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# EMPIRICAL INSIGHTS INTO SUPPLY CHAIN MANAGEMENT INTEGRATION WITH PRODUCT LIFECYCLE MANAGEMENT: BENEFITS AND CHALLENGES

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## ABSTRACT

Integration of product lifecycle management systems with supply chain management processes has proven challenging for companies that attempt it, with limited empirical research available on this topic. Consequently, this study aimed to explore whether implementing product lifecycle management systems can enhance supply chain management within an organisation. To obtain relevant data, this study employed a single qualitative case study design, using in-depth semi-structured interviews and on-site observations conducted at ABC TECH to examine how Sovelia PLM supports supply chain processes. The data was collected from a company in Northern Europe that uses Sovelia lifecycle management software. Findings showed that this software generally aids in enhancing supply chain process integration, traceability, and structure. However, it is design-centric, which makes it more difficult to adequately address the supply chain management department's operational requirements. These insights may enhance the decision-making processes and guide actionable strategies for seamless integration. The findings call for a more holistic product lifecycle management system that encapsulates both design and supply chain functionalities, thereby ensuring cohesive operations and improved communication within the company's supply chain network.

## KEY WORDS

**supply chain management (SCM), product lifecycle management (PLM), performance, management, PLM and SCM integration, benefits and challenges**

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## INTRODUCTION

Agile and flexible procedures are essential as the industrial sector moves towards Industry 4.0, which is characterised by more complex systems (Shakouhi et al., 2023). Industries must implement systems that not only

keep pace with technological advancements but also encourage cooperation and coordination across different production phases. Information was formerly often disseminated via email or presentations, but in today's fast-paced world, these methods are insufficient (Stark, 2022). Companies that stick to antiquated procedures risk falling behind their rivals and becoming obsolete.

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In large enterprises, efficient information sharing is essential as goods get increasingly complicated over time. Product lifecycle management (PLM) is essential in this situation (Conlon, 2024). PLM manages data and procedures at every stage of a product's lifetime, including design, engineering, manufacturing, sales, and service, from the time of its conception until the end of its useful life. Supply chain management (SCM), on the other hand, covers the movement of goods and information from raw materials to the final customer and guarantees the coordination and control of all operations involved in the manufacture and delivery of services or products (PTC, 2024). Industries must adopt more efficient methods and processes to manufacture goods that satisfy consumer wants. By coordinating processes with strategic planning and promoting internal cooperation, the combination of PLM and SCM provides an answer (Triguero et al., 2023). Throughout the product lifecycle, this integration facilitates a smooth flow of data and procedures that improve productivity, lower costs, improve product quality, and shorten time-to-market (Vidergar et al., 2021). As a result, merging PLM and SCM can stimulate technological advancement by guaranteeing that all industry players are linked and coordinated on a single platform (Deteix et al., 2024).

The significance of this study can be seen from different points. Although PLM research has made great strides, it is generally agreed that more studies are needed to fully comprehend its place in Industry 4.0 (Meeshi et al., 2021). Because relatively few manufacturers provide such solutions, there is a gap in the analysis of the advantages of integrating maintenance data into PLM systems. The advantages of centralising data management are still mostly unknown, even though numerous studies have suggested frameworks for integrating PLM with other systems like CRM, ERP, and SCM at various phases of the product lifecycle. Interoperability is hampered by the lack of standards, and PLM solutions demand a significant time and financial commitment, which makes integration difficult, particularly when dealing with original equipment manufacturers (Conlon, 2024). Guidelines are essential to improve PLM and ERP system interoperability since they would lower the cost of maintaining various systems and encourage supplier and customer collaboration without the need for superfluous processes.

Moreover, an increasing number of studies support web-based methods that let original equipment manufacturers communicate product details in standard forms with suppliers (Meeshi et al., 2021). Research, however, is scarce on data transfer beyond computer-

aided design, including product documentation and other related data (Deteix et al., 2024). Computer technology has improved SCM integration; yet empirical assessments of the effects of IT-enabled manufacturing processes on SCM performance are still scarce, especially when considering manufacturers' perspectives (Mulla et al., 2021). The literature also emphasises how important it is to cluster different supplier connections and create IT structures for data transmission while developing new products because these activities demand a lot of resources (Pang et al., 2021). Accordingly, this study aims to address this research gap and identify potential benefits and challenges of the integration between PLM and SCM, in a real case firm. The study answers the following research questions:

RQ1: In what ways can PLM systems improve the SCM process?

RQ2: What challenges might arise when implementing PLM systems within SCM?

This work makes several contributions to the subject of PLM and SCM integration. The study provides a detailed analysis of Sovelia PLM software's strengths, such as its ability to integrate with other systems, manage product data, and support engineering and business processes. Simultaneously, it highlights significant weaknesses, including the software's inflexibility, user interface challenges, and difficulties in handling mistakes and collaborating across departments. Moreover, this study offers tailored insights into how different departments within ABC TECH (i.e., Technology, Engineering, SCM, Business Systems, and After-sales) interact with and perceive the Sovelia PLM software. These insights help identify specific areas where the software meets departmental needs and where it falls short, providing a comprehensive view of its impact across the organisation. Furthermore, the study suggests specific improvements for Sovelia PLM software, such as enhancing user-friendliness, improving collaboration features, and increasing flexibility in handling errors and changes. These recommendations are informed by direct feedback from various departments and can guide future updates or customisations of the software to better align with ABC TECH's evolving needs. Finally, by examining the practical implementation and challenges of Sovelia PLM software in a real-world setting, the study adds valuable case-specific insights to the broader literature on PLM. It underscores the importance of aligning PLM software with organisational structures and processes, offering lessons that can be applied in similar industrial contexts.

The outline of the paper's structure is as follows: Background data and relevant literature on SCM and

PLM are presented in Section 1. The method of investigation used in this study is described in Section 2. The benefits and challenges of Sovelia PLM software are covered in Section 3, along with a meta-analysis of the department's use of the software. Section 4 explores the limitations of the study, practical implications and future avenues for research.

## 1. LITERATURE REVIEW

### 1.1. SUPPLY CHAIN MANAGEMENT

To generate net value, establish a competitive infrastructure, and align supply and demand, SCM is an essential discipline that includes the planning, delivery, supervision, and tracking of SC activities (Burke et al., 2023). Its inception can be linked to the development of operations management and logistics in the 20th century, when the main emphasis was on streamlining certain SC elements, including manufacturing, distribution, and procurement (Alzoubi, 2024; Hayrutdinov et al., 2020). However, the need for an integrated approach to managing these activities evolved as global trade increased and SCs grew more intricate and linked. By combining several operations from the procurement of raw materials to the delivery of the finished product to the customer, SCM developed to meet this need (Koc & Gurgun, 2021).

The smooth integration of these many elements and the capacity to react quickly to demand fluctuations, supply interruptions, and other unforeseen difficulties are prerequisites for effective SCM (Fernando et al., 2024). Strong channels of communication, cutting-edge data analytics, and cooperative partnerships with suppliers and partners are necessary for this (Burke et al., 2023). The need to strike a balance between speed and dependability, standardisation with innovation, and flexibility with cost-efficiency further complicates the relationships within the SC. Accordingly, SCM is now a strategic role in businesses and is necessary to stay competitive in a market that is becoming increasingly international and fast-paced (Chhetri et al., 2022).

An SC may be complicated if it includes the exchange of information and materials between several parties (Hayrutdinov et al., 2020). The multiplicity of interactions among the components that make up SCM is what makes it so complex. To guarantee the efficient movement of goods, information, and funding, these entities, which include manufacturers, distributors, suppliers, warehouses, and retailers, must

cooperate (Shao et al., 2021). Because every step of the SC is interconnected, problems in one place might have repercussions for the entire system (Eby, 2023). If there are delays in obtaining raw materials, manufacturing bottlenecks may occur, hence influencing delivery timelines and ultimately customer satisfaction (Fernando et al., 2024). Furthermore, the worldwide scope of contemporary SCs adds yet another level of complexity, including handling various legal frameworks, overseeing cross-border transportation, and negotiating exchange rate swings (Vidergar et al., 2021). A greater amount of data must be shared due to the evolving hybrid nature of systems, businesses, and organisations, and everyone must be connected to one another in some way. This ultimately results in the creation of a system that is more complicated, and in this case, a more complex SC (Chhetri et al., 2022). Businesses that prioritise technology development and need to create, store, analyse, and process large amounts of data in a standardised way must use approaches that can be managed throughout the product lifecycle (Hayrutdinov et al., 2020).

### 1.2. PRODUCT LIFECYCLE MANAGEMENT

PLM offers a thorough method for overseeing a product's whole lifecycle, from conception to retirement. PLM systems collect vital data from multiple sources, including client needs, product data management systems, and experience-based learning (Stark, 2022). This data helps to map out the product design, and all product-related data, from design to manufacturing, is connected and functions as a whole (Shearon, 2018). An efficient tool for managing complicated product data and procedures is a well-implemented PLM system, which can store a variety of product-related information and provide functions like revision history, search, and quick modifications (Lim et al., 2020). A PLM system's ability to smoothly exchange information is crucial for enabling necessary upgrades and modifications, which keep the product development process flexible and adaptable (Pinna et al., 2018). Fig. 1 illustrates the PLM process. The figure illustrates various stages a product undergoes from its inception to its end-of-life (Eby, 2023). It starts with the concept phase, followed by development, prototyping, launch, and manufacturing. Once the product is in the market phase, it goes through distribution, use, and service stages (Eby, 2023). Finally, at the end of its lifecycle, the product enters the end-of-life phase, where it can be recycled. PLM is positioned at the centre, emphasising its role in overseeing and managing the entire product

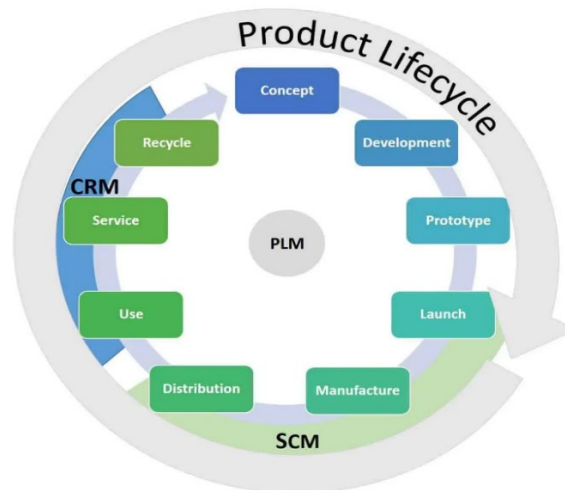


Fig. 1. PLM phases

Source: (Eby, 2023).

lifecycle (Eby, 2023). SCM in PLM covers all aspects of the launch and distribution, including manufacturing. CRM also encompasses everything that happens to a product once it is purchased, until its retirement or recycling (Eby, 2023).

Several prominent companies offer PLM systems: Dassault Systèmes offers PLM solutions through its 3DEXPERIENCE platform (Dassault, 2024); Oracle offers PLM software as part of its broader enterprise resource planning (ERP) suite (Oracle, 2024); PTC, which is well-known for its Creo CAD software and Windchill PLM platform (PTC, 2024); Siemens, which offers a comprehensive PLM suite, including Teamcenter (Siemens, 2024); and SAP, which offers PLM solutions integrated with its ERP system (SAP, 2024). Furthermore, there are open-source PLM systems, like open-source PLM, which are less popular than commercial solutions but still have choices for businesses with certain needs or limited resources (Technia, 2024). Moreover, several cloud-based PLMs that provide flexibility and scalability have emerged because of cloud computing's growing popularity (Technia, 2024).

For product development and delivery to be more efficient overall, PLM and SCM interaction is essential. Systems like Customer Relationship Management (CRM), ERP, and SCM are just a few of the enterprise systems that PLM systems are made to integrate with. Better departmental and system collaboration is encouraged by this integration, which guarantees smooth information flow throughout the company (Stark, 2022). Businesses can shorten lead

times in the innovation process by integrating PLM and SCM, particularly in intricate new product development scenarios involving numerous departments (Eby, 2023). Because of the synergy between PLM and SCM, products can be conceived, manufactured, and delivered more effectively and with greater responsiveness to market changes.

Moreover, PLM systems offer the traceability and visibility required for efficient product lifecycle management when they are coupled with SCM (Corallo et al., 2020). For industries dealing with recalls, regulatory compliance, or material compliance issues, traceability is essential (Shearon, 2018). Additionally, by offering a thorough perspective of the product's lifespan, from design to delivery, the integration facilitates better decision-making (Pinna et al., 2018). By guaranteeing that every facet of the product's lifecycle is effectively handled, this holistic approach not only improves product quality and shortens time-to-market but also fosters innovation and supports sustainable business practices (Fernando et al., 2024).

### 1.3. PRODUCT LIFECYCLE MANAGEMENT APPLICATIONS IN SUPPLY CHAIN MANAGEMENT

This section reviews the most relevant literature on PLM applications in SCM from the past five years. To ensure a focused and up-to-date overview of existing research, the literature included in this section was selected through a targeted search process. Academic databases, such as Scopus, Web of Science,

IEEE Xplore, SpringerLink, and ScienceDirect, were consulted. The following keywords and Boolean combinations were applied: “Product Lifecycle Management” AND “Supply Chain Management”, “PLM integration”, “PLM SCM case study”, “digital thread supply chain”, “PLM Industry 4.0”, and “lifecycle management supply chain”. The search was limited to 2019–2024 to capture contemporary developments, as both PLM and SCM have evolved significantly in the context of digital transformation and Industry 4.0. Studies were included if they met at least one of the following criteria:

- (1) examined PLM applications within supply chain contexts;
- (2) proposed or evaluated PLM–SCM integration frameworks;
- (3) investigated PLM implementation challenges affecting SCM processes; or
- (4) provided empirical or conceptual models relevant to PLM-enabled supply chain visibility, traceability, sustainability, or collaboration.

Based on these criteria, the literature was organised into five thematic clusters representing recurring research streams: PLM in specific SCM industries,

Tab. 1. PLM applications in SCM

PLM FOCUS	STUDY	FINDINGS
PLM in specific SCM industries	Meeshi et al., 2021; Mulla et al., 2021	<ul style="list-style-type: none"> <li>• PLM in the SCM aerospace industries.</li> <li>• PLM to data exchange, collaboration, and management across different domains.</li> </ul>
	Burke et al., 2023	<ul style="list-style-type: none"> <li>• PLM and SCM integration can support circular economy transitions.</li> </ul>
	Triguero et al., 2023	<ul style="list-style-type: none"> <li>• PLM is a key tool in implementing circular economy principles.</li> </ul>
PLM system selection and evaluation	Enríquez et al., 2019	<ul style="list-style-type: none"> <li>• Developing a quality model based on QuEF for selecting the most suitable PLM solution.</li> </ul>
	Chhetri et al., 2022	<ul style="list-style-type: none"> <li>• Alignment of SCM with product demand and design characteristics.</li> </ul>
	Omerali & Kaya, 2022	<ul style="list-style-type: none"> <li>• Proposing a multi-criteria decision-making method.</li> </ul>
	Conlon, 2024	<ul style="list-style-type: none"> <li>• Understanding industry practices and fostering innovative thinking.</li> </ul>
SCM solutions based on PLM	Hayrutdinov et al., 2020	<ul style="list-style-type: none"> <li>• Proposing an SCM model using blockchain for PLM information sharing.</li> </ul>
	Shao et al., 2021	<ul style="list-style-type: none"> <li>• Proposing a multi-stage implementation framework for Industry 4.0.</li> </ul>
	McKendry et al., 2022	<ul style="list-style-type: none"> <li>• Developing a PLM implementation framework.</li> </ul>
	Tao et al., 2022	<ul style="list-style-type: none"> <li>• Developed a product life cycle cost model.</li> </ul>
Sustainability and lifecycle methodologies	Nilsson-Lindén et al., 2019	<ul style="list-style-type: none"> <li>• Importance of sustainability managers and the business case in SCM.</li> </ul>
	Elias Mota et al., 2020	<ul style="list-style-type: none"> <li>• Identifying uncertainty sources in IPLM and their impact.</li> </ul>
	Vidergar et al., 2021	<ul style="list-style-type: none"> <li>• Importance of transparency and sustainability-oriented decision-making across various levels.</li> </ul>
	Iveson et al., 2022	<ul style="list-style-type: none"> <li>• Importance of shifting towards consumer-centric PLM modelling.</li> </ul>
Traceability and lifecycle management	Corallo et al., 2020	<ul style="list-style-type: none"> <li>• Reviewing the relationship between traceability and lifecycle management in the food industry.</li> </ul>
	Pang et al., 2021	<ul style="list-style-type: none"> <li>• Providing a framework combining digital twin and digital thread technologies to enhance production processes.</li> </ul>
	Razak et al., 2021	<ul style="list-style-type: none"> <li>• Developing a framework linking traceability to SC resilience.</li> </ul>
	Deteix et al., 2024	<ul style="list-style-type: none"> <li>• Exploring the impact of resource supply risk on life cycle assessments.</li> </ul>
Barriers and challenges in PLM implementation	Singh & Misra, 2019	<ul style="list-style-type: none"> <li>• Identifying critical barriers to PLM institutionalisation.</li> </ul>
	Koc & Gurgun, 2021	<ul style="list-style-type: none"> <li>• Investigating SCM risks in construction projects related to PLM.</li> </ul>
This study		<ul style="list-style-type: none"> <li>• Discusses the benefits and challenges of integrating PLM with SCM.</li> <li>• Provides several implications and future research directions.</li> </ul>

PLM system selection and evaluation, SCM solutions based on PLM, sustainability and lifecycle methodologies, traceability and lifecycle management, and barriers and challenges in PLM implementation. Table 1 provides a structured summary of these studies.

PLM deployment has been investigated in a number of SCM businesses. Mulla et al. (2021) performed a systematic analysis of PLM literature, emphasising its use in the aerospace sector. The study emphasised the connections between PLM and other fields like ERP and SCM. According to their analysis, PLM is an effective instrument for information interchange, especially when it comes to data management and retrieval procedures (Mulla et al., 2021). Similarly, Meeshi et al. (2021) examined global communication procedures across and inside enterprises, highlighting the usefulness of PLM as a tool. In the aerospace industry, PLM has been found to be an essential business strategy and cooperation tool that greatly improves product lifecycle management (Meeshi et al., 2021). Furthermore, Burke et al. (2023) looked into how SCM and product design could work together in the context of a shift to a circular economy. The study clarified how important it is to incorporate the SC context into conventional notions of product design. It also underlined how urgently corporate models must be updated to conform to circular SC designs. A successful shift to a circular economy depends on the incorporation of end-of-life, circular, and innovative thinking into routine company operations; all of these must be supported by a strong organisational commitment to sustainability (Burke et al., 2023). Triguero et al. (2023) investigated how product design, including circular economy principles, affects environmental and economic outcomes. The results showed that PLM is a useful instrument for bringing circular economy ideas into practice, which enhances economic performance (Triguero et al., 2023).

Another stream of the literature focused on PLM system selection and evaluation. Enríquez et al. (2019) created a quality model based on the Quality Evaluation Framework (QuEF), which has been proven in the aviation sector, namely with Airbus. Similarly, Omerali and Kaya (2022) presented a multi-criteria decision-making technique to assist manufacturing companies in choosing the best PLM solution and overcoming the difficulties associated with subjective decision-making. Additionally, Chhetri et al. (2022) developed techniques to improve SC alignment by modelling the alignment of SC

complexity with product demand and design features. Conlon (2024) discussed the insights, observations, and information obtained from an action research project that sought to create a PLM systems learning community. The results demonstrated that PLM produced an engaging learning atmosphere, which promoted the formation of a professional identity, encouraged critical and creative thinking, and enabled a thorough grasp of contemporary industry practices (Conlon, 2024).

In another theme, authors have proposed several solutions to enhance SCM using PLM. A blockchain-based SC coordination approach for sharing product lifecycle information was presented by Hayrutdinov et al. (2020), who also demonstrated higher chain-wide profitability. Parallel to this, Shao et al. (2021) suggested a multi-phase Industry 4.0 implementation strategy for SCs, emphasising enablers like culture, cross-functional methods, and continuous improvement. Additionally, McKendry et al. (2022) created a PLM implementation methodology that addressed issues of scale, complexity, and uncertainty specifically for high-value engineering-to-order initiatives. Furthermore, Tao et al. (2022) used revised multi-choice goal programming and multi-objective linear programming approaches to develop a product life cycle cost-based model with the goal of lowering rejections, late deliveries, and net costs. They designed a decision-making instrument tailored for use in sustainable procurement SCM at a high-tech Taiwanese light-emitting diode manufacturer. Using these two methods within the SC product life cycle cost model and changing for different parameters, managers can handle pertinent difficulties (Tao et al., 2022).

Another theme of literature focused on sustainability and lifecycle methodologies. Elias Mota et al. (2020) highlighted the sources of uncertainty in life cycle approaches and how they affect business and environmental initiatives, especially in the paper and pulp sector. Iveson et al. (2022) reviewed the literature on project lifecycle concepts and found that lifecycle modelling is shifting in favour of consumer-centric viewpoints. Comparably, Nilsson-Lindén et al. (2019) examined how corporate PLM was used in product chains, emphasising the function of sustainability managers and the significance of the business case in SCM. Furthermore, Videgar et al. (2021) examined studies on food SCM and PLM, highlighting the significance of openness and sustainability in decision-making at all levels.

One more theme that has been given a lot of attention in the literature is traceability and lifecycle

management. A thorough review examining the connection between traceability and PM, especially in the food industry, was performed by Corallo et al. (2020), with implications for a number of industries, including aerospace. On the other hand, Razak et al. (2021) created a conceptual framework that demonstrates the indirect and direct linkages between SC resilience and traceability, as well as flexibility, velocity, visibility, and collaboration. Comparably, Pang et al. (2021) offered a framework to improve information traceability and manufacturing processes in Industry 4.0 by fusing digital thread and digital twin technologies.

Finally, some studies focused on investigating the barriers and challenges in PLM implementation in SCM. Using an empirical investigation, Singh and Misra (2019) identified four primary barriers to PLM institutionalisation that include: lack of technical expertise, high investment costs, complex licensing policies, and training. Furthermore, by defining crucial decision entities and phases in construction SCM, Koc and Gurgun (2021) examined SCM risks in PLM-related building projects. Moreover, Deteix et al. (2024) examined how resource supply risk affected life cycle evaluations in the food business, demonstrating how resource risks and environmental effects may be traded off.

Despite the growing number of studies examining PLM frameworks, system selection, sustainability applications, and traceability solutions, the existing literature remains largely conceptual, with limited empirical evidence on how PLM systems are actually experienced and utilised across different departments within a single organisation. Very few studies provide multi-departmental, user-level insights into the practical challenges of PLM–SCM integration, particularly in firms with customised PLM solutions rather than standardised commercial platforms. Moreover, most prior work focuses on high-level benefits or technical models, offering little understanding of how operational realities, such as training, user interface issues, workflow integration, and data flow constraints, affect the success of PLM–SCM integration. To address this gap, the present study investigates the benefits and challenges of Sovelia PLM software within ABC TECH through department-specific qualitative analysis. This empirical focus directly informs the two research questions of the study by revealing how PLM systems can support SCM processes (RQ1) and identifying the integration challenges that organisations encounter in practice (RQ2).

## 2. RESEARCH METHODS

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This study distinguishes itself from others in the field by offering an in-depth, department-specific analysis of Sovelia PLM software within a real-world industrial context at ABC TECH. Unlike many studies that focus on the theoretical benefits of PLM systems or general case studies, this research delves into the practical challenges and successes experienced by different departments (i.e., Technology, Engineering, SCM, Business Support, and After-sales). By capturing the unique perspectives and specific needs of each department, this study provides a nuanced understanding of how PLM software functions in a complex organisational environment. Additionally, it focuses on actionable recommendations for improvement, based on direct user feedback, and ensures that the findings are not only academically rigorous but also practically relevant to enhancing PLM implementations in similar industrial settings.

The data used in this study were gathered for the thesis in Khan and Iftikhar (2022). This study is based on a single qualitative case study, following the guidelines of Yin (2009). The case study design was selected because it allows an in-depth exploration of how PLM systems function within real organisational contexts (Yin, 2009). Data were collected using two qualitative methods: (1) semi-structured interviews with employees from multiple departments at ABC TECH, and (2) comprehensive on-site observations of work processes, systems usage, and information flows. These complementary qualitative techniques provided rich empirical evidence to understand the practical integration of Sovelia PLM software into SCM processes. A case study ought to contain research questions, propositions, logical connections between the data and the propositions, and an analytical unit, as stated by Yin (2009).

The claims that Sovelia PLM software will improve collaboration and traceability between various SCM process components are made under Section 2.2 (data collection and analysis). The logical linking of this article to literature is that PLM systems have been developed to integrate different components of SCM. Finding, evaluating, and reporting themes in the data is made possible by the thematic analysis technique (Alzoubi & Mishra, 2024). To create a comprehensive picture of common patterns and crucial insights, all significant remarks from each participant were gathered, compared, and contrasted (Alzoubi & Mishra, 2024). This study adhered to the

four steps (data collecting, data reduction, data display, and conclusion drawing) outlined by Alzoubi and Gill (2021) to methodically examine and code the data that was gathered.

### 2.1. CASE CONTEXT

ABC TECH is a technology company established in 1990 as a spin-off from the main company's research and development division. They employ over 50 highly skilled professionals and focus on developing and delivering state-of-the-art, fully automated casting lines for the aluminium industry. Their core expertise lies in end-to-end aluminium cast house technology, utilising a combination of process know-how, mechanical engineering, electrical and automation engineering, project management, and SC expertise. Project deliveries are used to deliver ABC TECH goods to the end user. The selection of ABC TECH as the case company was intentional and theoretically justified. ABC TECH represents a highly relevant context because it is a technology-intensive manufacturing firm that relies heavily on engineering, customisation, and multi-departmental collaboration, conditions under which PLM-SCM integration is both critical and challenging. ABC TECH also uses a customised PLM solution (Sovelia), implemented across engineering, SCM, after-sales, business support, and technology functions. This makes the company an ideal setting for examining how PLM systems shape, enable, or constrain supply chain processes in practice. Furthermore, ABC TECH was chosen due to its willingness to provide full access to employees, systems, and internal workflows,

allowing for rich qualitative insight that is rarely available in PLM research.

The Sovelia software does not support the following processes: budget/cost, milestones, communication/meetings, and documentation. Although Sovelia is a customised PLM system developed specifically for ABC TECH, its core structure and functionalities are comparable to mainstream PLM platforms such as Siemens Teamcenter, PTC Windchill, Dassault 3DEXPERIENCE, and SAP PLM. Like other PLM systems, Sovelia supports item management, engineering change management, document control, revision handling, and integration with CAD and ERP systems. However, Sovelia differs in two important ways: (1) it is highly customised and therefore reflects ABC TECH's legacy processes, and (2) it places a strong emphasis on engineering and design functions while offering more limited support for downstream supply chain operations. These characteristics make Sovelia an informative example for studying both the strengths and limitations of PLM-SCM integration in real industrial settings. Table 2 provides a breakdown of participants' demographics from various departments included in this study. It lists the participants' experience levels and their years of experience.

ABC TECH currently uses Sovelia PLM software that was created specifically for the company. The SC was not fully incorporated into this design when it was created because it was still evolving at the time. But now, as it fully developed, ABC TECH wants to find out how to better integrate SC with the PLM software. They also want to address the side issue of product traceability to stay competitive in the market.

Tab. 2. Participants' demographics

DEPARTMENT	PARTICIPANT	EXPERIENCE LEVEL	EXPERIENCE (YEARS)
SCM	JD	Middle	15–20
	TS	Senior	20–25
	FG	Middle	15–20
Engineering	MFW	New	1–5
	GAAN	New	1–5
	ABB	Senior	20–25
	RH	Junior	5–10
	RF	Middle	15–20
	SOS	Senior	20–25
Technology	MC	Middle	15–20
After-sales	HINT	Middle	15–20
Business support	EC	Junior	5–10

Their system will function smoothly and efficiently once these are in place. All participants in this study are employees of ABC TECH and were interviewed face-to-face on-site. Specifically, three participants from the SCM department (JD, TS, and FG), six participants from the Engineering Department (MFW, GAAN, ABB, RH, RE, and SOS), one participant (MC) from the Technology Department, one participant (HINT) from the After-sales Department, and one participant (EC) from the Business Department were interviewed.

## 2.2. DATA COLLECTION AND ANALYSIS

Four unstructured interviews were conducted with staff members from various departments of ABC TECH prior to the semi-structured interviews to better understand the SCM process as well as the Sovelia PLM software. This was crucial for formulating semi-structured interview questions and determining the primary theme for later stage coding. The four steps in thematic analysis used in this study are discussed in the paragraphs below.

**Data collection:** Semi-structured interviews were used in this step to get participants' in-depth insights. To complete the questionnaire, staff members from the departments of business support, marketing, engineering, SCM, and technology development were contacted. This is because each of these departments utilises the PLM software that is currently tailored by ABC TECH. The open-ended format of the questions made it easier to gather rich, qualitative information that gave rise to a complex knowledge of the experiences and viewpoints of the participants. The notes made during a two-month observation of the ABC TECH site were used to gather more data. 45–60 minutes were allotted for each interview. Each interview began with a series of generic inquiries about the interviewee's role. Then, the interviewee was asked the following pre-planned questions.

- How do you use different modules of Sovelia PLM software?
- Do you believe that using software enables you to collaborate with others?
- Does it interact with other programs, such as CAD, SCM, ERP, or CAD?
- What advantages do the existing Sovelia PLM software offer?
- What are the problems of using Sovelia PLM software?

**Data reduction:** Following data collection, the vast amount of qualitative data was systematically

reviewed and condensed. This process involved identifying and coding recurring themes and patterns that emerged from the interviews, based on the pre-defined questions (Alzoubi & Gill, 2021). The goal was to distil the data into manageable, relevant segments that aligned with the research objectives, ensuring that the most significant information was retained while extraneous details were filtered out.

**Data display:** In this phase, the reduced data were organised and visually represented to facilitate further analysis. This involved creating charts, matrices, or tables that mapped out the key themes and sub-themes, enabling a clear comparison of the findings (Alzoubi & Mishra, 2024). Data display helped in identifying relationships and trends within the data, making it easier to interpret the complex interconnections between PLM and SC performance.

**Conclusion drawing:** The final step involved synthesising the data displayed to draw meaningful conclusions about the research problem. This step required interpreting the patterns and themes identified during the analysis to understand their implications for optimising SC performance through PLM (Alzoubi & Gill, 2021). Conclusions were drawn based on the evidence gathered, providing insights that could inform both theoretical understanding and practical applications in the field of SCM (Alzoubi & Mishra, 2024).

## 3. RESEARCH RESULTS

This section presents the key insights derived from the semi-structured interviews and site observations conducted across the Engineering, SCM, Technology, Aftersales, and Business Support departments at ABC TECH. The findings reveal a dual pattern: while Sovelia PLM software provides clear benefits in terms of collaboration, process control, traceability, and data management, several challenges limit its full integration into SCM processes. These challenges relate particularly to system usability, workflow configuration, technical stability, and the limited support for downstream supply chain activities. To provide an overarching view of these insights, Fig. 2 synthesises the main themes emerging from the interviews, highlighting both the strengths and weaknesses of Sovelia PLM software as experienced across departments. The subsequent subsections elaborate on each theme in detail.

Sovelia encompasses a range of modules, including Item, Document, Engineering, Baseline, Task,

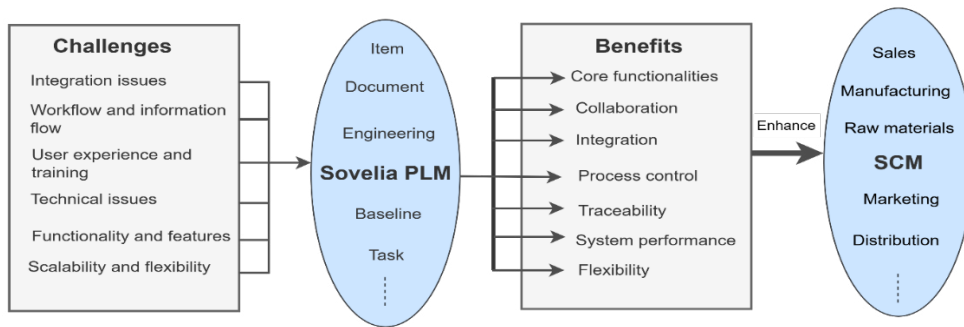


Fig. 2. Summary of the study findings

Operation, Design, SAP MM, Product, and Equipment, among others. Every department at ABC TECH uses Sovelia PLM software daily, except for one member from the engineering department and one from the technology department. This suggests that several people from different fields often rely on it. Most participants (over 60 %) felt that improvement in access, collaboration, and integration was required, with fewer reporting that it was already sufficient. Approximately half of the participants indicated that Sovelia PLM fulfils their requirements, although there were some who felt it could do better. Most participants perceived Sovelia PLM as up to date, with a smaller number feeling neutral.

Across all 12 participants, ten reported using Sovelia daily, indicating an 83 % active use rate across departments. Only two participants (one from Engineering and one from Technology) reported infrequent or limited use of the system. Moreover, the Engineering Department accounted for the highest number of daily users (6 out of 12 participants), followed by SCM (3 users), After-sales (1), and Business Support (1). Technology had the lowest number of active users (1). This distribution highlights that engineering-related tasks rely on Sovelia more heavily than downstream supply chain functions. Furthermore, 72 % of participants expressed mixed or negative perceptions of Sovelia's usability, while 66 % reported that integrations with other business systems need improvement. Conversely, 58 % of participants acknowledged Sovelia's value in supporting traceability, revision control, and document management.

### 3.1. BENEFITS OF USING SOVELIA PLM SOFTWARE

The evaluation of Sovelia PLM software at ABC TECH reveals a generally positive perception of its

functionalities and contributions to various operational processes. The software is widely used across multiple departments, including Engineering, SCM, Technology, Aftersales, and Business, indicating its integral role in the company's workflow. Participants highlighted Sovelia's capabilities in managing items, documents, projects, and equipment information, which are crucial for their day-to-day activities. Eleven out of 12 participants identified at least one benefit of Sovelia PLM software, with the most frequently mentioned benefits being traceability (mentioned by six participants), collaboration (five participants), and process control (four participants). Its ability to enhance collaboration, both within the company and with external stakeholders, was frequently noted, alongside its effective integration with other systems like SAP, E3-CAD, Inventor, and Vault. Furthermore, Sovelia was praised for its role in process control, traceability, and data management, with features like document linking, revision handling, and organised design/documentation significantly improving operational efficiency. The following paragraphs explain each of the benefits, supported by the participant quotes. Table 3 summarises these benefits and the feedback from participants.

#### 3.1.1. CORE FUNCTIONALITIES AND USE

This theme focuses on how the participants use Sovelia PLM software in their daily operations. The core functionalities and modules of the software are integral to how various departments carry out their tasks, such as managing items, documents, projects, and equipment information (Conlon, 2024). MC used Sovelia for accessing the "Items module to find drawings and information about equipment", indicating that Sovelia is crucial for retrieving essential design and equipment data. HINT used Sovelia for multiple functions, including "Item, documents, Installed Base,

Tab. 3. Benefits of Sovelia PLM for ABC TECH's SCM.

THEME	BENEFIT	PARTICIPANTS
Core functionalities and use	Retrieving essential design.	MC
	Managing various aspects of the project.	HINT
	Managing complex engineering processes.	EC
	Streamlining daily task management.	MFW
	Supporting diverse tasks in a role.	RF
Collaboration	Facilitating teamwork.	TS, FG
	Supporting the dissemination of critical information.	JD, TS, FG
	Distributing reports across different platforms.	JD
	Supporting both internal and external collaboration.	EC
Integration	Working in conjunction with other software.	JD, TS
	Integration with ERP systems for streamlined operations.	FG
	Utility in specialised engineering tasks.	MC
	Integrating with design and document management systems.	RF
Process control and efficiency	Controlling and managing various operational processes.	JD
	Managing product changes.	GAAN
	Enhancing easier access and management.	ABB
	Improving the organisation and tracking of revisions.	SOS
Traceability and data management	Maintaining a clear record of changes and integrations.	TS
	Improving accessibility to critical design information.	MC
	Comprehensive data management capabilities.	RF
System performance and satisfaction	Satisfaction with the software's capabilities.	FG, EC
	Sovelia is adequate for their needs.	JD, MC
	The need for improvement.	TS
Customisation and flexibility	Satisfaction with the software's adaptability.	RH
	Meeting evolving business demands.	EC
	Flexibility for further development.	ABB

and projects”, showing that Sovelia is central to managing various aspects of project work. EC reported using Sovelia for “Items, Documents, Engineering change management, Projects, Installed base management, and Baseline management”, highlighting the software’s broad functionality in managing complex engineering processes. MFW mentioned using Sovelia for “Items, Documents, ‘My assigned tasks’, and Project navigator”, indicating that Sovelia helps streamline daily task management and project navigation. Finally, RF used Sovelia for “Items, Documents, Engineering Change Management, Installed Base Equipment, and Projects”, showing that Sovelia supports diverse tasks in his role.

### 3.1.2. COLLABORATION

This benefit explores how Sovelia PLM software enhances collaboration within and outside the organisation. The ability to share reports and work collabora-

tively on projects is vital for efficient team coordination and cross-functional activities (Corallo et al., 2020). TS and FG highlighted that Sovelia PLM “enables collaboration”, emphasising the software’s role in facilitating teamwork. JD, TS, and FG mentioned that reports generated by Sovelia PLM software can be “shared with others”, indicating that the software supports the dissemination of critical information. JD added that “Sovelia PLM can share reports produced by it with email, SAP, Sovelia, and SharePoint to nominated personnel”, illustrating the software’s versatility in distributing reports across different platforms. Furthermore, EC noted that Sovelia “fits well for collaboration with internal teams (ABC TECH) as well as external teams (suppliers and customers), an extranet module is required”, showing the software’s capacity to support both internal and external collaboration. These findings are in line with previous studies by Hayrutdinov et al. (2020) and Nilsson-Lindén et al. (2019).

### 3.1.3. INTEGRATION

Integration refers to how Sovelia PLM software interfaces with other software and systems used by the company. Effective integration ensures that data flows seamlessly between different platforms, enhancing overall system efficiency and reducing redundancies (Chhetri et al., 2022). JD and TS reported that Sovelia PLM software “integrates with other programs”, highlighting its ability to work in conjunction with other software. FG specified that Sovelia integrates “especially with SAP”, showing the importance of integration with ERP systems for streamlined operations. MC mentioned that Sovelia provides integration with the “E3-CAD program for electrical system”, indicating the software’s utility in specialised engineering tasks. Additionally, RF stated that Sovelia integrates with “Inventor, Vault, and SAP”, demonstrating that Sovelia is well-integrated with other design and document management systems in use at ABC TECH. These findings are in line with previous studies by Burke et al. (2023), Meeshi et al. (2021), and Mulla et al. (2021).

### 3.1.4. PROCESS CONTROL AND EFFICIENCY

This benefit addresses how Sovelia PLM software contributes to controlling and optimising processes within the company. Process control and efficiency are crucial for ensuring that operations run smoothly and that tasks are completed within the required timeframes (Omerali & Kaya, 2022). JD reported that “it enables process control”, highlighting Sovelia’s role in overseeing and managing various operational processes. GAAN stated that Sovelia provides “full control of item revisions”, indicating that the software allows for precise management of product changes. ABB mentioned that Sovelia offers “one place for all technical documents” and links documents to projects, demonstrating how the software centralises information for easier access and management. Finally, SOS noted that Sovelia enhances document revision by applying “unique tags to items and documents”, showing how the software improves the organisation and tracking of revisions. These findings are in line with previous studies, such as by Omerali and Kaya (2022).

### 3.1.5. TRACEABILITY AND DATA MANAGEMENT

This benefit explores how Sovelia PLM facilitates traceability and effective data management, which are essential for tracking product history, managing revisions, and ensuring data integrity (Singh & Misra,

2019). TS reported that Sovelia “enables traceability and structure and integration”, showing that the software helps maintain a clear record of changes and integrations. MC emphasised that Sovelia ensures “Product/project-related drawings and documentation are available for all”, indicating that the software improves accessibility to critical design information. Lastly, RF listed several benefits, including “traceability, copy design of similar design, possibility to organise design/documentation. Document numbering/revision handling”, illustrating Sovelia’s comprehensive data management capabilities. These findings support previous findings, such as by Deteix et al. (2024) and Razak et al. (2021).

### 3.1.6. SYSTEM PERFORMANCE AND SATISFACTION

This benefit examines participants’ perceptions of Sovelia PLM software’s performance and their overall satisfaction with the software. It reflects how well the software meets user expectations and its standing relative to other tools on the market (Conlon, 2024). FG reported that Sovelia is “at par with the current market tech adoption”, indicating satisfaction with the software’s capabilities. JD and MC mentioned being “unaware of similar or alternative tools”, suggesting that they find Sovelia adequate for their needs. TS commented that Sovelia is “not at par with the current market”, pointing to some dissatisfaction and a desire for improvement. Additionally, EC noted that Sovelia “does not require any improvement as it complies with the Main companies’ security policies”, reflecting contentment with the software’s current performance. These findings are in line with findings by Conlon (2024) and Iveson et al. (2022).

### 3.1.7. CUSTOMISATION AND FLEXIBILITY

This benefit focuses on Sovelia PLM software’s ability to be customised and its flexibility in meeting the specific needs of ABC TECH. Customisation is essential for aligning the software with unique business processes and requirements (Vidergar et al., 2021). RH pointed out that Sovelia “has a benefit over other PLM software in that it’s possible to order custom functions which fit the customers”, highlighting the software’s adaptability. EC added that “Capabilities and features offered off-the-shelf did not fit with our requirements, therefore every year the software is improved based on business needs”, showing that Sovelia is continually tailored to meet evolving busi-

ness demands. Finally, ABB recognised the potential for customisation, stating that Sovelia offers “potential for comparing electrical and mechanical documentation for fabrication, potential for spare part lists, and potential for installed base”, indicating that the software has room for further development to meet specific needs. These findings supported previous studies’ findings, such as by Shao et al. (2021).

### 3.2. CHALLENGES OF SOVELIA PLM SOFTWARE

Based on the feedback from participants, it appears that Sovelia PLM software has been a valuable tool for ABC TECH, providing benefits in areas such as collaboration, process improvement, data management, and traceability. However, there are areas where the software could be improved, such as user adoption, technical issues, and specific functionalities. Addressing these challenges will be crucial for improving the effectiveness and efficiency of Sovelia PLM within ABC TECH. Ten out of 12 participants identified at least one significant issue with Sovelia PLM. The most frequently mentioned concerns included user interface complexity (reported by five participants), technical problems such as freezes or downtime (four participants), and limited integration with other systems (four participants). These recurring issues indicate that challenges are not isolated to a single department but are systemic. Table 4 summarises these challenges and the feedback from participants.

#### 3.2.1. INTEGRATION ISSUES

This challenge addresses the issues related to Sovelia PLM software’s integration with other software and systems (Eby, 2023). Participants expressed concerns over the need for improved integration, particularly with DCC, SAP, and other systems, which affect overall workflow and efficiency. JD reported that “this is especially needed for DCC”. This indicates that Sovelia PLM requires enhancement in its integration capabilities, particularly for DCC. FG noted that better integration is required for Fiori and two-way communication. He said, “Fiori and the two-way communication require better integration”. RH mentioned that “integration required between Sovelia and MS Office”, indicating the need for integration between Sovelia and MS Office. Additionally, SOS highlighted the need for improved integration with SCM and CRM software to enhance information flow. He said, “integration with SCM and CRM software should be improved and re-configured”.

#### 3.2.2. WORKFLOW AND INFORMATION FLOW

This challenge explores how well Sovelia PLM manages workflow and the flow of information within the company. Participants highlighted problems with the software’s configuration, which was not designed with a holistic view, leading to inefficiencies in the workflow and information sharing (Koc & Gurgun,

Tab. 4. Challenges of Sovelia PLM software for ABC TECH’s SCM

THEME	CHALLENGE	PARTICIPANTS
Integration issues	Integration capabilities	JD, FG
	Integration between Sovelia and MS Office	RH
	Integration with SCM and CRM	SOS
Workflow and information flow	Information sharing	JD
	The focus only on the design phase; suboptimal data flow	SOS
	Limited collaboration using Sovelia	MC
User experience and training	Lack of user-friendliness.	RF
	Training and user interface improvement	FG
	Difficulties in teaching how to use it	RH
Technical issues	Frequent software freezes	ABB
	Downtime and server issues	MFW
	Software glitches	RH
Functionality and features	Improvements for the software’s features	ABB
	Lack of fulfilment of business requirements	JD
	Workflows are hard to handle	SOS
Scalability and flexibility	Insufficient scalability	EC

2021). SOS stated that “the software is configured with the design-phase in mind, and less focus on the customer in a value chain”, indicating that Sovelia was configured with a focus on the design phase, leading to challenges in procurement, production, installation, and after-sales. SOS also added that “the data flow is not optimal, because the software has (in some cases) been configured as workarounds”, indicating that the data flow is not optimal due to workaround configurations. JD reported that “Sovelia PLM sometimes faces issues in information sharing”, which indicates issues with information sharing within Sovelia. Finally, MC noted that “collaboration using Sovelia is quite limited”, indicating that issues with collaboration between different departments using Sovelia are limited.

### 3.2.3. USER EXPERIENCE AND TRAINING

This challenge examines the user interface, ease of use, and the effectiveness of training for Sovelia PLM. Many participants reported that Sovelia is complex and difficult to use, with inadequate training provided to users, which hampers efficiency (Eby, 2023). RF commented on the complex interface and the lack of user-friendliness. He said, “UI is too complex (not user-friendly)”. FG also emphasised the need for better training and user interface improvements. He said, “the major challenges of Sovelia PLM are the training and user interface”. Additionally, RH highlighted difficulties in teaching people how to use Sovelia properly, saying, “it is hard to teach people how to use Sovelia properly and compliantly”. These findings are in line with findings by Singh and Misra (2019).

### 3.2.4. TECHNICAL ISSUES

This challenge focuses on the technical problems encountered with Sovelia PLM software, including glitches, performance issues, and downtime (Eby, 2023). Participants across multiple departments reported significant technical challenges when using Sovelia PLM software. A central issue concerns the system’s rigid locking mechanism, which prevents multiple users from working on related items simultaneously. When an item is opened or edited, it becomes fully locked and can only be released by an administrator. Several interviewees reported that this behaviour regularly disrupts workflows and creates avoidable delays. For instance, ABB described frequent interruptions due to item locking combined with system instability, explaining that “Sovelia freezes or stops working. Items get locked and can only be unlocked by admin”.

Similarly, RH observed that the system occasionally locks objects even when they are released correctly, noting that “there is a bug/glitch which locks released objects”.

These recurring lockouts appear to stem from Sovelia’s concurrency management model, which relies on hard item locks and administrator-controlled permissions. In legacy or heavily customised PLM environments, this type of locking model often becomes unstable when multiple users attempt to access interdependent items, causing unnecessary blocking and occasional corruption of lock states, consistent with RH’s report of a glitch. In addition to locking issues, several participants highlighted system freezes, downtime, and server-related interruptions that affect productivity. MFW, for example, emphasised the unreliability of the system infrastructure, stating that “Sovelia has downtime and server issues”. These performance problems likely originate from Sovelia’s on-premise server architecture, which is more susceptible to resource saturation, delayed updates, and limited scalability compared to modern cloud-based PLM solutions. When the server experiences load spikes or fails to process concurrent requests efficiently, users encounter freezing or forced restarts, as also noted by ABB and others.

Another source of frustration relates to Sovelia’s limited error-handling capabilities. Participants reported that even minor user mistakes often require restarting the operation or waiting for administrator intervention. As one participant summarised, the software “lacks a human error area and takes time to fix errors, nearly necessitating a restart in the event of a mistake”. This indicates that Sovelia may not have robust transaction rollback or conflict-resolution mechanisms, which are essential in modern PLM platforms to prevent small errors from escalating into systemic disruptions.

Taken together, these challenges suggest that the underlying causes are rooted in (1) the system’s legacy on-premise deployment, (2) extensive customisations that may reduce stability, and (3) outdated concurrency and error-handling logic (Benabdellah & Bennis, 2021; Duda et al., 2024). Addressing these issues would require a combination of technical and architectural improvements. Transitioning Sovelia to a cloud-based or hybrid infrastructure could help reduce downtime and improve performance scalability (Zhang et al., 2022). Enhancing its concurrency control mechanisms, for example, by introducing soft locks, version branching, or user-level conflict resolution, would reduce the frequency of lockouts (Alzoubi, 2024). Strengthening

error-handling features, including automatic rollback and improved fault tolerance, would minimise the need for administrator intervention (Alzoubi, 2024). Finally, reviewing and modularising customisations could improve system stability and reduce the likelihood of glitches such as the one reported by RH (Tariq et al., 2025).

### 3.2.5. FUNCTIONALITY AND FEATURES

This challenge addresses the limitations of Sovelia PLM software's functionalities and features. Participants noted that the software does not fully meet the business requirements, with certain functions lacking or being insufficiently developed (Koc & Gurgun, 2021). JD stated that Sovelia does not fulfil business requirements, particularly in document management. He said, "it is missing a user-friendly application for document management in a project, particularly for DCC". SOS added that the workflows are hard to handle and that the software is not standardised, saying "the workflows are hard to handle, difficult overview of status and progress". Finally, ABB suggested improvements for the software's features, including better report generation and stability, saying "improve functions like the Compare Function, and stability of application and server".

### 3.2.6. SCALABILITY AND FLEXIBILITY

This challenge covers the difficulties in scaling and adapting Sovelia PLM software to meet the growing demands and specific needs of the company. Issues were raised about the software's lack of flexibility and its ability to scale according to evolving business requirements (Eby, 2023). When it comes to resolving errors and facilitating collaboration, Sovelia is typically rigid. The user frequently must restart the procedure from scratch if an issue arises during it. Furthermore, because the software was largely created to satisfy the demands of the engineering phase, it is not easily modified to accommodate future developments within ABC TECH. EC expressed the need for better scalability to meet the company's growing demands. He said, "better flexibility to scale up on demand as per the company requirements".

## 3.3. META-ANALYSIS FROM EACH DEPARTMENT

Below is a comprehensive analysis of the insights from each department at ABC Tech regarding the use

of the Sovelia PLM software. This analysis highlights the benefits, challenges, and suggestions for improvement as reported by the SCM, Engineering, Technology, Business Support, and After-sales departments.

### 3.3.1. SCM DEPARTMENT

The participants from the SCM department are regular users with limited access to the SC module. All respondents use Sovelia regularly in conjunction with SharePoint and SAP MM. Overall, they reported that Sovelia is seen as useful but limited by user interface and integration capabilities. However, they reported mixed experiences regarding software shut-downs. Also, they reported that Sovelia partially fulfils needs, but issues with user-friendliness affect effectiveness. They reported some benefits of Sovelia, including the effectiveness in controlling processes and maintaining traceability, as well as providing structural benefits and some level of integration.

However, they reported several challenges, including restricted access to specific modules, user-unfriendly software, and the need for improvement, as well as challenges in training due to the complex interface. They also reported mixed feelings related to Sovelia's integration with other software. Improvements are needed, especially for Dedicated Contract Carriage (DCC) with third-party logistics (3PL). Moreover, varied responses regarding problems in data sharing indicate inconsistent experiences. Finally, mixed perceptions were found on whether Sovelia is on par with market standards, with some participants noting that the market has moved towards more comprehensive, multi-module software. They provided several suggestions, including improving the interface to make it more user-friendly, implementing general metrology across the organisation, and enhancing collaboration features, possibly through an extranet module.

### 3.3.2. ENGINEERING DEPARTMENT

This department has primary users with regular use. Almost all representatives use the software regularly, except for one. Overall, some participants believe Sovelia is on par with the market, while others disagree. The majority agree on technical issues, such as frequent shutdowns due to server downtime and limited supplier knowledge, making maintenance challenging. Additionally, they provided mixed responses on whether the software meets work requirements, with concerns about high costs and

inflexibility. They reported several Sovelia benefits, including seamless integration with other engineering tools, the ability to revise from scratch with full control, effective traceability of components and changes, efficient organisation and document numbering.

However, they also reported several challenges, including unexpected Sovelia freezes or stops, items getting locked, requiring admin intervention to unlock, inability to reverse item statuses without admin's help, high number of objects (45,000+) leading to rigidity, user-unfriendliness with a difficult overview of status and progress, requiring significant manual operations without standardisation, time-consuming training for new colleagues, expensive and resource-intensive efforts to correct and implement issues, partial integration with other software; mixed opinions on effectiveness, lack of holistic approach beyond the design phase, excess documents are sometimes shared due to software inflexibility, and challenges in exporting files in desired formats without excess data. They provided several suggestions to enhance the capabilities of Sovelia's development, a more user-friendly interface, an update to a more up-to-date PLM system that meets internal customer needs, improve collaboration capabilities and system stability, and enable the production of effective reports.

### 3.3.3. TECHNOLOGY DEPARTMENT

The role of a participant was more of an observer than a primary user. The use of Sovelia was minimal compared to other departments like Engineering or Business Support. The participants were generally satisfied and able to access detailed information from the equipment they had designed and worked on. Generally, the department does not experience significant problems with the software. However, he reported difficulty in accessing the software efficiently. As well as challenges in collaborating with other software and locating necessary documents. He also suggested implementing a single sign-on and transitioning to a web-based platform to enhance accessibility. Also, he suggested improving the ability to collaborate with other software and streamline document retrieval processes.

### 3.3.4. BUSINESS SUPPORT DEPARTMENT

This department has regular users with access to multiple modules. All respondents use Sovelia regu-

larly. Overall, the participants from this department reported that Sovelia is strong in managing and integrating product data, needs ongoing adjustments to better fit business requirements, and requires enhancements to better scale with company growth and needs. He reported that Sovelia has effective management of product data and changes, well-integrated with other systems, allowing data sharing in formats like PDF/JPEG, and utilises various modules such as items, documents, engineering change management, projects, installed base management, and baseline management. However, he reported that Sovelia has occasional shutdowns due to server and network issues and suggested that an ongoing annual improvement is needed based on business needs, implement an extranet module to enhance external collaboration, and improve flexibility to scale up according to company requirements. Furthermore, he acknowledged that the market trend towards cloud-based platforms, though the implications of switching have not been evaluated.

### 3.3.5. AFTER-SALES DEPARTMENT

This department encompasses daily users with specific module access. The participant reported that some improvements have been implemented, including master data (ERP) and metadata from Sovelia to BPA (CRM). However, overall, he suggested that the software does not fully meet the after-sales department's needs due to complexity and incomplete data migration. He also added that Sovelia is limited to after-sales modules, such as items, documents, Installed Base, and projects. Also, not all old projects and documentation have been moved to Sovelia, leading to the use of multiple systems. Accordingly, the system is perceived as very complex and time-consuming for after-sales tasks since it is a "Java" version, which is not preferred and needs improvement. Hence, he suggested improving the software access method, possibly moving away from the Java-based version, simplifying the system to make it less complex and more time-efficient for after-sales operations.

## 4. DISCUSSION OF THE RESULTS

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This study aims to explore the function of the PLM system in the SCM process. To do this, RQ1 was addressed (i.e., how PLM boosts the SCM process). In addition, by answering RQ2 (challenges with integrating SCM and PLM systems). Section 3 addressed

these two questions. The implications of Section 3 findings, future research directions, and study limitations are covered in this section.

#### 4.1. PRACTICAL IMPLICATIONS

This paper provides valuable insights for businesses using PLM solutions. Maintaining inventory accuracy and avoiding delays in product releases are dependent on the efficient handling of human data input and mistakes, which may be greatly reduced through the integration of PLM and SCM systems. Businesses may attain maximum profitability and efficacy by guaranteeing that product data is synced in real-time between the two platforms. Furthermore, the results show that integrating PLM and SCM systems can save SCM costs by preventing overspending and enhancing inventory control (Singh & Misra, 2019). For businesses like ABC TECH that must handle intricate SCs with several suppliers and components, this might be very helpful. Moreover, the difficulties ABC TECH had with its specially designed Sovelvia PLM indicate that although personalisation can meet certain requirements, it can also result in higher maintenance costs and ineffective operations (Vidergar et al., 2021). Businesses should compare the advantages of tailored solutions against the affordability and adaptability of cloud-based, standardised systems (Singh & Misra, 2019).

Business success requires effective collaboration with stakeholders, including manufacturers, suppliers, partners, and customers (Koc & Gurgun, 2021). The study demonstrates that by offering a single, unified platform for communication and data exchange, PLM integration with other business systems improves cooperation. This is essential for ABC TECH's operating procedures and project delivery. Furthermore, acceptance and efficient use of PLM systems depend on their user-friendliness (Singh & Misra, 2019). The results show that poor user engagement and challenges in onboarding new staff can be attributed to Sovelvia PLM's sophisticated and inflexible interface (Burke et al., 2023). The necessity to create more user-centric PLM systems with simple user interfaces that lower learning curves and boost user engagement is another practical implication. The overall feeling suggests a strong desire for improvement in access and collaboration, with a more mixed perception regarding integration. While Sovelvia PLM is generally perceived as meeting the requirements of participants, there is still room for enhancement in these areas.

#### 4.2. THEORETICAL IMPLICATIONS

By shedding light on the benefits and challenges of real-world integration, the study advances theoretical debates on PLM and SCM integration. The study emphasises how PLM and SCM are interrelated and how their complementary functions improve SC efficiency and product development. It highlights the need to create systems that are flexible and adaptive to changing business demands and the requirement for theoretical models that consider the challenges of such integrations (Koc & Gurgun, 2021). It is important for theoretical models to investigate the trade-offs between standardisation and personalisation. Although customisation could appear desirable for some business requirements, the study reveals that it can result in long-term problems, including increased expenses, troublesome maintenance, and a delayed capacity to adjust to changing market demands. Ways to standardise PLM systems and enhance their compatibility with other business tools, such as ERP and CRM systems, should be further investigated in research. This can entail creating industry-wide standards or protocols that make data interchange and system integration simpler.

The study highlights the value of multidisciplinary methods in system design, where engineering, SCM, and IT departments contribute (Burke et al., 2023). This reveals a flaw in the way that present theoretical frameworks frequently concentrate on one domain without properly integrating the demands of other domains (Vidergar et al., 2021). The creation and uptake of cloud-based PLM systems, which provide more affordability, scalability, and flexibility than conventional on-premises versions, should be the subject of future study. Additionally, by enabling improved interaction with additional cloud-based business tools, this change would improve overall operational efficiency. To increase user satisfaction and productivity, research might concentrate on creating PLM systems that are simpler to use and require less extensive training.

Furthermore, the study advances knowledge of lifecycle management in PLM systems, especially regarding how modifications, mistakes, and historical data are handled. It implies that additional study is required to create PLM systems that can smoothly connect with other systems and dynamically adapt to changing business processes. Future research should investigate how PLM and SCM systems can benefit from the integration of emerging technologies like artificial intelligence, machine learning, and the

Internet of Things (IoT) to further improve their capabilities, especially in areas like automation, real-time decision-making, and predictive analytics.

### 4.3. RESEARCH LIMITATIONS

There are several limitations to this study to consider. The handful of vendors that were accessible and the studies that concentrated on PLM integration limited the study's scope. Because of this restriction, it is challenging to extrapolate the results to other businesses or industries that use alternative PLM systems. Also, since the study was carried out during the COVID-19 epidemic, communication and information exchange may have been delayed, and the capacity to arrange direct meetings was impacted. This restriction could have affected the breadth and promptness of the information gathered. Furthermore, the study concentrated on a specially designed PLM system (Sovelia) for ABC TECH, which might not accurately represent the advantages or disadvantages of utilising more conventional PLM systems. The results may not be as applicable in other situations because of this customisation. Moreover, issues with the incomplete transfer of historical data to the new PLM system are brought to light in the research. This restriction could distort the findings since the challenges with data management and traceability can be specific to this implementation rather than a sign of wider patterns.

## CONCLUSIONS

Integration of PLM systems with SCM processes has proven to be challenging for companies that attempt it, with limited empirical research available on this topic. Consequently, this study aimed to explore whether the implementation of PLM systems can enhance SCM within an organisation. The study followed a single qualitative case study design, drawing on semi-structured interviews and site observations conducted at ABC TECH. The data was collected from ABC TECH, which utilises Sovelia as its PLM software. This study provides new empirical insights into how a customised PLM system (Sovelia) supports and constrains supply chain-related activities within a technology-intensive manufacturing environment. The key conclusions are summarised below:

- Sovelia provides clear benefits across departments, particularly in:
  - Improving traceability and revision control,
  - Enhancing the collaboration between engineering and SCM,
  - Increasing process visibility and document consistency,
  - Supporting lifecycle documentation and quality assurance.

However, several challenges limit its full integration into SCM, including:

- System freezes, downtime, and performance instability,
- Rigid item-locking mechanisms that interrupt workflows and require administrator intervention,
- Limited error-handling and rollback capabilities,
- Difficulty integrating Sovelia with other operational systems used by SCM and After-sales.

User experience issues are widespread, with participants highlighting:

- Interface complexity and unintuitive workflows,
  - High dependency on administrator rights,
  - Limited flexibility for non-engineering departments.
  - Adoption and utilisation vary across departments, with Engineering relying heavily on Sovelia while downstream supply chain functions use it less frequently due to functional gaps.
  - Overall, Sovelia is effective for engineering-driven PLM tasks but insufficiently optimised for SCM needs, particularly for real-time collaboration, data exchange, and operational planning.
- Improvement opportunities include:
- Migrating to a cloud or hybrid infrastructure,
  - Introducing soft locking, version branching, or improved concurrency controls,
  - Enhancing integration with ERP and operational systems,
  - Simplifying customised workflows to increase stability and usability.
  - The findings contribute to PLM–SCM research by offering rare, department-level insights into practical system usage, complementing the largely conceptual or technical focus of prior studies.

To create a system that satisfies the demands of the whole business, input from several departments is essential. Research is still needed to create standardised PLM systems that are simple to link with other business tools, which will lessen the difficulties associated with data management and interoperability.

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