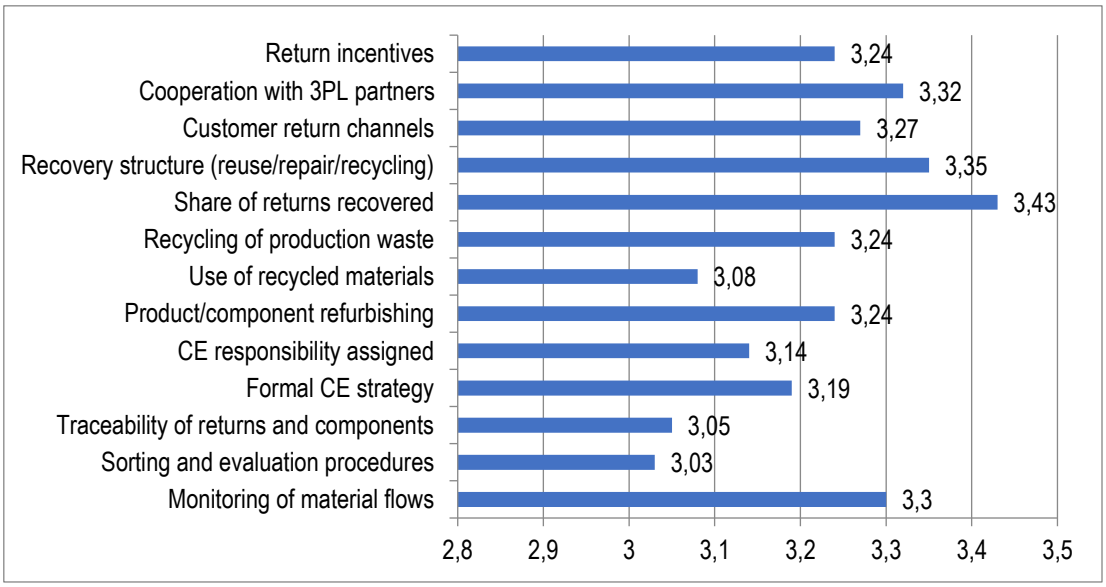

Fig. 2. Aggregated Results Based on Likert-Scale Survey Responses

Source: authors' own elaboration

4.1. Product Life Cycle Monitoring and Identification of Nonconformities

The results indicate that SMEs implement practices related to material flow monitoring and feedback information management at a moderate level. The mean score for the item addressing material flow monitoring was 3.30, suggesting that such practices are applied relatively frequently. Within the area of reverse logistics, firms exhibited a moderate level of maturity in the identification and evaluation of returns: sorting procedures (C2) achieved a mean score of 3.03, while traceability-related practices reached a mean value of 3.05.

These findings suggest that return processes constitute an important source of information on product quality; however, the level of formalization remains limited. Open-ended responses confirm that returns are primarily used as a source of knowledge about product defects (e.g., "high costs of return transportation result from frequent component nonconformities"), and in several cases as a means of identifying design deficiencies (e.g., "return analysis led to design modifications of devices"). From a QMS perspective, this indicates the existence of potential for the formal integration of feedback data into tools such as Pareto analysis, Failure Mode and Effects Analysis (FMEA), or Root Cause Analysis (RCA); nevertheless, this practice requires further development.

4.2. Standardization of Environmental and Recovery-Related Activities

The mean values of responses related to the formalization of CE and RL activities indicate a moderate level of standardization. Firms less frequently reported the existence of a formal CE strategy (mean = 3.19) and clearly defined organizational responsibility for circular initiatives (mean = 3.14). In contrast, within the area of reverse logistics, sorting procedures (mean = 3.03) and refurbishing processes (mean = 3.24) played a more prominent role and may constitute a basis for the development of standards aligned with quality management system requirements.

Open-ended responses suggest that firms are aware of the need for greater standardization (e.g., “we lack clearly documented recovery processes” and “a procedure for component assessment is necessary”); however, such initiatives often remain fragmented. Overall, the results indicate the existence of potential for the formal incorporation of recovery-related activities into QMS process documentation, which could enhance the transparency and controllability of value recovery processes.

The observed presence of sorting and refurbishing procedures in firms with active QMS supports H1, indicating that quality standardization provides a structural basis for reverse logistics activities.

4.3. Reduction of Waste, Losses, and Production Defects

Practices related to the reduction of material losses and the use of secondary raw materials achieved moderately high levels. The mean score for the use of recycled materials was 3.08, while regeneration and product refurbishment reached a mean value of 3.24. In addition, the recycling of post-production waste also recorded a mean score of 3.24, indicating that this practice is implemented by a considerable number of firms.

Results concerning recovery volumes (mean = 3.43) and recovery structure (mean = 3.35) suggest that enterprises are capable of recovering a substantial share of material and product value. From a QMS perspective, such activities may contribute to reducing nonconformities, lowering the incidence of production defects, and improving overall resource utilization efficiency.

Open-ended responses provided numerous examples of waste reduction initiatives (e.g., “the implementation of an aluminum recovery procedure reduced raw material costs”), which further underscores the relevance of these practices for the stability and performance of quality-related processes.

4.4. Collaboration with Suppliers and Customers in Closed-Loop Flows

The findings indicate a moderate, yet gradually increasing, level of collaboration across the value chain. The mean score for providing customers with return channels was 3.27, while cooperation with specialized partners reached a mean value of 3.32. In addition, firms reported the use of incentives to encourage returns (mean = 3.24), although typically on a limited scale.

Open-ended responses suggest that such collaboration is not always formalized (e.g., “there are no agreements defining specific recovery conditions” and “customers do not always return components despite incentives”), yet in many cases it plays a significant operational role. Integration with quality management systems could strengthen these areas by formalizing communication with suppliers and customers, particularly with regard to the assessment and control of secondary material quality.

4.5. Management of Knowledge on Products and Processes

Data related to knowledge management indicate that enterprises make use of feedback information, albeit to a limited extent. Traceability achieved a mean score of 3.05, while the use of reverse logistics KPIs reached a mean value of 3.41, representing one of the higher scores within this block of survey items. These results suggest that firms monitor selected aspects of return and recovery processes; however, the comprehensive use of such data for quality-related analyses remains underdeveloped.

Open-ended responses frequently referred to information gaps (e.g., “there is a lack of data on components” and “full traceability implementation is required”), confirming that knowledge management constitutes one of the key areas requiring further development. From a QMS perspective, this indicates substantial potential to expand the use of feedback data in corrective and preventive actions. Such information may support root cause analysis, process stability monitoring, and improvements in product design.

Overall, the findings indicate that Polish SMEs implement CE and RL practices at a moderate level, with the highest degree of advancement observed in activities related to recycling, value recovery, and selected reverse logistics processes. At the same time, the results reveal clear opportunities for integrating these practices with quality management systems, particularly in areas related to product life cycle monitoring, the standardization of recovery processes, and the management of product- and process-related knowledge. The prevalence of information gaps and procedural lacks over technical complaints in the open-ended responses confirms H2, highlighting that organizational barriers are the primary inhibitors of integration

5. DISCUSSION

The findings of this study provide empirical support for the proposed original integration model (Figure 1). Unlike previous fragmented approaches, this model demonstrates that QMS does not merely coexist with CE and RL, but functions as an operational 'anchor' that standardizes sustainability-oriented flows. The high mean scores for RL KPIs (3.41) and the observed link between sorting procedures and quality monitoring confirm that the integration nodes identified in the theoretical framework are practically relevant for SMEs The results of the study indicate that circular economy (CE) and reverse logistics (RL) practices are implemented at a moderate level among SMEs; however, their integrative potential with quality management systems (QMS) is substantial. Interpreting the findings in light of the existing literature provides deeper insight into how circular practices may support process improvement, operational stability, and organizational development.

The first area – product life cycle monitoring and the identification of nonconformities – finds strong support in the circular economy literature. Murray et al. (2017) emphasize that the effectiveness of CE depends on an organization’s ability to collect and analyze feedback data, enabling the assessment of product durability and quality. Similarly, Rogers and Tibben-Lembke (1998) argue that reverse logistics constitutes a natural source of quality-related knowledge, as it reveals product defects, design flaws, and recurring causes of returns. In the Polish context, it has been observed that data generated through return processes may serve as a valuable input for quality management systems and support the supervision of nonconformities (Huk, 2020). The empirical results confirm these observations: firms report the use of traceability mechanisms and sorting procedures, which creates tangible foundations for integrating

return-related analyses with quality tools such as Failure Mode and Effects Analysis (FMEA) or Pareto analysis.

The second area – standardization of recovery-related activities – corresponds closely with both CE literature and research on quality management systems. Kirchherr et al. (2017) identify the lack of process formalization as one of the key barriers to circular economy implementation. More recent studies further point to the absence of strategic planning for returns and limited transparency of recycling and reuse processes as critical challenges (Sonar et al., 2024). From a quality management perspective, Wolniak (2019) describes varying levels of QMS maturity, noting that the highest levels are typically achieved in areas directly derived from ISO standards and thus most amenable to standardization. The empirical findings are consistent with these arguments: although recovery activities are present, their level of formalization remains limited. Integrating CE and RL practices with QMS could therefore enhance process transparency and increase system-level maturity.

In the area of waste reduction and production defect minimization, a particularly strong alignment between CE principles and quality management philosophy can be observed. Womack and Jones (2003) demonstrated that waste elimination constitutes a core principle of lean management, while Bressanelli et al. (2019) and Genovese et al. (2015) argue that circularity pursues similar objectives through material recovery, regeneration, and recycling. Polish studies further emphasize that waste management – when embedded within broader environmental concepts - directly contributes to reduced operational risk and improved process quality (Anders and Starypan, 2007). The study results support these claims: firms engage in waste recycling, product refurbishment, and component reuse, thereby strengthening process stability and reducing the incidence of production nonconformities.

The fourth area – collaboration across the value chain – is widely emphasized in the CE and reverse logistics literature. Closed-loop material flows require intensive cooperation with suppliers, logistics operators, and recycling partners (Duong et al., 2024). Rogers and Tibben-Lembke (1998) note that the effectiveness of return processes depends largely on the degree of inter-organizational integration. Polish research, such as that by Kot (2017), confirms that insufficient cooperation with external partners remains a significant barrier to supply chain integration among SMEs. From a quality management perspective, in line with ISO 9001:2015, supplier supervision and customer relationship management are fundamental to quality assurance. The findings indicate that while such cooperation exists, its level of formalization is limited, suggesting that QMS mechanisms could be used to strengthen and structure these relationships.

The most challenging area appears to be the management of product- and process-related knowledge. Bressanelli (2020) and Sonar et al. (2024) identify data scarcity, low levels of digitalization, and insufficient tracking systems as major barriers to circular economy implementation. Polish studies similarly emphasize that the effectiveness of closed-loop systems depends heavily on the quality of information regarding components and material flow histories (Szołtysek, 2009; Szołtysek and Twaróg, 2017). At the same time, it is widely acknowledged that quality management tools can significantly support the management of environmental information (Nguyen, 2018). The empirical results indicate that enterprises are still developing capabilities in this area, and that integration with QMS could improve data quality, enhance root cause analysis, and increase process resilience.

In summary, the findings confirm that CE and RL practices exhibit a natural compatibility with quality management principles and that their integration may generate tangible operational benefits for enterprises. Both international and Polish literature highlight the need for stronger formalization of circular activities, the development of information-related competencies, and enhanced collaboration across the value chain. At the same time, the results reveal new areas of scholarly contribution—particularly the role of reverse logistics as a source of quality-related data and the function of circularity as a factor stabilizing organizational processes. Future research should therefore focus on integration models, in-depth case studies, and sector-specific analyses to further elucidate the relationships between circular economy practices and quality management systems.

6. CONCLUSIONS

The study demonstrates that circular economy (CE) and reverse logistics (RL) practices offer significant, yet underutilized, potential for enhancing quality management systems (QMS) in SMEs. The proposed original integration model (Fig. 1) highlights that data from return and recovery processes can strengthen an organization's capacity for root cause analysis and process stabilization. The findings support H1 and H2, confirming that while operational synergies exist, their full exploitation is hindered more by organizational formalization gaps than by technical limitations.

Practical implications: Managers should focus on embedding circular metrics (e.g., RL KPIs) directly into ISO 9001 documentation. This transition from ad hoc activities to standardized processes is crucial for ensuring the reliability of secondary material flows and reducing waste-related nonconformities.

Limitations and future research: This study is limited by its exploratory nature and a sample of 37 Polish SMEs. Future research should apply the proposed integration framework to larger, multi-national samples and investigate the impact of digital traceability tools (Industry 4.0) on the maturity of integrated CE-QMS structures.

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