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Institutionalising sustainability in reverse logistics: an exploratory study and DMAIC-based framework

Abstract

Research background and purpose: Sustainability has become a managerial imperative, yet many enterprises still struggle to translate sustainability intentions into operational routines. Reverse logistics – covering product returns, reuse, recycling, and end-of-life management – offers a practical pathway to improve resource efficiency and reduce environmental impact, but its integration into firm governance and measurement systems remains uneven. This exploratory study examines the level of sustainability institutionalisation in Slovak enterprises and discusses implications for embedding sustainability into reverse logistics. Specifically, it focuses on the presence of formal sustainability strategies, the assignment of responsibility for sustainability, and the incorporation of sustainability metrics into reporting practices.

Design/methodology/approach: The study uses data from a computer-assisted web interview (CAWI) survey conducted among enterprises across sectors in the Slovak Republic. The survey captures sustainability governance arrangements (strategy and accountability) and monitoring practices (use of sustainability metrics in reporting) and relates these to managerial intentions in companies regarding future sustainability activities. The analysis descriptive statistics and non-parametric correlation methods to identify patterns in sustainability governance and implementation readiness.

Findings: The results indicate a moderate level of sustainability institutionalisation. A formal sustainability strategy is reported by 51% of surveyed companies, while only about one third have appointed a person responsible for sustainability. At the same time, 72 % of respondents expect to intensify sustainability-related activities in the future. Together, these findings suggest a persistent implementation gap: although many firms anticipate stronger sustainability engagement, governance and measurement practices are not yet consistently embedded.

Value added and limitations: The paper adds evidence from a Central and Eastern European context and proposes a DMAIC-based implementation framework (Define–Measure–Analyse–Improve–Control) to help companies embed sustainability objectives into reverse logistics routines and

measurement practices. Limitations include reliance on self-reported survey data and a single-country setting, which may constrain generalisability; future research could test the proposed framework in other contexts and practice-oriented managerial guidance.

Keywords: *sustainable strategy; reverse logistics; Sustainable Development Goals (SDGs); DMAIC framework; circular economy*

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Classification: Q56, M11, M14, L23

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1. Introduction

In recent years, sustainability has shifted from a largely normative concept to a practical managerial imperative. Rather than being viewed only as a compliance obligation, sustainability is increasingly framed as driver of innovation, competitiveness, and long-term organisational resilience. This perspective is considered in the report “Better Business, Better World” (Business & Sustainable Development Commission, 2017), which links progress on the United Nations Sustainable Development Goals (SDGs) to substantial business potential.

As published, achieving the Sustainable Development Goals (SDGs) called global goals opens significant market opportunities across major sectors calculated as \$12 trillion in business opportunities in the areas of food production and agriculture, cities, energy and materials, and health and well-being. In particular, SDG 9 (Industry, Innovation and Infrastructure) and SDG 12 (Responsible Consumption and Production) encourage a transition from linear models to circular and resource-efficient production and logistics system. For organisations including small and medium enterprises, this implies that sustainability objectives need to be translated into operational routines, measurable targets, and accountable managerial roles. The top 60 the opportunities areas highlighted in the report – such as packaging waste reduction, product take-back, reuse and refurbishment, and circular models in electronics and automotive – are directly linked to reverse logistics implementation and closed-loop supply chain practices (Business & Sustainable Development Commission, 2017).

In this context, reverse logistics emerges as a practical and impactful domain through which businesses can actively respond to sustainability challenges while contributing to the achievement of the Sustainable Development Goals. Reverse logistics is the collective term for activities related to the planning, management, and implementation of the material and information flow of products, waste, and packaging from the customer to the distributor or producer for reclamation, reuse, recycling, or disposal (reverse logistics, waste logistics, recycling logistics) according

to the regulations. Reverse logistics encompasses the management of returned goods, reuse, recycling, remanufacturing, and disposal processes, and represents a direct lever through which organisations can reduce waste, optimize resource use, and move towards circular business models. Reverse logistics is therefore not only an operational necessity, but a strategic tool for fulfilling sustainability commitments. However, its potential remains largely untapped, particularly among small and medium-sized enterprises (SMEs) in Central and Eastern Europe. Previous studies have predominantly focused on sustainability at the level of product design, energy use or carbon footprint, while the role of reverse logistics in achieving sustainability outcomes has not been adequately examined. We agree with the authors (Sun, 2017) that reverse logistics can be a strategic tool for economic benefits, thus a better understanding and efficient reverse logistics, including strategic management, and provide a competitive advantage.

The strategy and management of reverse logistics processes must respect the specificities of reverse material and information flows, in particular, ambiguity, inconsistency in pricing, heterogeneity, and complicated predictability of the material flow, more difficult to predict life cycle, less transparency, more nocturnal determination of both the customer and the responsibilities between the actors.

Accordingly, this paper examines the institutionalisation of sustainability in Slovak industrial enterprises and its implications for reverse logistics implementation. Specifically, we analyse sustainability strategy, responsibility assignment, and sustainability metrics/reporting, and relate these two firms' expectations regarding future sustainability activities. Building on the findings, we propose a structured process-improvement framework for embedding sustainability into RL.

A quantitative research approach based on a structured CAWI survey was used to collect data from a sample of industrial enterprises to discuss research questions:

The presented study addresses the following research questions:

- RQ1. To what extent are sustainability principles understood and recognised by companies (sustainability awareness)?*
- RQ2. How is sustainability institutionalised in firms' governance and management systems (strategy, responsibility assignment, and metrics/reporting)?*
- RQ3. What is the declared intention of companies to intensify sustainability-related activities in the future, and how does this relate to institutionalisation indicators?*

To bridge the implementation gap identified in the survey evidence, the paper additionally proposes a DMAIC-based methodology (Define–Measure–Analyse–Improve–Control) to guide the integration of sustainability objectives into RL routines and associated measurement practices. The study contributes by combining firm-level evidence from a Central and Eastern European context with an actionable managerial

framework that links governance (strategy and accountability) to operational execution and monitoring.

The structure of the paper is as follows. The second section reviews the relevant literature on sustainability and reverse logistics in the context of SDG implementation. The third section outlines the research methodology, including data collection and analytical techniques. The fourth section presents and interprets the empirical findings. The fifth section offers a discussion of the results, highlighting managerial implications and theoretical contributions. Finally, the sixth section concludes the article and provides recommendations for future research.

2. Theoretical background

Sustainability has evolved from a normative concept to a strategic pillar of modern business management, particularly as enterprises seek alignment with the Sustainable Development Goals (SDGs) of the United Nations. In management research, the shift from sustainability intent to sustained practice is often described as institutionalisation, i.e., the extent to which sustainability becomes embedded in formal strategy, organisational responsibilities, and control systems. In this study, sustainability institutionalisation is operationalised through the presence of a formal sustainability strategy, the appointment of responsible personnel, and the use of sustainability metrics in reporting and monitoring. These seventeen global goals, as defined in the 2030 Agenda, provide a universal framework that guides countries, industries, and organisations toward sustainable development. Among these, SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation, and Infrastructure) and SDG 12 (Responsible Consumption and Production) are especially relevant for industrial enterprises seeking to implement sustainability within their operational processes, including reverse logistics. Because SDG 12 explicitly targets waste prevention and resource efficiency, reverse logistics can be viewed as an operational mechanism that supports SDG alignment through product take-back, reuse, remanufacturing, and recycling. SDG 9 complements this by emphasising innovation and infrastructure needed for resilient return and recovery systems. SDG 8 emphasises the promotion of sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all, which directly influences labour practices and economic strategies in industrial sectors (Bilek-Steindl et al., 2022). SDG 9 calls for the development of resilient infrastructure, the promotion of inclusive and sustainable industrialisation, and fostering innovation, which are critical to the improvement of reverse logistics systems and circular economy models (Krauss et al., 2022). SDG 12 focusses on ensuring sustainable consumption and production patterns, encouraging industries to minimise waste and optimize resource efficiency through practices such as reverse logistics (United Nations, 2015).

Recent research highlights the interconnectedness of these goals and the need for integrated approaches. For instance, mapping SDGs 8, 9, and 12 through a decolonial lens reveals systemic trade-offs and equity challenges that must be addressed to achieve genuine sustainability (Krauss et al., 2022). In addition, the prioritisation of economic growth in SDGs has been criticised for overshadowing ecological and social dimensions, suggesting a need for balanced implementation strategies (Coscieme et al., 2020). These debates imply that firms need governance and measurement systems that go beyond symbolic SDG referencing and enable evidence-based implementation, monitoring, and continuous improvement. This is particularly important for operational domains such as reverse logistics, where sustainability outcomes depend on process design and performance control. Reverse logistics emerges as a key enabler of SDG 12, enabling the return, reuse, and recycling of products, thus reducing environmental impact and supporting sustainable production (Govindan & Hasanagic, 2018).

Furthermore, the implementation of these SDGs in industrial enterprises requires robust monitoring and policy frameworks. A special issue on SDG 8 discusses the necessity of integrating environmental and climate concerns into employment and production systems, emphasising the role of green technologies and labour market policies (Bilek-Steindl et al., 2022). These insights are crucial for industries aiming to align their operations with the 2030 Agenda and contribute meaningfully to global sustainability efforts. Bibliometric analyses confirm a growing research interest in linking reverse logistics with the SDGs through circular economy, innovation, and sustainable supply chain practices (Yadav et al., 2020; Schröder et al., 2020).

The adoption of sustainability strategies means new opportunities for innovation, efficiency improvement, and market differentiation. However, sustainability awareness does not automatically translate into implementation. This suggests that implementation depends on formalisation (strategy), accountability (responsible roles), and performance measurement (metrics), which together enable coordination, learning, and managerial control. Recent bibliometric analyses show that green knowledge management significantly enhances firms' capacity to institutionalise sustainability practices and translate environmental awareness into operational innovation (Ulhaq et al., 2024). Nevertheless, empirical studies show that while companies increasingly acknowledge the importance of sustainability, the depth and consistency of implementation vary considerably. Sohns et al. (2023), for instance, found that although all 10 German SMEs they studied demonstrated awareness of sustainability, only two had formally adopted green Business Process Management (BPM) as a strategic priority. The remaining firms had either nascent initiatives or were only begun to define their sustainability objectives. Similarly, Johnson (2015) highlighted a direct correlation between the level of awareness and the actual use of sustainability tools, observing that widely known tools - frequently cited in the business literature - tend to be adopted more readily than newer or more specialised instruments.

Broader international comparisons point to significant regional and structural disparities. A study by Das, Rangarajan et al. (2020) revealed that while SMEs in the United Kingdom and Belgium often recognised the strategic value of sustainability, enterprises in the Czech Republic, Poland, Lithuania, Latvia, and China typically engaged in isolated eco-friendly activities without embedding them into their core business operations. Raharjo (2019) also emphasized that stakeholder pressure, resource availability, managerial knowledge, and product characteristics significantly influence the level of green management maturity. Across diverse contexts, internal drivers such as employee commitment and external enablers such as partnerships and training emerge as essential factors for success (Polas et al., 2023; Matinaro et al., 2019). These findings suggest that enterprises in Central and Eastern Europe may face a distinct combination of constraints – limited resources, uneven access to expertise, and weaker formalisation of sustainability governance – which can hinder the institutionalisation of sustainability and, consequently, the systematic adoption of reverse logistics practices. Similar patterns of partial sustainability institutionalisation have been observed in South-Eastern European enterprises, where sustainability strategies are often declarative but weakly embedded in governance and performance systems (Dichovska et al., 2023).

Despite growing awareness of the environmental impact of business activities, studies reveal that implementation often remains limited. For example, Ayu Kusumawardani et al. (2024) noted that many companies continue to underutilise sustainable materials, energy-saving technologies, or eco-efficient waste management practices. Similar barriers, such as lack of training, insufficient infrastructure, or low perceived economic benefit, were observed in studies conducted in Nigeria (Mallick et al., 2023), Thailand (Piyathanavong et al., 2019), and Poland (Burzyńska et al., 2018).

These findings underscore the importance of not only building awareness but also creating conditions for effective knowledge transfer and operational readiness. Such barriers are also repeatedly reported in reverse logistics implementation, where firms often lack dedicated competencies, infrastructure for returns and recovery, and reliable data for evaluating the costs and benefits of recovery options. Consequently, reverse logistics may remain fragmented and reactive rather than strategically managed.

One area with significant potential to operationalise sustainability is reverse logistics (RL). RL encompasses activities such as return, refurbishment, resale, recycling, or repackaging of goods and materials. When strategically implemented, it contributes not only to environmental objectives by minimising waste and resource use, but also to economic performance through cost savings, value recovery, and enhanced customer satisfaction. Several authors have emphasized the growing relevance of reverse logistics as both a business opportunity and a driver of sustainability innovation (Klapalová et al., 2020; Fidlerová et al., 2020; Witkowski, 2015; Grzesik & Starostka-Patyk, 2012; Sadowski,

2008; Gnap & Rovňaník, 2012; Brezina et al., 2011; Starostka-Patyk, 2017; Straka et al., 2020).

Koszorek and Huk (2021) categorize reverse logistics activities according to their primary orientation: commercial (resale, redistribution), ecological (recycling, packaging reuse), and legislative (compliance with waste regulations). These functions are interconnected and reinforce both sustainability and business strategy. However, the management of RL processes is often more complex than forward logistics. Empirical evidence from Central European industrial settings confirms that reverse flows require higher levels of process transparency, coordination intensity, and structured monitoring compared to traditional forward logistics systems (Legiedz & Huk, 2021). As Blumberg (2005) explains, RL must cope with variable product quality, uncertain disposition paths, irregular inventory valuation, unpredictable return volumes, and ambiguous customer expectations. These characteristics increase the need for formal governance and control mechanisms - clear strategic priorities, assigned accountability, and measurement systems - so that reverse logistics decisions can be coordinated across functions and improved over time. Time planning and cost estimation become more difficult, while environmental risks (e.g. handling of hazardous materials) and regulatory compliance must be carefully managed.

Despite extensive research on sustainability and reverse logistics, empirical evidence linking sustainability institutionalisation (strategy-accountability-metrics), SDG framing, and actionable process-oriented implementation approaches in Central and Eastern Europe remains limited. This study addresses this gap by providing survey evidence from Slovak industrial enterprises and proposing a DMAIC-based methodology for embedding sustainability into reverse logistics routines and measurement practices.

Conceptually, we expect that stronger sustainability institutionalisation - captured by strategy formalisation, accountability assignment, and the use of sustainability metrics - supports more systematic reverse logistics implementation and strengthens firms' intentions to intensify sustainability activities. The DMAIC cycle is proposed as an implementation mechanism that translates sustainability priorities into operational routines and measurable improvements.

3. Research methodology

The aim of the research was to examine the level of sustainability institutionalisation in Slovak enterprises and its implications for reverse logistics (RL). Specifically, the study focused on sustainability awareness, the presence of a formal sustainability strategy, the assignment of responsibility for sustainability, and the use of sustainability-related metrics and practices. The study also sought to identify the extent to which companies use industrial engineering tools to support sustainable operations and assess their readiness to implement structured improvement

methodologies. An examination of global, European, and national policy documents, along with relevant literature on sustainability awareness research, helped define the research area.

A quantitative research design was adopted, using a structured online survey (CAWI method – Computer-Assisted Web Interviewing) to collect data. The questionnaire was developed based on a review of relevant academic literature and international sustainability frameworks and consisted of closed and semi-open questions covering sustainability and SDG awareness, the existence and formality of sustainability strategies, responsibility assignment for sustainability, reverse logistics practices, and the use of selected industrial engineering tools supporting sustainable operations. The target group consisted of industrial enterprises operating in Slovakia, with a particular focus on manufacturers, logistics, and technical service providers. Companies were invited to participate via online invitations distributed through industry associations /professional networks / business directories. Participation was voluntary and anonymous, and the survey targeted respondents with sufficient knowledge of sustainability and operational processes (e.g., managers or specialists). The final sample collected in 2023 included 103 valid responses. To ensure the reliability of the survey instrument, a pilot test was conducted with 10 companies, and adjustments were made based on the feedback received.

To obtain primary data, we used anonymous online CAWI surveys addressed to representatives of companies. The structure of the questionnaire consisted of three follow-up parts and a total of 16 questions, using closed, semi-open, and single or multiple-choice questions. The first part of the questionnaire consisted of classification questions (region/country, sector of the organisation, position, and seniority of the respondent). The second part of the questionnaire explored the extent of knowledge, interest, competence in sustainability and SDGs in companies, the content of sustainability, and the implementation of SDGs in organizations using a categorisation according to a five-point Likert scale. For Likert-type items, responses were coded from 1 to 5 (1 = strongly disagree/not at all; 5 = strongly agree/to a very high extent). The final third section of the questionnaire focused on identifying the organisation's current and future activities in the context of sustainability and SDGs to improve identification of new and existing opportunities for business growth in the context of SDGs, using a five-point Likert scale. Data were processed using descriptive statistics and nonparametric methods, given the ordinal and categorical nature of most variables. In addition to descriptive statistics, associations between categorical variables were examined using cross-tabulations; where appropriate, chi-square tests and effect size measures (Phi or Cramér's V) can be reported to complement rank-based associations. In particular, Spearman's rank correlation coefficient was used to examine relationships between key variables, such as the presence of a sustainability strategy and the use of reverse logistics or engineering methods.

All data were analysed using IBM SPSS Statistics (version 27) and Microsoft Excel software. The results were interpreted with a significance level of $p < 0.05$.

H0 (null hypothesis):

There is no statistically significant association between having a formal sustainability strategy and appointing a person responsible for sustainability.

H1 (alternative hypothesis):

There is a statistically significant association between having a formal sustainability strategy and appointing a person responsible for sustainability.

To test the hypothesis, Spearman's rank correlation coefficient was used because the variables were measured on ordinal and/or dichotomous scales. As a robustness check for categorical associations, cross-tabulations and chi-square statistics (with effect sizes) may be reported. The research followed ethical standards; respondents participated voluntarily and anonymously, and no sensitive data were collected. The findings were summarised and discussed in relation to the objective of the research. The final part of the research focused on identifying opportunities to implement sustainable strategies, including reverse logistics, in companies.

The distribution of the research sample is presented in Table 1. The final dataset includes 103 valid responses from enterprises operating in the Slovak Republic. The sample size is similar to Richnák and Gubová (2021) for the analysis of green and reverse logistics under the conditions of sustainable development in 165 companies in Slovakia. The sample is dominated by manufacturing and service enterprises, reflecting the structure of Slovak industrial activity.

Table 1. **Structure of the sample studied by industry**

Sector	Absolute frequency	Relative frequency [%]
Manufacturing	54	0.524
Service	26	0.252
Other	12	0.117
IT	9	0.087
Agriculture	2	0.019
Total	103	1.000

Source: own elaboration based on empirical research results

4. Results

4.1. Awareness of sustainability and SDGs

The results indicate that 33.0% of respondents (n=34) reported familiarity with the United Nations Sustainable Development Goals (SDGs), whereas 51.5% (n=53) indicated unfamiliarity and 15.5% (n=16) selected a neutral or no-response option. The sectoral analysis revealed higher levels of awareness in the services sector (47.5%) and the IT sector (41.2%), compared to lower familiarity in manufacturing and agriculture (figure 1). *These sector-level percentages should be interpreted considering sector sample sizes; as smaller subsamples may inflate apparent differences.* This pattern suggests an implementation gap in which sustainability frameworks such as the SDGs are not consistently translated into operational routines, which is particularly relevant for reverse logistics due to its process and coordination requirements. The relatively low familiarity with the SDGs observed in this study (33%) is consistent with previous research indicating that sustainability awareness among SMEs and industrial enterprises often remains fragmented and uneven across sectors and regions (Das et al., 2020; Sohns et al., 2023). Similar conclusions were reported by Johnson (2015), who noted that awareness alone does not automatically translate into the systematic use of sustainability management tools.

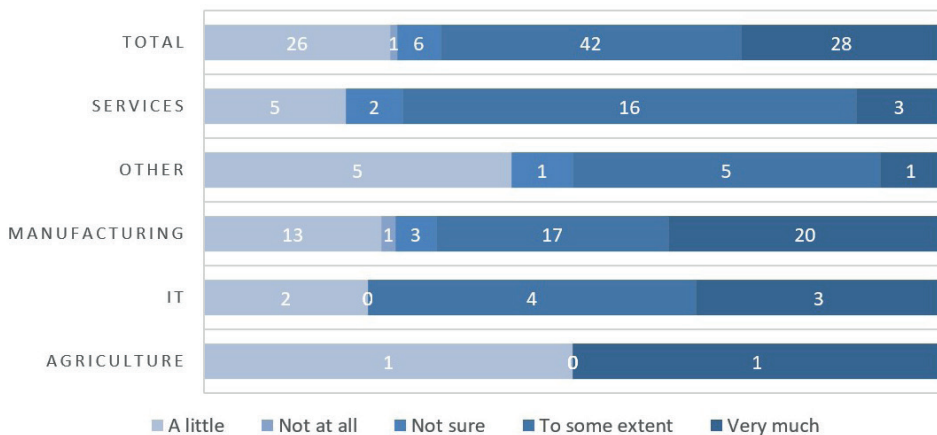


Figure 1. Perceived extent of sustainability integration across organisational sectors and functions

Source: own elaboration based on empirical research results

Within the analysed responses, reporting on sustainability issues is dealt with by the Human Resources Department (35 responses), Production (29 responses), Procurement (23 responses), Logistics and Distribution (17 responses), Accounting and Finance (20 responses). This distribution suggests that sustainability responsibilities are spread across functions; however, the relatively limited presence of logistics and distribution may indicate that sustainability reporting is not yet consistently anchored in supply-chain functions that typically own reverse logistics processes. Other departments such as the Continuous Improvement Department, Quality and Environment Department, Quality Department, Communication Department, HSE, Legal Department and Corporate Management were mentioned with less frequency.

4.2. Organisational commitment to sustainability

Regarding the extent to which sustainability guides company operations, 28 companies (27%) responded “very much”, 42 (41%) “to some extent”, and 26 (25%) “a little or not at all”. Taken together, 68.0% of firms (n=70) report that sustainability guides their operations ‘to some extent’ or ‘very much’ (top-two-box), whereas 26.2% (n=27) report ‘a little’ or ‘not at all’ (bottom-two-box). The strongest engagement was observed in the manufacturing sector, where 35.2% of the respondent’s declared sustainability to significantly influencing business operations.

More than half of respondents reported that their organisation has a formal sustainability strategy (51.0%, n=53). However, only about one third reported having a designated person responsible for sustainability (approximately 35%, n=36), and 34.0% (n=35) indicated that sustainability indicators are included in their reporting systems. To examine the association between the existence of a sustainability strategy and the designation of a responsible employee, Spearman’s rank correlation was applied.

Based on the results of the nonparametric Spearman correlation test. Spearman’s rank correlation analysis revealed a strong positive association between having a formal sustainability strategy and appointing a responsible person ($r_s = 0.805$, $p < 0.05$; $\alpha = 0.05$).

The results indicate that 72.0% of respondents expect sustainability to play a significant or partial role in future company activities. However, intent alone may not be sufficient: research on circular economy-oriented reverse logistics highlights that resource commitment, and managerial capabilities shape whether sustainability initiatives translate into operational and financial outcomes (Fernando et al., 2023). Only 16% expected minimal integration, while 9% believed that no further change is necessary. Figure 2 presents the distribution of responses.

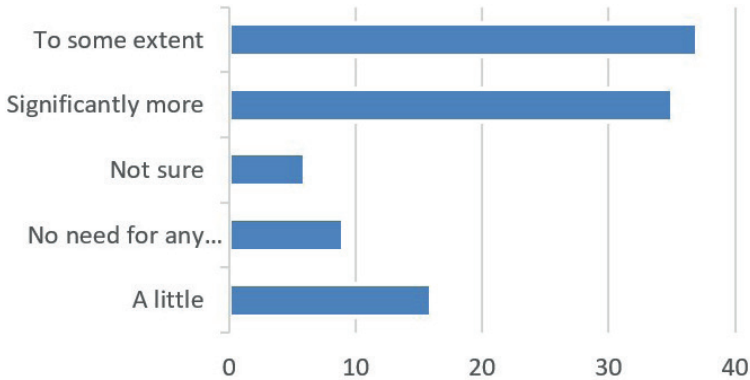


Figure 2. The degree of implementation of sustainability in future activities of the enterprise

Source: own elaboration based on empirical research results

In terms of human resources, 53 respondents stated that they did not know whether new staff with sustainability expertise would be hired. However, 28 companies reported plans to recruit staff with sustainability expertise to some extent, while 9 companies stated that they do not plan to do so (Figure 3). The high share of ‘don’t know’ responses (n=53) suggests uncertainty in workforce planning and may indicate limited readiness to operationalise sustainability through specialised capabilities.

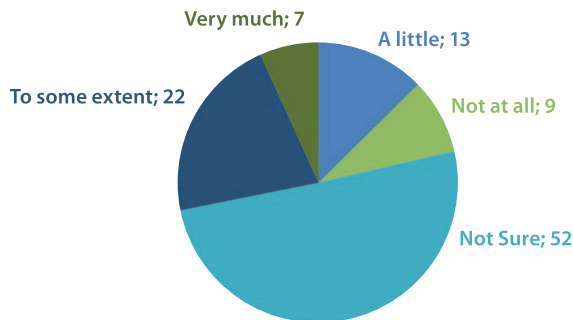


Figure 3. The extent of future implementation of sustainability criteria when hiring employees

Source: own elaboration based on empirical research results

5. Discussion

The results highlight only a partial adoption of sustainability practices among Slovak industrial enterprises. This pattern is consistent with broader European evidence that circular economy and sustainability ambitions increasingly require firm-level governance and measurement systems to move from intent to execution (European Environment Agency, 2024a; European Environment Agency, 2024b). Although more than half of the companies surveyed reported having a sustainability strategy, the relatively low share of firms with assigned sustainability personnel or integrated reporting indicators suggests that the strategic intent is not yet fully translated into operational structures. This supports previous findings by Sohns et al. (2023), who noted that awareness often precedes meaningful implementation. A formal sustainability strategy appears to function as an enabling condition rather than a guarantee of operational implementation. These findings correspond with earlier studies on SMEs in Central and Eastern Europe, which similarly identified gaps between strategic declarations and operational implementation (Das et al., 2020, Richnak & Fidlerova, 2022). Taken together, the findings across the three research questions suggest that sustainability awareness, governance institutionalisation, and future strategic intentions evolve at different speeds, which contributes to the persistence of an implementation gap.

Only one third of respondents from companies reported familiarity with the SDGs, while more than half indicated unfamiliarity. This indicates that SDG-related terminology has not yet become a common managerial reference in many firms, which may hinder structured prioritisation, target setting, and reporting. From a managerial perspective, the result suggests a need for capability building (training, internal communication, and cross-functional coordination) so that sustainability goals can be translated into operational routines - particularly in reverse logistics, where implementation requires process ownership and data. Respondents from companies reported that more than 51% of organisations have a sustainability strategy, approximately one third have an official designated person responsible for sustainability issues, and several confirmed (34 positive responses out of 103) that the reporting system includes sustainability criteria. This configuration points to partial institutionalisation: strategy is present in many firms, but accountability and measurement are less consistently embedded. Prior research suggests that without performance measurement, reverse logistics initiatives remain difficult to manage and scale (Škapa & Klapalová, 2012). The statistical test indicates a strong positive association between having a formal sustainability strategy and appointing a person responsible for sustainability ($r_s = 0.805$, $p < 0.05$). This supports the interpretation that formalisation is linked to accountability structures - an important prerequisite for implementing cross-functional processes such as reverse logistics. Comparable results have been reported in other European SME contexts, where assigning sustainability

responsibility significantly improved the likelihood of structured sustainability implementation (Raharjo, 2019).

In general, up to 72% of the survey respondents responded that sustainability will be significantly or partially reflected in the future activities of the organization, 15% responded a little and, according to 9 respondents, the current level is sufficient. This creates an important prerequisite for new opportunities for sustainability-focused business growth in different sectors.

As indicated by results of a previous study (Richnak & Fidlerova, 2022), the implementation of sustainability and the SDGs was identified in the following activities in decreasing order: use of renewable energy sources, waste separation and recycling, continuous reduction of CO₂ in all logistics activities, cooperation with suppliers to achieve the SDGs and environmental certification, selection of suppliers according to their environmental profile. Logistics including reverse flow emerges as an underutilised operational mechanism capable of translating sustainability commitments into measurable process outcomes. These activity patterns align with international evidence that circular economy and reverse logistics initiatives often begin with relatively visible practices (recycling, waste separation) but face barriers when moving toward more complex, process-intensive closed-loop systems (Mallick et al., 2023; Sonar et al., 2024). In this regard, logistics and especially reverse flows represent an underutilised operational mechanism capable of translating sustainability commitments into measurable process outcomes. This underutilisation corresponds with research from Czech, Polish, and Lithuanian enterprises, which similarly report that reverse logistics remains one of the least systematically managed sustainability domains across industrial sectors (Richnák & Gubová, 2021).

On the other hand, the expectations for future development are cautiously optimistic: 72% of respondents anticipate increasing sustainability efforts, though many remain uncertain about the resources required, especially in terms of human capital. Similar cautiously optimistic expectations have been reported in studies from emerging economy contexts, where companies often express strategic sustainability intentions but face constraints in operational implementation, particularly related to workforce capabilities and resource allocation (Kusumawardani et al., 2024). Similar evidence from European SMEs suggests that sustainability practices are frequently uneven across firms and depend on internal competencies and process ownership, which reinforces the importance of assigned roles and measurable routines (Moursellas et al., 2023; Olipp et al., 2025).

Recent management-oriented reviews similarly emphasise that reverse logistics research increasingly focuses on performance measurement, governance, and pathways to sustainability – areas where structured improvement approaches can provide practical value (Anandhabalaji, 2025).

Finally, the limited use of industrial engineering tools to support sustainability transitions may indicate a missed opportunity. Quantitative optimisation approaches in logistics decision-making have been shown to improve resource allocation and cost control, which supports the measurement and analysis phases required for systematic process improvement (Teplická & Čulková, 2020). Methodologies such as DMAIC, SIPOC, or Ishikawa diagrams, if properly applied, could help firms structure improvement efforts, quantify performance gaps, and reduce variability in reverse logistics processes. Integrating these tools more systematically could support data-driven decision-making and continuous improvement. Recent studies in digital supply chain analytics demonstrate that advanced monitoring systems and data-driven optimisation significantly improve traceability and control in reverse logistics networks (Onofrei et al., 2023). The need for stronger sustainability competencies is emphasised not only in industrial practice but also in economic education, where sustainability awareness is identified as a strategic competitive advantage (Richnák, 2025).

To address this gap, we propose a set of recommended tools that align with the five phases of the DMAIC framework (Define - Measure - Analyse - Improve - Control). These instruments have been successfully applied in process optimisation contexts and are suitable for enhancing reverse logistics implementation in sustainability-focused industrial environments (Table 2).

Table 2. Recommended tools and methods for sustainable reverse logistics improvement using DMAIC framework

DMAIC framework	Recommended tools and methods	Purpose
Define	SIPOC diagram	Process scoping and stakeholder identification
Measure	Flowchart, checklists, control charts, data collection plan	Mapping current processes and data collection
Analyse	5 Why, Ishikawa diagram	Identifying root causes of inefficiencies
Improve	FMEA, Kaizen events, design of experiments (DOE)	Developing and prioritizing improvement actions
Control	Kamishibai boards, balanced scorecard (BSC)	Monitoring process performance and sustaining improvements

Source: own elaboration based on empirical research results

Several published studies demonstrate that industrial engineering tools can improve decision quality and risk management in reverse logistics by supporting structured problem identification, prioritisation, and monitoring. Examples include the use of FMEA for analysing risks in reverse flows (Sameer et al., 2009), multi-criteria decision-making for selecting waste facilities (Mikušova et al., 2019), elimination of hazardous waste in an industrial enterprise (Fidlerova & Poplawski, 2022), risk assessment (Fouladgaran & Lim, 2020, Senthil et al, 2018) and statistical analysis of waste data to reduce reverse logistics costs (Witkowski, 2012). Collectively, this evidence supports the applicability of DMAIC-aligned tools in sustainability-oriented reverse logistics contexts

To complement the findings and address the observed gaps in strategy and operational integration, we propose a structured framework for implementing sustainability and the SDG principles in reverse logistics. This framework is based on the DMAIC methodology and integrates key strategic and process elements.

Strategic Dimensions of Sustainable Reverse Logistics:

- time horizon: Distinguish short-term actions from long-term commitments, focusing on systemic benefits,
- competitive advantage: Identify opportunities such as innovation, stakeholder engagement, or new market access,
- shared value: Balance economic results with social and environmental value.

DMAIC-based Implementation Model:

1. Define: Understand external and internal environments using tools such as PESTEL, Porter's Five Forces, and SWOT analysis. Identify key stakeholders, set goals, and sustainability criteria.
2. Measure: Use SIPOC mapping to define processes by input, output, costs, time, and environmental impact. Establish KPIs in environmental, social, and economic dimensions.
3. Analyse: Apply tools such as FMEA, Pareto analysis, cause-and-effect diagrams, and 5 Whys to identify root causes and risks. Use correlation and regression analysis for quantitative relationships.
4. Improve: Design targeted solutions, allocate resources, develop action plans, and pilot sustainable interventions in RL.
5. Control: Monitor the results of the implementation, evaluate the performance against the expected goals, and introduce corrective actions. Focus on standardisation, compliance, and alignment with SDG objectives. In addition, incorporating recent circular economy and reverse logistics evidence from European and Central and Eastern European contexts can strengthen the international positioning of the discussion and support benchmarking beyond Slovakia.

6. Conclusion

This study highlights how sustainability is institutionalised in Slovak enterprises and what this implies for integrating sustainability into reverse logistics (RL). Based on a CAWI survey of 103 Slovak companies operating across industrial sectors, the findings indicate a moderate and uneven level of institutionalisation. While more than half of the surveyed organisations report having a formal sustainability strategy, only about one third have appointed a person responsible for sustainability and roughly one third incorporate sustainability indicators into reporting. Together, these results point to an implementation gap: sustainability intent is present, but accountability and measurement routines are not yet consistently embedded. The analysis further shows a strong positive association between having a formal sustainability strategy and assigning responsibility for sustainability, suggesting that formalisation is linked to the creation of organisational structures that enable implementation. In practical terms, this matters for RL because reverse flows require cross-functional coordination, process ownership, and performance monitoring. This interpretation is aligned with prior evidence that RL performance measurement and governance routines are critical for moving from ad hoc initiatives to systematic implementation (Škapa & Klapalová, 2012) and with systematic research highlighting barriers when firms attempt to “close the loop” through more complex circular practices (Mallick et al., 2023).

To support managerial action, the paper proposes a DMAIC-based methodology (Define–Measure–Analyse–Improve–Control) that links strategic intent to operational routines and control mechanisms. By combining tools such as PESTEL/SWOT for context analysis and SIPOC/process mapping, root-cause analysis, and KPI-based monitoring, the framework provides a structured pathway for embedding sustainability objectives into RL processes and for sustaining improvements over time. Rather than treating sustainability as a one-off initiative, the proposed approach emphasises data-driven learning and continuous improvement.

This study has limitations. The evidence is based on self-reported survey data and a single-country sample, which may limit generalisability and causal interpretation. Our findings confirm that integrating sustainability into reverse logistics not only ensures compliance with environmental and regulatory requirements but also serves as a key driver of innovation and competitive advantage. This implementation gap is consistent with systematic evidence that firms often face substantial barriers when progressing from basic sustainability actions toward closed-loop systems enabled by reverse logistics (Mallick et al., 2023). This observation is consistent with the findings of Sun (2017), who argues that the strategic integration of reverse logistics can deliver significant environmental and economic benefits. Similarly, our results are consistent with the research of Salas-Navarro et al. (2024), who highlight that the implementation

of reverse logistics (RL) in context of sustainability is a strategic decision with significant attention amongst organisations. Recent modelling-based studies further emphasise that embedding reverse logistics into circular production systems requires structured performance evaluation and formal governance alignment (Salas-Navarro et al., 2025). Overall, the consistency between our findings and previous empirical research supports the exploratory conclusions of this study and reinforces the relevance of the proposed DMAIC-based framework.

In the future, we would like to expand our research through comparative cross-country studies (e.g., within Central, South and Eastern Europe), in different national and industry contexts that focus on how external factors influence the adoption of SDGs and the success of sustainability strategies. Another direction for future planned research incorporates objective performance indicators, and tests how digital technologies and analytics can enhance measurement and decision-making in sustainability-oriented reverse logistics.

Authors' contribution

H.F.: article conception, theoretical content of the article, research methods applied, conducting the research, data collection, analysis and interpretation of results, draft manuscript preparation. **P.B.:** article conception, analysis and interpretation of results. **H.G.C.:** article conception, conducting the research, analysis and interpretation of results, draft manuscript preparation.

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Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author used ChatGPT 5.2 in order to check references (APA7 style) and grammar. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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