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Identifying Expected Benefits of SAP Material ID in Supply Chain Management

A Design Science Approach to Value Realization

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ABSTRACT:

In the era of digital supply chains, the ability to automate processes and generate reliable analytics depends fundamentally on the quality of underlying material master data. This study addresses the critical role of standardized material identification in enabling supply chain management digitalization. In the case company, the management of third-party materials has historically relied on inconsistent free-text descriptions and fragmented identifiers rather than governed master data. This lack of standardization has resulted in significant operational inefficiencies, including the proliferation of duplicate records, a widespread reliance on manual "shadow processes" such as spreadsheets and emails, and severely limited visibility for procurement decision-making and sustainability reporting. Consequently, the organization faces a strategic challenge: while it invests in advanced ERP capabilities, the expected value cannot be realized without a foundational restructuring of how materials are identified and managed.

Addressing this pre-implementation challenge, the study investigates two primary research questions: (1) what specific benefits are expected from the implementation of SAP Material ID in SCM, and (2) how these benefits can be systematically linked to Key Performance Indicators to support post-implementation value realization. Adopting a Design Science Research Methodology within a single-case setting, the research utilizes qualitative data gathered from fourteen semi-structured expert interviews with professionals from Supply Chain Management (n=9) and Digitalization (n=5) functions.

The study develops two primary artifacts to guide the case company. The first is a Benefit Identification Framework, which synthesizes twelve empirically identified benefits—ranging from reduced procurement cycle times and error rates to enhanced lifecycle traceability and installed-base visibility. These benefits are rigorously classified according to Shang and Seddon’s ERP benefit dimensions and explicitly mapped to measurable KPIs. This structure transforms abstract "value expectations" into actionable evaluation targets, allowing the organization to prepare for benefit realization. The second artifact consists of five Design Principles, which provide prescriptive guidance on how these benefits are achieved. These principles specify the necessary mechanisms for standardization, duplicate prevention, clarified ownership, and mandated data governance routines.

A central finding of the research is that Material ID functions as a foundational enabling capability rather than a standalone solution. The results demonstrate that while technical identification facilitates automation and advanced analytics, the actual realization of business value is contingent upon rigorous organizational governance.

KEYWORDS: ERP, Material Master Data, Supply Chain Management, Benefits, Data Governance

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TIIVISTELMÄ:

Digitaalisten toimitusketjujen aikakaudella prosessien automatisointi ja luotettavan analytiikan luominen riippuu pohjimmiltaan pohjana olevien materiaalien perustietojen laadusta. Tämä tutkimus käsittelee standardoidun materiaalien tunnistuksen kriittistä roolia toimitusketjun hallinnan digitalisoinnin mahdollistamisessa. Kyseisessä yrityksessä kolmansien osapuolten materiaalien hallinta on perinteisesti perustunut epäjohdonmukaisiin vapaamuotoisiin kuvauksiin ja pirstaloituneisiin tunnisteisiin hallittujen perustietojen sijaan. Tämä standardoinnin puute on johtanut merkittäviin operatiivisiin tehottomuuksiin, mukaan lukien päällekkäisten tietueiden lisääntyminen, laajalle levinnyt riippuvuus manuaalisista "varjoprosesseista", kuten laskentataulukoista ja sähköposteista, sekä erittäin rajoitettu näkyvyys hankintapäätöksenteossa ja kestävän kehityksen raportoinnissa. Tämän seurauksena organisaatiolla on strateginen haaste: vaikka se investoi edistyneisiin toiminnanohjausjärjestelmiin, odotettua arvoa ei voida saavuttaa ilman materiaalien tunnistamisen ja hallinnan perustavanlaatuista uudelleenjärjestelyä.

Tämän käyttöönottoa edeltävän haasteen ratkaisemiseksi tutkimuksessa tarkastellaan kahta ensisijaista tutkimuskysymystä: (1) mitä erityisiä hyötyjä SAP Material ID:n käyttöönotosta odotetaan toimitusketjun hallinnassa, ja (2) miten nämä hyödyt voidaan systemaattisesti linkittää keskeisiin suorituskykyindikaattoreihin käyttöönoton jälkeisen arvon toteutumisen tukemiseksi. Tutkimus soveltaa suunnittelutiede menetelmää yksittäisessä tapaustutkimuksessa ja hyödyntää neljästätoista puolistrukturoidusta asiantuntijahaastattelusta kerättyä laadullista dataa toimitusketjun hallinnan (n=9) ja digitalisaation (n=5) ammattilaisten kanssa.

Tutkimuksessa kehitetään kaksi ensisijaista tekijää tapausyrityksen ohjaamiseksi. Ensimmäinen on hyötyjen tunnistamiskehys, joka syntetisoi kaksitoista empiirisesti tunnistettua hyötyä – hankintasyklin lyhentyneistä ja virhetasoista parantuneeseen elinkaaren jäljitettävyyteen ja asennettujen laitekantojen näkyvyyteen. Nämä hyödyt luokitellaan tarkasti Shangin ja Seddonin ERP-hyötyulottuvuuksien mukaan ja ne on selkeästi yhdistetty mitattavissa oleviin suorituskykyindikaattoreihin. Tämä rakenne muuttaa abstraktit "arvo-odotukset" toimiviksi arviointitavoitteiksi, jolloin organisaatio voi valmistautua hyötyjen toteutumiseen. Toinen tekijä koostuu viidestä suunnitteluperiaatteesta, jotka tarjoavat ohjaavia ohjeita siitä, miten nämä hyödyt saavutetaan. Nämä periaatteet määrittelevät tarvittavat mekanismit standardoinnille, päällekkäisyyksien estämiselle, selkeytetylle omistajuudelle ja pakollisille tiedonhallintarutiineille.

Tutkimuksen keskeinen havainto on, että materiaalien tunnistaminen toimii perustavanlaatuisena mahdollistavana ominaisuutena eikä erillisenä ratkaisuna. Tulokset osoittavat, että vaikka tekninen tunnistaminen helpottaa automaatiota ja edistynyttä analytiikkaa, liiketoiminnan arvon todellinen toteutuminen riippuu tiukasta organisaation hallinnasta.

AVAINSANAT: ERP, Material Master Data, Supply Chain Management, Benefits, Data Governance

Contents

Figures

Tables

Abbreviations

AI	Artificial Intelligence
DSRM	Design Science Research Methodology
ERP	Enterprise Resource Planning
IS	Information Systems
IT	Information Technology
KPI	Key Performance Indicator
MDM	Master Data Management
MMD	Material Master Data
PLM	Product Lifecycle Management
PO	Purchase Order
PR	Purchase Requisition
RFQ	Request for Quotation
RPA	Robotic Process Automation
SCM	Supply Chain Management

1 Introduction

The digitalization of supply chain management (SCM) is widely recognized as an enabler for responding to changing customer demands and improving efficiency (Seyedghorban et al., 2020, p. 96; Tiwari et al., 2024, p. 2919). However, to successfully digitalize supply chain processes and achieve improvements, material master data (MMD) must contain accurate and consistent details of each material, as deficiencies in data can cause negative consequences (McMillan et al., 2017, p. 133). Inconsistencies in MMD have led to problems such as duplicate data records, suboptimal inventory control, and reduced operational efficiency, which can disrupt key SCM activities such as procurement, inventory management, and logistics (Merwe et al., 2024, pp. 569-570). Wei et al. (2023, p. 1) emphasize that MMD is one of the most important components of an enterprise's basic data system. Industry evidence supports this view: in a 2023 survey of more than 80 global organizations, McKinsey & Company (2024) found that 82% of respondents spent one or more days each week to resolve master data quality issues.

To realize the value of implementing SAP Material ID, it is essential to establish a framework for identified benefits, ensuring that potential benefits are identified and monitored already from the beginning of the post-implementation phase. Prior research has emphasized that the achievement of expected benefits from master data initiatives requires systematic monitoring and evaluation of data quality (Gualo et al., 2023, p. 795). Shang and Seddon (2002, pp. 278-279) emphasize that the benefits of enterprise system can be categorized into five main dimensions: operational, managerial, strategic, information technology (IT) infrastructure, and organizational. Based on their analysis of 233 enterprise system case studies, they found that operational and IT infrastructure benefits were the most frequently realized, with 73% of cases reporting operation improvements and 83% reporting IT infrastructure benefits (Shang & Seddon, 2002). The five dimensions also differ in how they can be measured, as some benefits are tangible and quantifiable, while others are intangible but still critical for long-term organizational performance (Shang & Seddon, 2002, p. 285). Therefore, both tangible and intangible measures must be considered when assessing value realization.

Additionally, sustainability has become a central global theme, with many industries striving for a renewable future (Wang et al., 2025, p. 4), and the European Union targeting climate neutrality by 2050 (European Commission, 2022, p. 16). To achieve such sustainability goals, organizations must integrate sustainability initiatives into their information systems (ISs), since fragmented data hinders sustainability-related decision-making (Abobakr et al., 2024, pp. 2–3). Efficient MMD is a prerequisite for such integration, as it enables the traceability of materials (Gelderman et al., 2021, p. 1; Germani et al., 2015, p. 227) and provides the basis for reliable sustainability key performance indicators (KPIs) (Gualo et al., 2023, p. 795). Without accurate material data, it is not possible to ensure seamless monitoring of sustainability outcomes (Gelderman et al., 2021, p. 6; Gualo et al., 2023, p. 795). Furthermore, structured data governance frameworks are essential for enabling data-driven decision-making and organizational resilience (Hua et al., 2025, p. 2). These factors highlight that the implementation of SAP Material ID is not only a technical improvement, but also a strategic enabler of sustainability, compliance, and governance.

Artificial intelligence (AI) is increasingly viewed as a key enabler of efficiency, responsiveness, and sustainability in SCM, and many leading firms such as Amazon and Walmart have already adopted AI-based solutions in their operations (Helo & Hao, 2022, p. 1574; H. Wu et al., 2025, p. 3831). However, the successful application of AI depends critically on the availability of accurate, consistent, and timely data, since studies highlight that data quality is one of the main barriers to AI implementation and that algorithms require large, reliable datasets to deliver accurate outputs (Cannas et al., 2024, p. 3352). Without high-quality material master data, including standardized material identification, organizations cannot fully leverage AI-driven tools in SCM processes. Therefore, SAP Material ID implementation is not only relevant for current data governance and operational efficiency but also serves as a foundational prerequisite for enabling future digital technologies such as AI.

1.1 Research Gap

Prior research has extensively examined the implementation and benefits of enterprise resource planning (ERP) systems, highlighting both the operational efficiencies and organizational transformations that such systems can enable (Govindaraju et al., 2018; Shang & Seddon, 2002). In parallel, master data management (MDM) has been recognized as a key enabler of data quality, compliance, and governance in digital supply chain environments (Gualo et al., 2023; Merwe et al., 2024). Recent studies have also emphasized the importance of integrating sustainability initiatives into information systems and ensuring traceability across supply chains (Abobakr et al., 2024; Gelderman et al., 2021).

Despite these insights, limited attention has been paid to the role of material identification as a specific enabler within ERP and SCM. Prior research has largely focused on the classification of realized ERP benefits (Estébanez, 2021; Legare, 2002; Shang & Seddon, 2002), post-implementation governance and alignment practices (Govindaraju et al., 2018), and the measurement of benefits in areas such as supply management maturity (Huang & Handfield, 2015). However, little is known about the early value expectations associated with implementing SAP Material ID, even though setting and monitoring such expectations is critical for ensuring value realization in the post-implementation phase.

The absence of research on early expectations of benefits is particularly significant because organizations often struggle to translate ERP and MDM investments into measurable outcomes without clear benefit frameworks (Anaya & Qutaishat, 2022; Nour, 2023; Silvola et al., 2011). If expected benefits are not systematically identified and linked to relevant KPIs from the beginning, post-implementation assessments risk overlooking critical process improvements, governance outcomes, or compliance advantages (Estébanez, 2021; Govindaraju et al., 2018). This lack of structured expectations not only weakens value realization but also limits the ability of organizations to justify and sustain investments in material data initiatives. Consequently, there is a need for research that explicitly defines the benefits of SAP Material ID implementation in SCM and links them to performance measurement practices, providing both theoretical clarity and practical guidance for organizations undertaking such projects.

1.2 Research Problem, Scope and Objectives

The business problem addressed in this research is that third-party materials in the ERP system currently lack consistent Material IDs, which limits efficient material management. As a result, it becomes difficult to link specific materials with data related to compliance, sustainability, procurement, and other critical supply chain functions. Furthermore, several digital tools and analytics capabilities cannot be fully utilized without reliable material identification. Thus, it is important to understand the benefits of implementing SAP Material IDs. If the potential benefits and the areas where they are expected to occur are not systematically studied, it may become challenging to realize the intended value in the post-implementation phase of the project.

The scope of this research is limited to SCM operations. The study examines the value expectations of implementing Material IDs, focusing on how processes may change, what effects can be anticipated, how these effects can be linked to existing KPIs, and how data governance practices may evolve. While the implementation project will also influence functions outside SCM, this research is restricted to the SCM perspective. Furthermore, the study concentrates on benefits expectations rather than realized value, since the project itself will not be completed during the research period. Instead, the objective is to develop a framework that defines the expected benefits, which can later serve as a foundation for evaluating value realization after implementation.

Two research questions guide this study. Their purpose is to deepen the understanding of expected value outcomes from the implementation of SAP Material ID and to link these outcomes to existing or potential KPIs. The research questions are:

1. What benefits are expected from the implementation of SAP Material ID in supply chain management?

2. How can the expected benefits be linked to existing or potential KPIs and evaluation practices to support value realization after implementation?

The objective of this study is to define a framework for identified benefits from the implementation of third-party Material IDs. The framework aims to clarify what process changes can be anticipated, and how these changes may create value. To achieve this, the study applies the Design Science Research Methodology (DSRM), which is used both to analyze the problem and to develop two artifacts. In this case, the artifacts will be a framework that can be applied in future evaluations of value realization and associated design principles. The research draws on theory from ERP, value outcomes, MDM, and the role of material data in SCM, to ensure a structured and academically grounded use of the DSRM.

1.3 Structure of the Research

This thesis is structured into five main chapters that together support the design, development, and demonstration of artifacts for understanding and supporting early value realization in the context of an SAP Material ID implementation.

Chapter 1 introduces the research by presenting the background, motivation, research problem, and objectives. It identifies the research gap in both academic and practical knowledge, defines the scope and objectives of the study, and outlines the overall structure of the thesis.

Chapter 2 combines the theoretical foundation and literature review. It introduces key concepts related to ERP systems and value realization, material data, digitalization, and product lifecycle management (PLM). The chapter also discusses the SAP Material ID initiative in the context of supply chain management, the role of digitalization in connecting systems and processes, and the importance of PLM–ERP integration through the concept of the digital thread. Furthermore, it reviews value outcomes in SCM—such as efficiency, governance, and compliance—and explains how performance measurement and

KPIs can be used to link expected benefits to value realization. The chapter concludes by identifying the research gap that this study addresses.

Chapter 3 outlines the research methodology. It introduces Design Science Research (DSR) as the overarching approach and explains how the Design Science Research Methodology (DSRM) guides the study. The chapter describes the data collection and analysis methods, and considerations of trustworthiness and research ethics. It also maps the six steps of the DSRM process and illustrates the overall research flow.

Chapter 4 presents the implementation and research results. It begins with a description of the case company, SCM processes, and the SAP Material ID project. The chapter then identifies the key challenges related to early value realization and defines the objectives for the solution. It continues with the design and development of the benefit framework and design principles, which are demonstrated in the case company context. The chapter concludes with the communication of results and contributions. While the evaluation phase of the DSRM process is planned, it falls outside the scope of this thesis and is discussed in Chapter 5.

Chapter 5 provides the conclusions and discussion. It summarizes the main findings and outlines both theoretical and practical contributions. The chapter also discusses the limitations of the study and proposes directions for future research, including the post-implementation evaluation of value realization through KPIs.

2 Theoretical Background and Prior Research

The purpose of this chapter is to establish the theoretical foundations for the study. It introduces the main concepts and perspectives that underpin the research, including ERP systems, MDM, digitalization, and product lifecycle management (PLM). The chapter also discusses how these concepts are connected to value outcomes in SCM and how performance measurement is used to evaluate such outcomes.

The framework is structured to first provide an overview of ERP systems and how value realization has been conceptualized in previous research. This includes a review of widely cited ERP success models and a discussion of value outcomes typically associated with ERP implementations. The focus then shifts to material data and digitalization, with particular attention to the role of material master data in SCM, the function of SAP Material ID, and the relationship between digitalization initiatives and PLM systems.

Building on this foundation, the chapter examines value outcomes in SCM, categorizing them into efficiency, governance, compliance, financial outcomes, and sustainability perspectives. Finally, the chapter considers how performance measurement frameworks, such as KPIs, are applied in ERP projects to assess value realization and link expected benefits to measurable outcomes. Together, these perspectives form the theoretical basis for analyzing the value outcomes of SAP Material ID implementation in the case company.

2.1 Enterprise Resource Planning (ERP) Systems and Value Realization

Enterprise Resource Planning (ERP) systems are comprehensive, integrated software platforms designed to manage and coordinate the core functions of an organization (Jacobs & Weston, 2007, p. 357; Samara, 2015, p. 15). They typically encompass modules for material management, finance, human resources, and production, enabling data to flow seamlessly across different business processes (See Figure 1) (Samara, 2015, p. 15). The central idea of ERP is to provide a single, unified system that reduces information silos and creates one consistent source of truth for decision-making (Nestell & Olson, 2017, p. 2).

Figure 1. Material Master Data as the connecting link between ERP modules.

The implementation of ERP represents a significant organizational initiative, as these systems enable process standardization, automation, and organizational integration (Barna & Igna, 2021, p. 269). Particularly in SCM, ERP plays a critical role in coordinating procurement, managing inventory, ensuring data consistency across suppliers and warehouses, and supporting logistics and order fulfilment (Nestell & Olson, 2017, pp. 6–7). As a result, ERP systems are often positioned as digital backbones of modern enterprises, forming the foundation for more advanced digitalization initiatives.

Despite their potential, ERP projects represent one of the most challenging technology initiatives an organization can undertake. Failure rates can be alarmingly high; for instance, Chakraborty and Sharma (Helo et al., 2008, p. 1046) reported that 90% of projects failed when measured against project management criteria. This staggering risk is not an anomaly isolated to ERP but reflects a broader pattern in large-scale digital transformation. Reinforcing this point, Ramesh and Delen (2021, p. 22) note that a high percentage of all digital transformation programs fail to achieve their intended outcomes, often despite strong management commitment. Likewise, Coşkun et al. (2022, p. 3) highlight that while ERP vendors frequently showcase success stories, many projects have led to significant financial and operational losses. They cite well-known cases such as Nike, which lost $100 million in sales due to the wrong ERP selection and faulty supply chain design, and Hewlett Packard, whose ERP implementation failed because of poor scope planning and a “big-bang” rollout approach (Coşkun et al., 2022, p. 3).

These recurring challenges illustrate that ERP success cannot be taken for granted and that organizations must deliberately manage how value is realized from such large-scale investments. Consequently, both academic and practical discussions emphasize the critical challenge of deliberately managing value realization from ERP investments.

2.1.1 ERP Success Models

Defining what constitutes a successful ERP system has long been a central question in information systems (IS) research. Measuring success is complex because ERP implementations extend beyond technical deployment—they entail process change, user adoption, and organizational learning. Scholars have therefore developed conceptual models to capture the multidimensional nature of IS success and to explain how systems generate value for individuals and organizations. Among these, the DeLone and McLean (1992, 2003) Information Systems Success Model, the ERP Success Measurement Model by Gable et al. (2008), and the ERP Benefits Framework by Shang and Seddon (2002) form the theoretical basis for understanding ERP value realization.

DeLone and McLean’s (1992) model remains one of the most widely applied frameworks in IS success research. It conceptualizes IS success as a multidimensional construct consisting of system quality, information quality, use, user satisfaction, individual impact, and organizational impact. In their ten-year update, DeLone and McLean (2003) refined the model to reflect the evolution of information systems and added two key revisions: service quality as an independent dimension and the combination of individual and organizational impact into the broader category of net benefits. The updated model thus comprises six interrelated dimensions: system quality, information quality, service quality, use, user satisfaction, and net benefits, which together form a causal sequence linking technical performance and user experience to organizational outcomes (DeLone & McLean, 2003).

They explain that high system, information, and service quality enhance user satisfaction and system use, which in turn lead to positive net benefits such as improved productivity and decision-making (DeLone & McLean, 2003, pp. 10–25). The model has been validated across diverse IS contexts, including ERP, customer-relationship management, and e-commerce, demonstrating its robustness in capturing the interplay between technological and organizational success factors. For this study, the model provides a foundational lens for understanding value realization as the result of cumulative interactions among system quality, user experience, and organizational outcomes rather than as a one-time event following implementation.

While DeLone and McLean's model offers a generic view of IS success, Gable et al. (2008) tailored and empirically validated it for the ERP environment. Their IS-Impact Model is a comprehensive and empirically grounded framework, developed from survey data collected across 27 Australian government agencies using SAP Financials and one large university using Oracle Financials (Gable et al., 2008). The model defines IS success as a formative, multidimensional construct consisting of four core dimensions: System Quality, Information Quality, Individual Impact, and Organizational Impact (Gable et al., 2008, pp. 394–395). These dimensions are visually presented in Figure 2, which illustrates the IS-Impact Measurement Model and highlights the distinction between quality (future impacts) and impact (benefits realized to date) (Gable et al., 2008, p. 395). These four constructs are used to measure the stream of net benefits realized by the organization. Collectively, they represent both the technical foundation (quality half) and the resulting business consequences (impact half) of ERP performance. Gable et al. (2008, p. 380) specifically argue that ERP success should not be evaluated solely through traditional financial measures or project management metrics—such as cost, time, or functionality—but rather through its impacts on individuals and organizations, which encompass considerable intangible benefits.

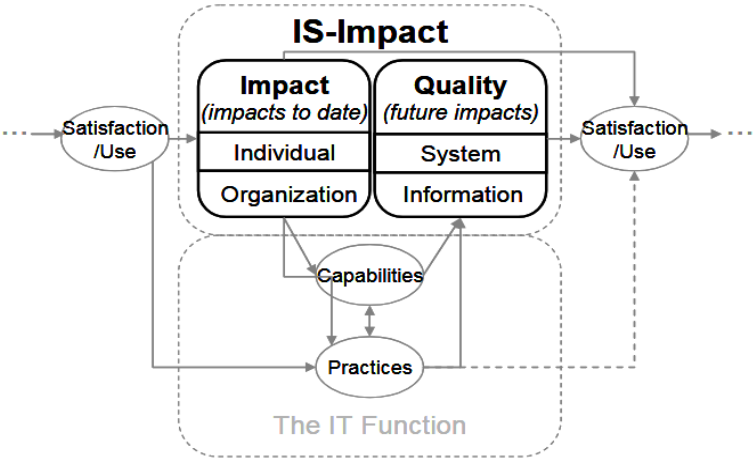


Figure 2. The IS-Impact Measurement Model (Gable et al., 2008, p. 395).

Whereas the models of DeLone and McLean (2003) and Gable et al. (2008) focus primarily on the dimensions and measurement of system success, Shang and Seddon (2002) address the question of what kinds of benefits organizations actually obtain from ERP implementations. Drawing on an extensive review of 233 ERP vendor case studies and 34 interviews with ERP-experienced organizations, they identified five major categories of ERP benefits: operational, managerial, strategic, IT infrastructure, and organizational. Operational benefits concern improved efficiency, productivity, and quality through process standardization and automation, while managerial benefits relate to enhanced decision-making, performance monitoring, and planning through better information availability. Strategic benefits refer to the organization’s ability to support growth, innovation, and competitiveness. IT infrastructure benefits include improved system integration, data consistency, and technological flexibility, whereas organizational benefits capture broader effects such as knowledge sharing, collaboration, and the development of a unified corporate vision (Shang & Seddon, 2002).

The main contribution of Shang and Seddon's (2002) framework lies in translating ERP success from an abstract construct into tangible categories of realized value. By distinguishing among operational, managerial, strategic, IT, and organizational dimensions, it provides a structured means of classifying and comparing ERP outcomes across contexts. This perspective aligns closely with the objective of this study, which seeks to identify early value outcomes from SAP Material ID implementation. Many of these early benefits, such as improved data quality, compliance, and process efficiency, can be interpreted as operational or managerial benefits in Shang and Seddon's (2002) taxonomy, whereas long-term digital transformation advantages correspond to strategic or IT infrastructure outcomes.

Together, these frameworks highlight that ERP success is multidimensional, evolving, and deeply tied to both technical and organizational capabilities. They also illustrate that value realization is not a singular outcome of system deployment but a continuing process of translating data quality and process improvements into measurable business benefits. These theoretical insights form the conceptual basis for examining the early value expectations associated with SAP Material ID in the case company's supply chain context.

2.1.2 ERP Value Outcomes in Organizations

As discussed previously, the value outcomes of ERP implementations can be categorized into operational, managerial, strategic, IT infrastructure, and organizational dimensions (Shang & Seddon, 2002). Building on this framework, this section examines how these value dimensions manifest in organizational contexts and how they relate to the early-stage benefits expected from the SAP Material ID implementation. Prior research emphasizes that while ERP systems integrate processes and data across functions, the realization of these benefits is not automatic (Nour, 2023, pp. 1–5). It depends on the alignment between technology and business processes, user adoption, and especially the quality and governance of master data (Nour, 2023; Silvola et al., 2011).

Among the earliest and most critical ERP outcomes is improved data quality. Balić et al. (2022, p. 2) describe ERP as enabling the "once-only principle" in data entry, ensuring that information is entered once and reused across functions, reducing errors and manual rework. This directly improves reliability and operational efficiency. Empirical studies show that data quality strongly predicts organizational performance, with Nour (2023, p. 18) confirming that information accuracy and completeness are significant contributors to ERP value realization.

Poor data governance, however, undermines these benefits. Silvola et al. (2011, p. 147) note that inconsistent master data can cause “mistakes, lost opportunities, failed deliveries and invoicing problems,” estimating that poor data quality can cost firms up to 10 percent of revenues. Tufano (2023, p. 57) similarly notes that without strong governance, “data may lose its value without appropriate data controls.” These findings resonate with the SAP Material ID project, which aims to assign clear ownership and validation rules for material data. Improved data governance is therefore not only a process objective but a value enabler—ensuring that clean, consistent, and verified data supports efficiency, compliance, and decision-making.

ERP systems also generate value through operational efficiency, achieved by integrating procurement, inventory, and logistics processes. Koh et al. (2008, pp. 248, 252–253) and Su and Yang (2010, pp. 457, 466) both demonstrate that ERP-enabled process integration reduces cycle times and enhances coordination between suppliers and customers. By providing transparency across departments, ERP fosters faster transactions and enhanced organizational processes and capabilities (Balić et al., 2022, p. 1). In the case organization, the introduction of SAP Material ID aims to remove bottlenecks caused by inconsistent material data. When all functions use standardized IDs, processes such as purchasing, inventory management, and logistics can operate seamlessly.

These outcomes reflect the operational and managerial benefit categories in ERP theory but are not guaranteed. Research shows variation in post-implementation results, depending on user adoption and process redesign (Koh et al., 2008). Similarly, Nour (2023) notes that contextual factors such as alignment and governance influence how quickly efficiency gains appear. Thus, while early value is expected from process streamlining and fewer data errors, sustained results depend on organizational readiness and data discipline.

Beyond efficiency, ERP systems provide the digital foundation for automation and integration with other enterprise systems. Nguyen et al. (2023, p. 689) show that robotic process automation (RPA) within SAP can make order processing up to ten times faster than manual execution. Dumitru et al. (2023) describe how modern ERP systems integrate automation and AI capabilities to improve sustainability reporting and eliminate repetitive tasks. Yet, research cautions that realizing these gains requires compatible infrastructure and skilled users (Dumitru et al., 2023). For the Material ID project, these insights are directly relevant. Standardized material data enables future automation of transactions, such as automatic purchase order matching, and integration with PLM tools and supplier portals. The project thus serves as an early-stage enabler of digital transformation. By improving data consistency, it allows later adoption of analytics, RPA, and sustainability tools that rely on accurate and structured master data.

ERP-driven data integration supports broader strategic outcomes, including improved visibility and responsiveness across the supply chain. Seyedghorban et al. (2020, p. 96) identify “real-time information access and control” as a key driver of supply chain competitiveness in digital environments. As SAP Material ID establishes consistent identifiers across internal and external systems, it directly contributes to this goal. The standardized data model not only enhances collaboration but also enables advanced analytics and sustainability reporting, as highlighted by Dumitru et al. (2023).

However, long-term benefits depend on maintaining governance and user engagement. Anaya and Qutaishat (2022) emphasize that ERP systems must be continuously managed to support ongoing growth and sustainability, rather than treated as one-time implementations. Therefore, the Material ID initiative should be viewed as a foundation for ongoing digital capability development, not a one-time project.

In summary, the literature shows that ERP value realization begins with data quality and process efficiency but extends toward automation and strategic digitalization. Early outcomes, including improved data reliability, faster transactions, and reduced manual work, form the foundation for later gains in analytics and automation. For the case company, this implies that measuring improvements in purchasing speed, data accuracy, and workflow automation will reveal the first signs of value from the SAP Material ID implementation. At the same time, sustained benefits will depend on continuous governance, cross-functional collaboration, and alignment between technology and organizational processes.

2.2 Data Governance, Digitalization, and Product Lifecycle Management (PLM)

Effective supply chain digitalization depends on one critical foundation: high-quality material master data. Digital technologies can indeed streamline processes and improve responsiveness in supply chains (Seyedghorban et al., 2020, p. 96; Tiwari et al., 2024, p. 2919), driving overall performance gains for firms, including specific ESG-related outcomes (Chen et al., 2024; Salamah et al., 2024). However, these benefits are only realized if the underlying material data is accurate, consistent, and well-governed (Altendeitering et al., 2024). Material master data (MMD) encompasses all key information defining a material: descriptions, specifications, units, supplier details, and inventory status, which enterprise systems require to execute supply chain processes. MMD is among the most important elements in an enterprise's basic data system, running through procurement, production, sales, and other business modules in ERP systems (Wei et al., 2023). In practice, deficiencies in MMD have been linked to serious inefficiencies—inconsistencies can disrupt procurement, production, and distribution activities, leading to duplicate records, inventory control issues, and reduced operational efficiency (Merwe et al., 2024).

The root of these MMD deficiencies often traces back to a single, fundamental problem. Zong et al. (2017, pp. 434–435) identify this as the “lack of unique and global identifiers for material records” coupled with users assigning different names for the same item. In other words, without a standardized material identification system, the same physical material may be recorded under multiple aliases in the ERP, fragmenting information. This duplication not only causes data inconsistency but also “confusion in the entire business process”, as the system treats one real item as if it were several, undermining inventory accuracy and procurement decisions (Zong et al., 2017, p. 435). The SAP Material ID project at the case company directly targets this problem by introducing a single, unified identifier for each third-party material. By enforcing a one-to-one relationship between physical materials and system records, the project aims to eliminate duplicate entries and ensure that all departments and systems refer to a given material in a consistent way. This forms a crucial first step toward realizing ERP value: a coherent, enterprise-wide view of materials.

High-quality material data is a prerequisite for supply chain automation and data-driven improvements (Haug & Arlbjørn, 2011; Tiwari et al., 2024). Researchers have long noted that master data quality and negative consequences go hand in hand—as Silvola et al. (2011, p. 147) observe, “the decisions a company makes are no better than the data on which they are based”. Haug, Arlbjørn (2011) and Silvola et al. (2011) emphasize this fundamental relationship between data quality and business outcomes. A product’s lifecycle spans many phases (design, sourcing, manufacturing, service, and others), each generating and requiring different data; unless this material data is managed in an integrated, systematic manner, stakeholders will not have accurate information at the right time (Silvola et al., 2011). In practice, disparate systems and siloed processes historically led to “variance in business concepts and object definitions” across departments, with each using its own data for the same materials (Silvola et al., 2011, p. 147). As organizations attempt to unify and share data across the enterprise and the extended supply chain, these hidden inconsistencies and errors become apparent. Research similarly notes that firms invest substantial time and resources in correcting master data errors, indicating that poor data quality remains one of the most persistent operational bottlenecks in digital supply chains (Gualo et al., 2023; Haug & Arlbjørn, 2011).

Conversely, when material master data is well-maintained, the positive impact is significant. Gualo et al. (2023, p. 796) report that “the better the levels of data quality of the master data repositories, the better the intra- and inter-organizational performance”. Clean, standardized material data reduces process friction and rework, allowing supply chain transactions to flow smoothly. For instance, a recent case study at a global manufacturing firm showed that a well-implemented material master data management system led to improvements in supply chain performance (Merwe et al., 2024, p. 575). In that case, establishing a single source of truth for material information enabled higher inventory turnover and faster, more accurate order fulfillment (Merwe et al., 2024). These findings reinforce a key point: ERP value realization begins with getting the material data right. Even advanced analytics or automation will falter if fed flawed data. Indeed, poor data quality is a primary reason why nearly 40% of business initiatives fail to reach their target benefits and can weaken 20% of an organization's productivity; as more supply chain processes become automated and AI-driven, data quality becomes “the limiting factor for overall process quality” (Gualo et al., 2021, p. 1). In short, without high-quality material identifications and records, an ERP system cannot deliver its promised efficiencies – a reality that justifies the case company’s current Material ID initiative.

Beyond the quality of material data itself, supply chain digitalization also depends on how product and material information flows across digital systems throughout the lifecycle. Digitalization refers not merely to converting processes into digital form but to transforming how data is created, shared, and used to enable transparency and collaboration across the value chain (Seyedghorban et al., 2020, pp. 96–97; Tiwari et al., 2024, pp. 2918–2919). In manufacturing contexts, Product Lifecycle Management (PLM) systems play a key role in this transformation. PLM manages all product-related data—from initial design and engineering to production and service—and ensures that changes made in design are systematically reflected in downstream systems (Bruun et al., 2015, p. 99; McMillan et al., 2017, pp. 136–137; Milicic et al., 2017, p. 109). According to Saaksvuori and Immonen (2008, p. 53), effective PLM implementation requires that "information should always be updated in one place", with other systems reading from PLM databases as needed. They emphasize that "it is essential that the original source of all information and the business process responsible for it is known within the company” (Saaksvuori & Immonen, 2008, p. 53). However, this digital potential is only realized when PLM data is consistent with and accessible through ERP systems, where operational and financial transactions occur. As Saaksvuori and Immonen (2008, pp. 58–59) explain, while PLM manages product items and structures as the system for "product data producers," ERP functions as the system for "product data consumers," controlling operational information such as inventory levels while drawing basic item information from PLM. Hence, material master data and PLM cannot be viewed separately: both are foundational for digital supply chain performance. Effective governance, semantic consistency, and integration between these domains are prerequisites for sustaining the value created by digitalization initiatives.

Research on master data management emphasizes that achieving and sustaining high-quality master data requires robust data governance, including clear data ownership, organizational commitment, and standardized data definitions and formats across systems (Gualo et al., 2023; Silvola et al., 2011). Data governance refers to the overall management of data’s availability, usability, integrity, and security in an organization. Tufano (2023, p. 57) proposes implementing data governance quality controls after data collection from source systems (ERP, MES, WMS, PLM) to verify consistency in smart factory environments. International standards and frameworks call for: assigning data ownership, mapping data sources and users, clarifying the meaning of each data element through a common data glossary, establishing data lineage, and ensuring data quality for all stakeholders (Tufano, 2023, p. 57).

These governance practices help enforce semantic consistency across systems, so that, for example, the term "material weight" or a specific material code carries the exact same definition in the PLM system as it does in the ERP or warehouse system. By instituting a controlled vocabulary and unified data definitions, organizations avoid the scenario where different units “speak the same language” in name only but not in substance.

Maintaining this semantic consistency is particularly vital when integrating data from multiple sources, as data integration processes can reveal discrepancies and incompatibilities across organizational silos (Silvola et al., 2011, pp. 147–150). Tufano (2023) proposes mathematical consistency checks across datasets to automatically flag discrepancies in key operational metrics – an approach illustrating how governance can be technologically enforced. In practice, one critical governance mechanism is to prevent duplicate or conflicting material entries through upfront standards and validation rules (e.g. disallowing a new material record unless a proper naming convention and attribute set are followed) (Gualo et al., 2021, 2023; Zong et al., 2017). The SAP Material ID project embodies this by instituting company-wide rules for creating and classifying third-party materials, eliminating ad-hoc, inconsistent entries.

Strong governance also entails continuous data quality monitoring and improvement cycles. Researchers advocate for regular data quality evaluations and even formal certifications of master data repositories to sustain trust in organizational data (Gualo et al., 2023, p. 795). For instance, Gualo et al. (2021, p. 1) describe how several European companies underwent a rigorous data quality certification (against ISO/IEC 25012 standards) and subsequently reported benefits like “better internal knowledge of data and more efficient management of data quality”. This kind of disciplined, rule-based management of material data is what allows an ERP system to consistently generate accurate outputs. Figure 3 illustrates the one master data framework, showing that successful master data management requires the integration of three elements: high-quality data content (organized by parties, places, and content entities), well-defined data processes, and supporting information systems (Silvola et al., 2011, p. 151). In essence, data governance provides the organizational and technical “framework” that keeps material data correct and coherent throughout the enterprise. Without it, any gains from digital tools will be short-lived – a reminder that technology alone (the “digital”) does not create value unless the data (the “material”) is fit for use.

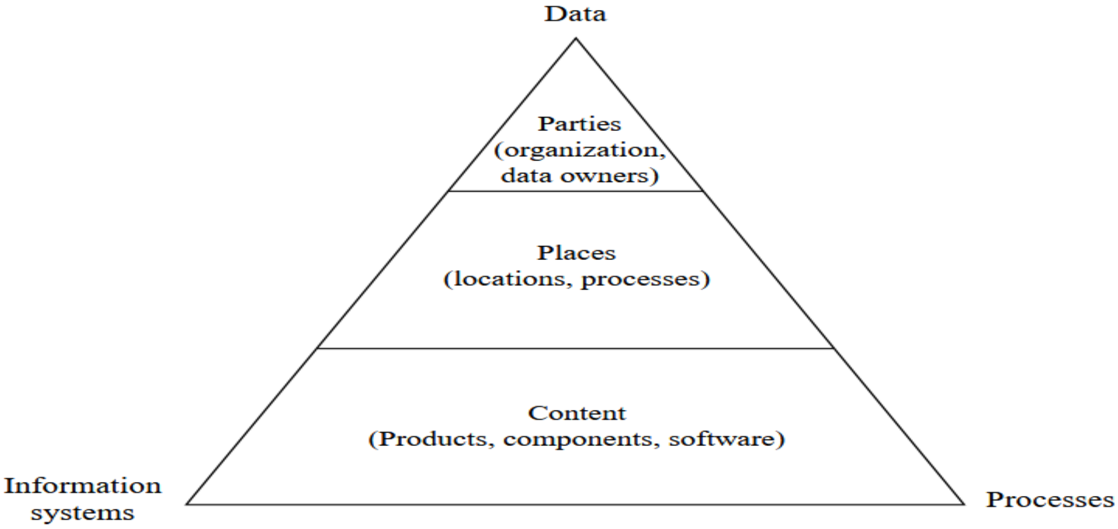


Figure 3. The concept of one master data (Silvola et al., 2011, p. 151).

2.2.1 SAP Material ID

In SAP ERP, each material is uniquely identified by a material number (MATNR), an alphanumeric identifier that can be up to 40 characters in SAP S/4HANA (Goel, 2022, p. 20). This material number serves as the primary key for all material-related transactions across organizational units, ensuring that procurement, production, sales, and accounting functions reference the same master data record (Goel, 2022, pp. 20, 22–23). Material numbers can be assigned using either internal number ranges (automatically generated by the system) or external number ranges (manually specified by users), with the choice typically depending on whether the organization needs to maintain consistency with external systems such as PLM (Goel, 2022, pp. 20–21). The material number works in conjunction with the material type (e.g., FERT for finished products, ROH for raw materials) to determine which business processes and data views are available, ensuring that each material's system configuration aligns with its role in the supply chain (Goel, 2022, pp. 20–22).

The SAP Material ID project at the case company applies these principles to third-party materials by implementing internal number ranges that generate unique identifiers for each purchased component. For example, instead of relying on free-text descriptions, each generator, valve, or auxiliary module component will receive a standardized SAP Material ID that remains consistent across purchasing, logistics, and lifecycle systems. This approach directly addresses the fundamental problem identified by Zong et al. (2017, pp. 434–435)—that material data deficiencies stem from the absence of standardized, enterprise-wide identifiers for materials. By establishing a one-to-one relationship between physical materials and system records, the project ensures that all organizational units reference identical material information, thereby creating the unified data foundation that governance literature identifies as critical for effective master data management (Silvola et al., 2011, pp. 147–148; Tufano, 2023, p. 57).

2.2.2 Digitalization

At the case company, digitalization represents the transformation of business processes from manual, document-driven practices to integrated, data-driven workflows. This involves converting analog operations into digital formats, enabling automation, reducing manual errors, and improving operational efficiency. The company's digitalization strategy focuses on creating seamless data flows across enterprise systems through robust data governance and standardized data structures, moving away from disconnected tools and fragmented information silos toward unified digital environments.

This digital transformation aligns with the principle that effective digitalization depends critically on high-quality data as its foundation (Altendeitering et al., 2024, p. 1; Gualo et al., 2021, p. 1; Valencia-Parra et al., 2021, p. 1). Without consistent, well-governed data structures, particularly for materials, digital systems would automate existing inconsistencies rather than eliminate them. The company therefore prioritizes establishing standardized data structures and governance mechanisms, including unique material identifiers and standardized classifications, to enable advanced digital capabilities such as automated procurement workflows, real-time inventory visibility, and integrated production planning.

2.2.3 PLM–ERP Integration

The integration of PLM and ERP systems represents a critical interface in the digital supply chain, bridging the design and manufacturing domains (see Figure 4). As Wu et al. (2014, p. 6093) explain, PLM focuses on design and development functions while ERP focuses on production and manufacturing; though distinct in scope, "the two mechanisms are complementary and need to be integrated." The PLM domain is characterized by engineering focus, project-driven processes, and the creation of new products, whereas the ERP domain emphasizes manufacturing execution, resource planning, order-driven operations, and ongoing production (McMillan et al., 2017, pp. 136–137). A fundamental challenge in this integration concerns ownership and accessibility of the Bill of Materials (BOM): while product structure ownership has shifted from manufacturing to engineering, "BOM information must still be supported and accessible within ERP applications, thus increasing the importance of integrating PLM and ERP to ensure consistency of BOM, product change and other related information used throughout an enterprise" (Wu et al., 2014, p. 6093).

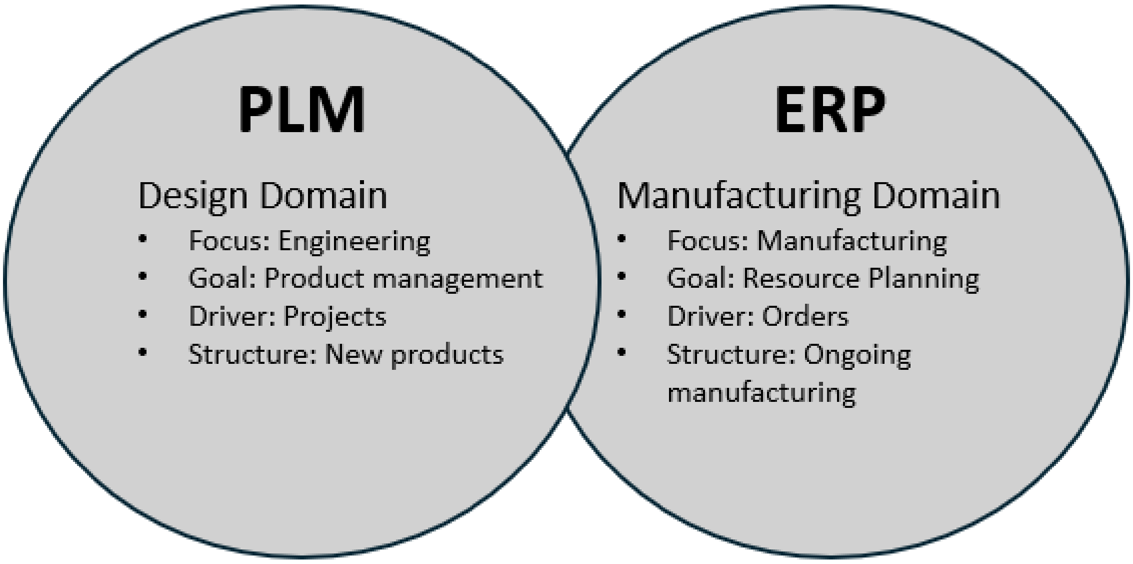


Figure 4. Integration domains of PLM and ERP systems (adapted from Wu et al., 2014, p. 6095).

Effective PLM–ERP integration delivers significant business benefits by ensuring that product information created in PLM is properly referenced in ERP before operational use (Wu et al., 2014, pp. 6092–6093). According to Wu et al. (2014, p. 6093), these benefits include ensuring consistent use of product information throughout the enterprise, reducing time-to-market at lower cost, and establishing common product-related terminology and processes across the business. However, as Saaksvuori and Immonen (2008, p. 53) emphasize, integration requires more than data transfer—it demands that "the original source of all information and the business process responsible for it is known within the company." Wu et al. (2014, p. 6093) further note that "integration between PLM and ERP is as much about integrating key processes (e.g. change management) as it is about transferring data from one application to another." Without such integration, organizations face risks of version conflicts, inconsistent material information, and inefficient manual reconciliation efforts that undermine digitalization benefits.

2.3 Value Outcomes in Supply Chain Management (SCM)

Having established the foundational role of material master data and governance in Section 2.2, this section examines the value outcomes that organizations can expect from SAP Material ID implementation in SCM contexts. SCM can be defined in many ways, as some authors define it in operational terms and some as an integrated system (Habib, 2011, p. 4). Supply chain management in the case company refers to the coordinated planning and execution of sourcing, supplier development, logistics, and procurement activities to ensure timely, high-quality, and cost-efficient delivery of products and services. It focuses on building a resilient supplier network and optimizing processes to meet customer commitments while minimizing total cost and operational risks.

These value outcomes directly address the first research question by identifying the specific benefits anticipated in the early post-implementation phase. Following Shang and Seddon's (2002) classification of ERP benefits, five categories of value outcomes are discussed: operational efficiency (2.3.1), organizational governance (2.3.2), strategic compliance (2.3.3), managerial optimization (2.3.4), and IT infrastructure enablement (2.3.5).

These categories have been selected based on their relevance to the case company's industrial context and the specific challenges addressed by the Material ID implementation, rather than representing an exhaustive taxonomy of all possible SCM value outcomes. Together, these outcomes form the basis for the value expectation framework developed in Chapter 4.

2.3.1 Time Savings and Process Efficiency

Operational efficiency improvements represent the most immediate and tangible value outcomes of ERP implementations, as process standardization and automation reduce manual work and accelerate transaction cycles (Koh et al., 2008, pp. 248, 252–253; Su & Yang, 2010, pp. 456, 466). Research on RPA in procurement demonstrates the magnitude of potential efficiency gains, with processing times reduced from 24 hours to 1 hour through automated data handling (Viale & Zouari, 2020, p. 190). Similarly, van Hoek et al. (2022, p. 293) report that buyer handling time improved from 13.1 days to 3.6 days following RPA implementation at Maersk, with the automated system providing continuous processing capability beyond standard working hours although not being the only reason for this improvement. These improvements illustrate how standardized material identification enables automation by providing consistent data structures that digital processes can reliably execute. For the Material ID implementation context, such efficiency gains stem from digitalization's capacity to create end-to-end real-time information access and control across supply chain activities, enabling faster responses to changing customer needs (Seyedghorban et al., 2020, p. 96).

Conversely, realizing these operational benefits depends critically on addressing the data quality barriers that create inefficiencies in the first place. Haug and Arlbjørn (2011, p. 300) identify lack of delegated responsibility for master data maintenance as the single most significant barrier to data quality, with poor data quality causing mistakes, lost opportunities, and failed deliveries that disrupt business processes. The root cause of material master data deficiencies traces to the absence of unique identifiers coupled with inconsistent naming practices, which fragment information and create confusion throughout business processes (Zong et al., 2017, pp. 434–435). Standardized material identification addresses these deficiencies by enforcing unique identifiers and the "once-only principle" in data entry, ensuring information is entered once and reused across functions, thereby reducing errors and manual rework (Balić et al., 2022, p. 2).

The efficiency outcomes extend beyond immediate transaction speed improvements to encompass broader process optimization and resource reallocation. Rather than reducing workforce requirements, automation in procurement enables organizations to redirect employee time from repetitive data handling toward more strategic priorities (Viale & Zouari, 2020, pp. 190–191). For the case organization these efficiency gains are expected to manifest as reduced procurement cycle times, fewer data-related errors requiring correction, and improved capacity to focus on supplier relationship management and strategic sourcing activities rather than administrative data reconciliation.

2.3.2 Data Governance as an Enabler

Beyond improving data quality, the implementation of SAP Material ID is expected to deliver significant value by formalizing data governance. By replacing inconsistent, user-generated descriptions with a systematic, rule-based approach to material creation, the project establishes clear accountability and enforces the single data entry suggested by Balić et al. (2022, p. 2). This transition from ad-hoc data handling to a structured process, where ownership and data standards are defined, represents a tangible organizational outcome. It ensures that master data is not merely clean at the point of entry but is actively managed throughout its lifecycle, addressing the core governance challenges identified as significant barriers to data quality (Haug & Arlbjørn, 2011; Hua et al., 2025).

This enhanced data governance functions as a critical enabler for nearly all other value outcomes. With a reliable and consistent data foundation, the organization is better positioned to achieve process efficiencies, as automation tools can operate without the risk of data-related exceptions (Viale & Zouari, 2020). Furthermore, strong governance is a prerequisite for ensuring compliance, managing working capital effectively, and ultimately enabling the advanced digital and analytical capabilities that depend on trustworthy master data (Gualo et al., 2023). In this context, improved governance is not an isolated benefit but the foundational platform upon which future SCM digitalization and value realization are built.

2.3.3 Compliance and Sustainability

Compliance in material data management encompasses the standards, conventions, and regulations governing how material information adheres to quality requirements within specific operational contexts (Gualo et al., 2023, p. 800). The absence of specific, verified data for individual materials creates significant challenges in tracking both data compliance and the physical materials themselves, limiting organizations' ability to meet regulatory and industry requirements. Material traceability has emerged as a fundamental prerequisite for optimized and sustainable supply chain operations, defined by ISO 9000 as the ability to trace the history, application, location, origin of raw materials and parts, manufacturing processes, distribution pathways, and final product location (Germani et al., 2015, p. 228). Organizations increasingly implement traceability measures to comply with various regulations while effectively gathering information from supply chain partners, addressing concerns related to environmental regulation, component tracking for quality issues, product recalls, and reverse logistics (Gelderman et al., 2021, p. 2).

Sustainability has become both a strategic priority and a regulatory imperative for modern organizations. Supply chain digitalization demonstrates significant positive impacts on corporate ESG (Environment, Social, and Governance) performance, as evidenced by research examining Chinese listed companies from 2012 to 2021 (Chen et al., 2024, p. 875). Digital technologies such as cloud computing, blockchain, internet of things, AI enable data-driven decision-making and create operational processes enriched by digital capabilities, with tools such as smart contracts, digital storage, and intelligent labels achieving traceability throughout the product lifecycle while significantly improving supply chain transparency and integrity (Salamah et al., 2024, p. 4). The sharing of high-quality traceability data positively affects dimensions of corporate sustainability, though data quality alone represents a necessary but insufficient condition for sustainability performance, as organizations must actively use this data to restructure supply chains or implement mitigating practices (Gelderman et al., 2021, pp. 6–8). As organizations transition to new generation ERP systems to meet reporting requirements and transparency expectations, early adopters can achieve superior environmental performance through improved material efficiency, energy savings, and enhanced corporate image, supported by governance policies and internal controls that ensure compliance and reduce risk (Dumitru et al., 2023, pp. 2–3). Material ID implementation thus serves as a critical enabler by establishing the reliable data foundation necessary for comprehensive ESG reporting, supply chain compliance, and traceability.

2.3.4 Working Capital and Financial Outcomes

Material master data quality directly impacts financial performance through multiple channels. Accurate material identification prevents duplicate purchasing and excessive safety stock, as RPA-enabled procurement processes reduce processing times from 24 hours to 1 hour while improving accuracy rates from 97% to 100% (Viale & Zouari, 2020, pp. 190–191). The implementation of robust material master data management practices demonstrated improvements in inventory turnover and order fulfillment accuracy, which are key indicators of supply chain performance that enhance organizational profitability (Merwe et al., 2024, p. 574). ERP systems can enable improved inventory control, improved cash management, and reduction in operating costs through better information management capabilities (Su & Yang, 2010, p. 461).

Beyond immediate cost reductions, improved material data governance created sustained financial benefits by optimizing working capital allocation. Enhanced operational benefits from ERP implementation include improved production quality and information sharing between supply chain levels, with correlation between operational benefits and SCM competencies (Su & Yang, 2010, p. 461). By decreasing lead times and boosting inventory turnover through sustainable supply chain methods, companies can significantly enhance profitability while reducing logistics expenses and increasing financial returns (Merwe et al., 2024, p. 570). Additionally efficient data cleaning processes and automated workflows help organizations reduce the administrative workload and operational costs associated with maintaining master data repositories (Viale & Zouari, 2020, p. 191).

2.3.5 Enablement of Advanced Digital Capabilities

While earlier subsections have focused on immediate operational and managerial benefits, this section addresses the longer-term IT infrastructure outcome that SAP Material ID enables. These benefits align with Shang and Seddon's (2002) IT infrastructure value and concern the organization's ability to support digital transformation. High-quality material master data is foundation for advanced digital capabilities such as AI, machine learning, and predictive analytics. Several studies have shown the effectiveness of AI solutions in SCM centers on the availability of standardized, consistent, and well-governed data (Cannas et al., 2024; Wu et al., 2025). Cannas et al. (2024, p. 3351) describes how a company identified the lack of data-driven company culture and appropriate people to lead as the main issues of AI development projects. This is part of the case company's digitalization strategy, moving to a more data-driven approach and the Material ID project enhances that part significantly.

Research shows that AI technologies such as demand forecasting, inventory optimization, and route planning are only as effective as the data that feeds them (Fu et al., 2024; Wu et al., 2025). In an Industry 5.0 context, AI-driven automation, customization, and, and data-centric decision-making require real-time traceability, accurate material classification, and interoperable system integration each of which depends on material-level data integrity (Wu et al., 2025, pp. 3831–3834). Moreover, advanced analytics and generative AI functionalities embedded in ERP systems are only viable when underlying data structures, including material identifications, are standardized and accessible across modules (Sarferaz, 2025). While the short-term benefits to the Material ID implementation may center on operational efficiency, its broader value lies in enabling digital resilience and responsiveness over sustained innovation, regulatory adaptability, and competitive differentiation in the evolving digital supply chain landscape.

2.4 Performance Measurements

ERP systems represent significant organizational investments, yet translating these investments into measurable business value remains challenging (Nour, 2023, p. 2). While ERP success models discussed in Section 2.1.1 establish theoretical dimensions of success, such as system quality, information quality, and net benefits (DeLone & McLean, 2003; Gable et al., 2008), they provide limited guidance on operationalizing these dimensions through concrete metrics. Performance measurement frameworks address this gap by defining specific indicators that track the realization of expected benefits (Gunasekaran et al., 2004). As Shang and Seddon (2002) demonstrated, different types of benefits types require distinct measurement approaches, making the selection of appropriate key performance indicators (KPIs) critical for demonstrating ERP value.

In supply chain management context, performance measurements must capture both process improvements and strategic outcomes (Gunasekaran et al., 2004, p. 335). Each value outcome identified in Section 2.3, including efficiency gains, data governance improvements, compliance enhancement, financial optimization, and digital capability enablement, requires specific metrics to demonstrate realization. This section examines KPIs commonly used in SCM and establishes how these indicators can be linked to ERP value realization, directly addressing the second research question regarding the connection between expected benefits and evaluation practices.

2.4.1 Key Performance Indicators (KPIs) in SCM

Supply chain performance measurement requires systematic categorization of metrics across organizational hierarchies to ensure alignment between measurement practices and decision-making needs. Gunasekaran et al. (2004, p. 335) establish a foundational framework distinguishing strategic, tactical and operational levels of SCM metrics, where strategic measures influence top-level management decisions regarding competitive positioning and organizational goals, tactical measures address resource allocation and performance against targets, and operational metrics assesses day-to-day execution results. This hierarchical structure recognizes that “the metrics that are used in performance measurement and improvement should be those that truly capture the essence of organizational performance” and that effective measurement systems require balance between financial and non-financial measures across all decision-making levels (Gunasekaran et al., 2004, p. 335). In procurement contexts specifically, this hierarchy manifests through strategic measures including purchase order cycle time efficiency and capacity flexibility, and operational measures encompassing delivery performance and detect-fee achievement rates (Gunasekaran et al., 2004, p. 336).

The emergence of digital supply chains has expanded traditional KPI frameworks while reinforcing the importance of selective measurement. Rasool et al. (2024, p. 554) emphasize that experts increasingly advocate for reducing KPI volume and focusing on critical data points, with one expert noting that “it’s not how many times you measure it. It is how, where, and why you measure it”. This perspective aligns with the balanced scorecard methodology employed by Ali et al. (2024, pp. 2–3) to achieve holistic representation of supply chain performance across five broad dimensions. Contemporary research demonstrates that while traditional KPIs such as inventory turnover, cycle time, and on-time delivery remain relevant, digital technologies enable enhanced measurement capabilities through real-time data sharing, automated tracking, and improved transparency (Rasool et al., 2024, pp. 555–556). Industry 4.0 technologies further impact KPI selection and measurement precision, as Marinagi et al. (2023, p. 15) note that decision-makers continuously monitor KPIs not only to evaluate performance but also to identify problem origins within increasingly complex supply chain networks.

In the Material ID implementation context, KPI selection must reflect the specific value outcomes identified in Section 2.3. Operational efficiency improvements (2.3.1) can be assessed through time-based metrics including order lead-time and procurement cycle time, which directly capture benefits from standardized material identification (Gunasekaran et al., 2004, p. 336). Data governance outcomes (2.3.2) require quality-oriented metrics tracking master data accuracy and consistency, while compliance and sustainability objectives (2.3.3) necessitate KPIs such as material traceability rates and transparency levels across the supply chain (Rasool et al., 2024, p. 556). Financial performance (2.3.4) remains measurable through established indicators including inventory turns and total logistics cost (Gunasekaran et al., 2004, p. 338), whereas digital capability enablement (2.3.5) demands newer metrics such as automation rates and information availability levels (Rasool et al., 2024, p. 556). The following sections examine how these KPIs can be systematically linked to ERP value realization processes.

2.4.2 Linking KPIs to ERP Value Realization

A persistent challenge in enterprise system research concerns the gap between ERP implementation success and the realization of measurable business value. While ERP systems integrate and automate business processes, tangible outcomes are often difficult to demonstrate without linking expected benefit to well-defined KPIs. As Shang and Seddon (2002, pp. 271–272) argue, ERP value must be assessed across multiple dimensions; operational, managerial, strategic, IT infrastructure, and organizational, each requiring measurable outcomes to validate benefit realization. Success depends on translating system and information quality into improved organization performance (DeLone & McLean, 2003, p. 24; Gable et al., 2008, p. 386), typically through a combination of perceptual indicators such as user satisfaction and service quality alongside objective measures including time, cost, and accuracy. In this context, KPIs serve as the operational bridge between theoretical benefit categories and quantifiable business impact, transforming abstract concepts such as “improved decision-making” or “enhanced data visibility” into measurable targets.

Effective KPI frameworks must reflect the hierarchical and multidimensional nature of organizational performance. Gunasekaran et al. (2004, pp. 334–335) emphasize that SCM performance assessment requires measures across strategic, tactical, and operational levels, allowing organizations to align ERP-driven process improvements with broader supply chain objectives. This hierarchical approach ensures that short-term operational gains, such as reduced cycle times, support longer-term strategic outcomes including competitive positioning in supply chain resilience. Recent studies further underscore this connection in digital contexts, demonstrating that as ERP systems evolve into data-centric platforms, KPI frameworks must capture both efficiency metrics and adaptability indicators (Rasool et al., 2024). Without this structured measurement approach, organizations risk implementing systems that deliver real improvements yet fail to demonstrate value, ultimately undermining stakeholder confidence and continued investment.

From the SAP Material ID project perspective, this linkage between benefits and KPIs is particularly critical because the project establishes the data foundation upon which accurate and automated performance measurements depend. Material ID standardization ensures that operational and analytical KPIs can be calculated reliably across systems by eliminating duplicate records, enforcing consistent material definitions, and enabling accurate aggregation of procurement cycle times, inventory accuracy rates, and supplier performance metrics. The systematic mapping of value outcomes to measurable indicators creates a structured framework for benefit realization. Specifically, operational efficiency gains (Section 2.3.1) map to cycle time reduction and error rate KPIs; data governance improvements (2.3.2) correspond to master data accuracy and duplicate elimination metrics; compliance and sustainability outcomes (2.3.3) link to traceability completion rates and regulatory reporting efficiency; financial optimization (2.3.4) connects to inventory turnover and working capital indicators; and digital capability enablement (2.3.5) relates to system integration completeness and automation readiness scores (Gunasekaran et al., 2004; Rasool et al., 2024). Table 1 illustrates these linkages between the benefit categories identified in Section 2.3 and corresponding KPIs drawn from supply chain performance literature.

Table 1. Mapping Value Outcomes to KPIs.

Benefit Category	**Representative KPIs**	**Primary Sources**
Operational efficiency (2.3.1)	Procurement cycle time, Order processing, Error rates	(Gunasekaran et al., 2004; Viale & Zouari, 2020)
Data Governance (2.3.2)	Master data accuracy rate, Duplicate elimination rate, Data completeness	(Gualo et al., 2023; Haug & Arlbjørn, 2011)
Compliance and Sustainability (2.3.3)	Material traceability rate, Reporting efficiency, Transparency scores	(Gelderman et al., 2021; Rasool et al., 2024)
Financial Optimization (2.3.4)	Inventory turnover, Working capital days	(Gunasekaran et al., 2004; Merwe et al., 2024)
Digital Enablement (2.3.5)	System integration score, Automation rate, Information availability	(Dumitru et al., 2023; Rasool et al., 2024; Wu et al., 2025)

By establishing these KPI linkages during pre-implementation phase, organizations create a foundation for systematic value assessment throughout the post-implementation period. This approach transforms qualitative benefit expectations into a structured measurement framework that supports continuous monitoring, ensuring that improvements in data governance, process standardization, and digital enablement translate into tangible, evidence-based business value. Chapter 4 operationalizes this KPI framework in the case company context establishing baseline measures and defining specific benefit expectations for Material ID implementation that will enable future evaluation of value realization.

2.5 Synthesis of Literature and Theoretical Gaps

The literature reviewed in this chapter establishes a robust theoretical foundation for understanding ERP value realization, master data governance, and supply chain performance measurement. However, three interconnected gaps emerge that limit both academic understanding and practical guidance for organizations implementing material identification initiatives.

First, existing ERP success research focuses predominantly on post-implementation outcomes rather than pre-implementation benefit identification. While models by DeLone and McLean (2003), Gable et al. (2008), and Shang and Seddon (2002) provide comprehensive taxonomies of realized benefits, they offer limited methodological guidance for systematically defining and structuring benefit expectations before implementation begins. This gap is problematic because organizations frequently struggle to translate ERP investments into measurable value outcomes without clear ex-ante frameworks (Nour, 2023; Silvola et al., 2011), and because the absence of structured expectations weakens post-implementation assessments (Estébanez, 2021; Govindaraju et al., 2018). Research has examined what benefits organizations eventually realize, but not how organizations should prospectively identify, categorize, and prepare to measure these benefits during the critical pre-implementation phase when stakeholder alignment and measurement systems must be established.

Second, despite extensive acknowledgement that material master data quality is foundational for supply chain digitalization (Altendeitering et al., 2024; Gualo et al., 2023; Tiwari et al., 2024), empirical research has not adequately examined how material identification creates measurable value. Prior studies document the consequences of poor material data—including duplicate records, process inefficiencies, and governance failures (Merwe et al., 2024; Zong et al., 2017)—yet the mechanisms through which standardized material identifications enable operational, governance, compliance, financial, and strategic outcomes remain underspecified. This represents a significant gap given that material identification is a fundamental prerequisite for advanced capabilities such as traceability (Gelderman et al., 2021), sustainability reporting (Dumitru et al., 2023), and AI-driven supply chain optimization (Wu et al., 2025). Understanding these enabling mechanisms is essential for both theoretical advancement and practical implementation success.

Third, while supply chain performance measurement frameworks identify KPIs (Gunasekaran et al., 2004; Rasool et al., 2024), research has not systematically connected these metrics to the specific value dimensions of material master data initiatives. The literature treats KPIs as general performance indicators rather than as targeted instruments for demonstrating ERP-driven improvements in data governance contexts. This disconnection is consequential because organizations cannot effectively manage or communicate value realization without explicit linkages between expected benefits and measurable outcomes (Huang & Handfield, 2015). Furthermore, the evolution toward digital supply chains demands measurement frameworks that capture both traditional efficiency metrics and emerging capabilities such as system integration readiness and automation potential (Marinagi et al., 2023; Rasool et al., 2024), yet guidance for constructing such frameworks in master data contexts remains absent.

This study addresses these three gaps by developing a theoretically grounded framework that defines expected benefits from SAP Material ID implementation and explicitly maps these benefits to actionable KPIs. By focusing on the pre-implementation phase and the SCM context, the research contributes both to ERP value realization theory and to practical guidance for organizations undertaking material identification initiatives. The following chapter presents the design science research methodology employed to develop and demonstrate this framework.

3 Research Methodology

This chapter presents the methodological approach used to achieve the objectives of the study and to answer the research questions introduced earlier. It explains how the research was designed and executed to explore the expected benefits of the SAP Material ID implementation within the supply chain management function of the case company. The purpose of the chapter is to provide transparency regarding the research design, the logic behind the methodological choices, and the means used to ensure rigor and credibility.

This chapter begins by introducing Design Science Research (DSR) as the guiding research paradigm. DSR offers a structured way to bridge theoretical understanding and practical problem solving by developing an artifact—in this case, the artifacts are a framework for identified expected benefits associated design principles to help achieve the benefits. The subsequent sections describe how the DSR process was applied in a single-case setting using qualitative data collected through semi-structured expert interviews. The chapter concludes with an outline of the overall research process and the procedures ensuring the validity, reliability, and ethical integrity of the study.

3.1 Design Science Research

Design Science Research is an established research paradigm within the information systems discipline that aims to create and evaluate innovative artifacts designed to solve identified organizational problems while simultaneously contributing to scientific knowledge (Hevner et al., 2004; Peffers et al., 2007). The central idea of DSR is that purposeful design of artifacts, such as models, methods, frameworks or system, can bridge the gap between theoretical understanding and practical application in sociotechnical environments. According to Hevner et al. (2004, p. 83), the objective of DSR is to extend the boundaries of human and organizational capabilities by building and evaluating artifacts that address relevant business problems. This dual focus on relevance and rigor distinguishes DSR from purely descriptive approaches: it not only seeks to explain phenomena but to change them through design (Hevner, 2007, p. 91). The paradigm emphasizes iterative problem solving and relies on rigorous grounding in existing knowledge bases, ensuring that design efforts are both scientifically credible and practically useful (Gregor & Hevner, 2013).

The DSR approach is characterized by its cyclical nature, as described by Hevner (2007, p. 88) who conceptualized it through three interrelated cycles—the relevance, rigor, and design cycles. The relevance cycle connects the research to its application domain by bringing in real-world problems and requirements, while the rigor cycle draws from existing theories, methods, and empirical findings to ensure methodological soundness (Hevner, 2007). The central design cycle, in turn, involves the iterative building and evaluation of artifacts enabling continual refinement of both problem understanding and solution design (Hevner, 2007). Within this paradigm, knowledge creation occurs through the generation of prescriptive design knowledge, which is formalized as design entities or design principles (Gregor et al., 2020; vom Brocke & Maedche, 2019). DSR therefore contributes not only by producing practical solutions but also by creating theoretical insights into how and why these artifacts deliver value (Winter, 2008, pp. 470–472). In essence, DSR provides a structured, iterative, and theory-driven approach to developing innovative artifacts that address real organizational challenges while simultaneously enriching the scientific knowledge base.

Building on the conceptual foundations of DSR, Peffers et al. (2007) formulated a structured DSR methodology that outlines six interrelated steps guiding the research process from problem identification to communication of results. The process begins with problem identification and motivation, where the practical need for an artifact is established, followed by the definition of objectives for a solution, which specify what the designed artifact should achieve. The third step, design and development, focuses on constructing the artifact itself, while demonstration involves showing how the artifact can solve the identified problem in a relevant context. The fifth step, evaluation, assesses the artifact’s utility and performance, after which the final step, communication, disseminates the results both academic and practitioner audiences (Peffers et al., 2007). The DSR methodology thus provides a logical and iterative structure for producing and presenting design-oriented research outcomes that balance relevance and rigor. In this study, the methodological emphasis is on the early DSR stages given the pre-implementation nature of the study, while the detailed execution of the research flow will be further elaborated in Chapter 3.3.

The DSR approach was chosen for this study because it directly addresses a genuine organizational challenge faced by the case company. The SAP Material ID project is progressing toward technical implementation, yet stakeholders lack a shared understanding of the project's benefits, why it is being undertaken, what value it aims to deliver, and through which mechanisms. This uncertainty threatens both commitment and alignment across functions. DSR is particularly suited to this challenge because it enables the development of a benefit realization framework, a practically relevant artifact that systematically identifies and structures expected benefits. Unlike purely observational approaches, DSR produces prescriptive knowledge: the artifact not only describes the problem but provides a structured solution. The approach's iterative design-demonstration logic allows the framework to be refined through stakeholder input while remaining grounded in academic theory, particularly in the benefits realization and ERP value literature. This combination of rigor and relevance ensures that the resulting framework is both theoretically sound and organizationally acceptable, supporting a more confident transition toward post-implementation benefit realization.

3.2 Data Collection and Analysis

A qualitative research approach was applied to gain an in-depth understanding of expert perspectives and organizational experiences related to the expected benefits of the SAP Material ID project. In Design Science Research, qualitative methods can provide essential input to the relevance cycle by revealing the practical needs, perceptions, and contextual factors that shape artifact design (Gregor & Hevner, 2013, p. 338; Hevner, 2007, p. 88). The study employed semi-structured expert interviews, a flexible qualitative technique that enables the exploration of both common and role-specific viewpoints within a unified thematic structure (Kallio et al., 2016). Semi-structured interviews are particularly effective when investigating complex sociotechnical environments, as they allow participants from different functional areas to elaborate on issues most relevant to their expertise while maintaining comparability across cases (Skinner et al., 2022, p. 646). In this study, this adaptability was vital: Supply Chain Management experts and Digitalization experts were expected to view the Material ID project from distinct operational and architectural perspectives. The open yet guided format allowed questions to be tailored to each participant's role while ensuring methodological consistency and data adequacy—an essential criterion of qualitative rigor in information systems research (Abdalla Mikhaeil & Robey, 2024, pp. 3–4).

Participants were selected through purposive sampling, focusing on individuals with direct expertise or decision-making responsibilities related to Material ID project. A total of fourteen interviews were conducted: nine with experts and management representatives of SCM function and five representatives from digitalization. The SCM participants were chosen for their process-level and strategic understanding of how lack of material identification influences day-to-day operations, procurement, supply management, and other supply chain operations. They were expected to provide insights into both current practices and how these may be affected by standardized material identification. The Digitalization participants, in turn, contributed a system-level perspective, focusing on architectural design, data integration, and governance mechanisms. Their involvement was essential for validating and extending the identified process-related benefits to the broader digital and ERP landscape. This combination of SCM and Digitalization perspectives ensured comprehensive coverage of both the operational and technical dimensions of the Material ID project and provided a balanced foundation for the development of benefit-identification framework and design principles for benefits.

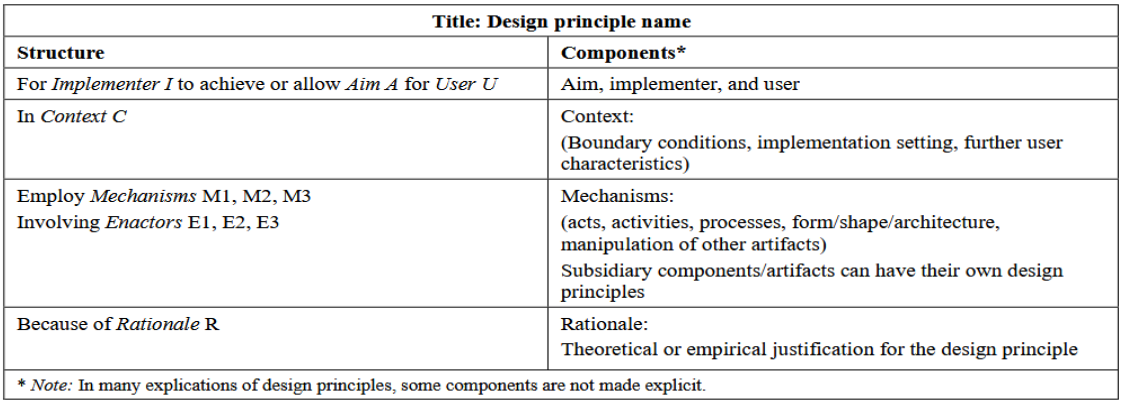
The interviews were conducted during weeks 47 and 48 of 2025 using Microsoft Teams as the communication platform. Each session lasted approximately 20 to 45 minutes and were held in English or Finnish. With participant consent, the discussions were transcribed and recorded to support systematic analysis. The interviews followed a semi-structured format, guided by five key discussion topics: (1) connection of Material ID to current processes and workflows, (2) expected benefits and improvements, (3) mechanisms through which these benefits may emerge, (4) challenges, risks, and process changes, and (5) digitalization, data governance, and end-to-end process integration. The sequence of interviews was intentional: experts from the SCM function were interviewed first to establish a grounded understanding of operational expectations, followed by Digitalization representatives to explore technical perspectives and validate process-level insights. This sequencing ensured methodical progression from practical process understanding to architectural and governance consideration, aligning with the iterative logic of Design Science Research. An overview of all conducted interviews, including the interview ID, role, date, and duration is presented in Table 2. To protect anonymity, official job titles have been generalized into functional descriptions. In total, the fourteen interviews amounted to approximately 7 hours of discussion.

Table 2. Summary of Conducted Interviews.

ID	Role	Date (2025)	Duration (min)
1	Supply Chain Management Representative	24.11	28
2	Supply Chain Management Representative	17.11	24
3	Supply Chain Management Representative	24.11	37
4	Supply Chain Management Representative	25.11	25
5	Supply Chain Management Representative	24.11	32
6	Supply Chain Management Representative	19.11	41
7	Supply Chain Management Representative	24.11	30
8	Supply Chain Management Representative	17.11	30
9	Supply Chain Management Representative	20.11	32
10	Digitalization Representative	27.11	31
11	Digitalization Representative	26.11	36

12	Digitalization Representative	26.11	30
13	Digitalization Representative	27.11	32
14	Digitalization Representative	27.11	22

The interview data were analyzed using thematic coding approach, which allowed the large volume of qualitative material to be systematically organized and interpreted. Following the principles of thematic coding outlined by Vaughn and Turner (2016), the analysis began by repeatedly reviewing the transcripts and interview notes to identify meaningful patterns across responses. To facilitate this, each excerpt was coded using four color-coded categories: identified benefits, perceived risks or challenges, design principles to the value mechanism, and other relevant observations. This approach aligns with the recommendation that qualitative analysis should highlight meaning through systematic categorization and the identification of themes that emerge across participants (Vaughn & Turner, 2016, p. 41). After initial coding, the categorized excerpts were compared and grouped to map relationships between benefits, risks, and underlying value creation mechanisms, reflecting the author’s suggestion to use coding to conceptualize relationships and structure findings (Vaughn & Turner, 2016, pp. 45–46). This process enabled both consolidation of recurring themes and the identification of distinct value mechanisms that informed the development of the benefit framework and the subsequent design principles that used the design principle schema (see Figure 5) from Gregor et al. (2020, p. 1633).



Title: Design principle name	
Structure	**Components***
For *Implementer I* to achieve or allow *Aim A* for *User U*	Aim, implementer, and user
In *Context C*	Context: (Boundary conditions, implementation setting, further user characteristics)
Employ *Mechanisms* M1, M2, M3 Involving *Enactors* E1, E2, E3	Mechanisms: (acts, activities, processes, form/shape/architecture, manipulation of other artifacts) Subsidiary components/artifacts can have their own design principles
Because of *Rationale* R	Rationale: Theoretical or empirical justification for the design principle
* *Note:* In many explications of design principles, some components are not made explicit.	

Figure 5. The Design Principle Schema (Gregor et al., 2020, p. 1633).

3.3 Research Process Flow

This section outlines the research process used in this study, demonstrating how Design Science Research Methodology (DSRM) guided the overall progression of the research. The DSRM framework by Peffers et al. (2007) structures the research into six sequential and iterative phases. This structured process ensures that the study proceeds systematically from the identification of a relevant business problem toward the creation and validation of a practically relevant artifact. The overall research process applied in this thesis is presented in Figure 6 below.

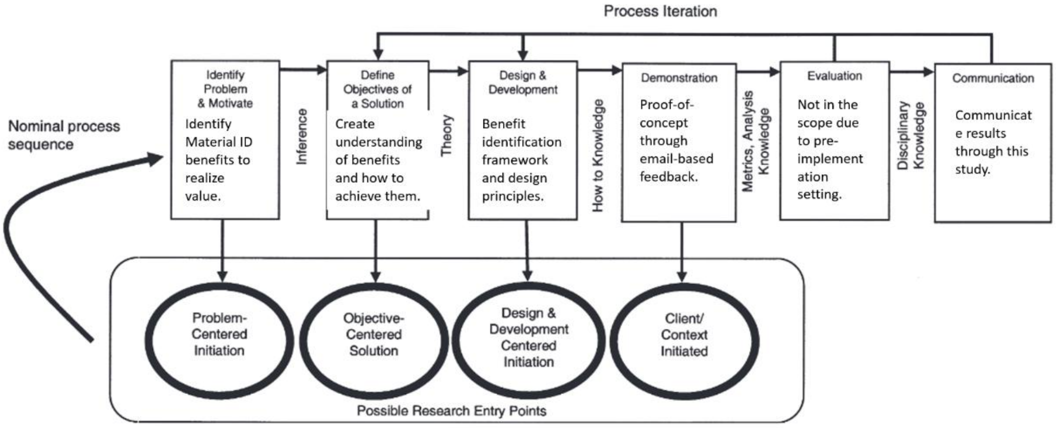


Figure 6. The DSRM and its application in this study (adapted from Peffers et al., 2007, p. 54).

The study follows the DSRM logic starting from the Problem identification phase, where a lack of structured understanding of Material ID benefits before implementation was recognized as a central challenge. The Definition of Objectives step aimed to define the need for a framework capable of identifying and structuring these expected benefits. In the Design and Development phase, the benefit identification framework and design principle were developed by combining insights from literature and empirical data from expert interviews. The Demonstration phase was conducted through email-based feedback, where selected experts review and comment on the proposed framework, ensuring its clarity, relevance, and practical alignment with organizational needs.

The fifth step Evaluation, which in DSR traditionally assess the effectiveness and efficiency of the artifact (Sonnenberg & vom Brocke, 2012, p. 384), is not included within the scope of this thesis. Due to time constraints and the ongoing pre-implementation status of the SAP Material ID project, the artifact cannot yet be tested in practice. However, the evaluation is suggested as future research once the material identification has been implemented and operational data becomes available. The final step, Communication, occurred through this master's thesis and through internal presentations within the case company. Together, these phases form a coherent and iterative research process that integrates theoretical rigor with practical relevance.

3.4 Research Quality and Ethics

Ensuring research quality and ethical integrity is essential in both qualitative and design-science-oriented studies. In this thesis, the credibility and trustworthiness of the findings were strengthened through systematic design, transparent data collection, and adherence to ethical standards throughout the process.

Research rigor in DSR stems from the careful alignment between the relevance of the business problem and the theoretical foundation of the artifact (Hevner et al., 2004, p. 83). The DSR approach inherently balances relevance and rigor by addressing a practical organizational challenge while maintaining scientific contribution (Gregor & Hevner, 2013, p. 345). In this study, rigor was achieved through the iterative and transparent design of the benefits framework and through triangulation between multiple expert perspectives from supply chain management and digitalization functions.

Within the qualitative component, the principles of credibility, confirmability, and dependability (Kallio et al., 2016, pp. 2962–2963) were followed. Credibility was promoted through purposeful expert selection and consistent semi-structured interview execution. Confirmability was enhanced by maintaining a clear audit trail, including systematic transcription and anonymized documentation of findings. Dependability was supported by a transparent presentation of the research process (see Figure 6), allowing replication of the methodological logic.

Ethically, all participants were informed about the study’s purpose and voluntary nature in the initial invitation email. Consent for participation and recording was requested prior to each interview. Transcripts were handled confidentially, and all names and specific job titles were replaced with generalized functional roles to ensure anonymity. Data were stored securely and used solely for academic purposes. Together, these practices ensured that the research process maintained methodological rigor, transparency, and ethical integrity, reinforcing the credibility and reliability of the findings.

4 Implementation and Research Results

This chapter presents the empirical results of the study and describes the development of the proposed benefit identification framework and the associated design principles for achieving value from SAP Material ID. In accordance with the Design Science Research Methodology (DSRM) outlined in Chapter 3, the chapter follows a structured progression from problem analysis to artifact design and demonstration.

First, the case company's supply chain context and current material management practices are revisited and described to establish the operational environment of the study. Second, key business problems and pain points identified through expert interviews are analyzed to motivate the research. Third, objectives for the solution are derived from these operational requirements. Finally, the chapter presents the primary research contributions: the Benefit Identification Framework and the five associated Design Principles for achieving value from SAP Material ID, followed by a conceptual demonstration of their applicability within the case context.

4.1 Case Description: Company, SCM, and Material ID

This study is conducted in a Finnish industrial company operating in a complex supply chain environment where reliable material master data is essential for efficient procurement execution, coordination across functions, and supplier collaboration. In the case company, supply chain management (SCM) includes activities such as sourcing, purchasing, supplier interface, and the management of material-related information that supports downstream logistics and lifecycle-related needs.

At the time of the study, third-party material management is characterized by inconsistent identification and varying data practices across stakeholders. Interview findings indicate that material information is often handled through descriptive texts, local workarounds, and person-dependent knowledge rather than standardized master data. This results in recurring challenges such as unclear purchase requisitions, time-consuming manual investigation to confirm what is being purchased, and limited ability to reuse historical information reliably. Additionally, the current state includes duplicate or fragmented material records, which reduces transparency into purchasing volumes, supplier history, and price comparability, and complicates data-driven monitoring.

To address these issues, the case company is progressing an SAP Material ID project focused on establishing consistent identification for third-party materials. The project aims to shift material handling from document and text driven practices toward a standardized and governed approach where materials have unique identifiers and more reliable master data. In the context of SCM, this is expected to improve process clarity and efficiency, strengthen traceability and material-level metadata availability, enable automation and analytics through consistent data structures, and reduce dependence on individual experience by clarifying ownership and governance of material creation and maintenance.

This case context provides practical foundation for the following sections, where identified pain points and objectives are translated into the Benefit Identification Framework and the associated Design Principles developed in this study.

4.2 Problem Identification and Motivation

This section presents the central problems identified in the case company's current material management practices and explains why the Material ID project is considered necessary from a SCM perspective. The problems were synthesized from expert interview findings and reflect to recurring operational challenges related to material master data, end-to-end process execution, and the organization's ability to leverage ERP-enabled digitalization.

A core issue is the lack of consistent and unambiguous identification for third-party materials, which limits the reliability of material master data across functions. Interviewees described that when a single physical material may exist under multiple entries, or when materials are created with inconsistent naming and incomplete attributes, it becomes difficult for different stakeholders to interpret whether they are working with the same item or not. The ambiguity creates a structural data problem: information that should accumulate over time, like pricing history, supplier performance, compliance information, cannot be reliably linked to a single material record. As a result, the organization needs to make an estimate or manually interpret what data belongs to what material, which reduces trust in reporting and complicates decision-making.

A second challenge relates to traceability and lifecycle transparency. Several interview observations emphasized that a standardized identifier functions as a “primary key” that enables the linkage of materials to broader datasets, such as country-of-origin information, classification data, and other lifecycle-relevant attributes. Without this linkage, the organization’s ability to provide transparent and consistent material-level visibility is constrained, particularly when materials change supplier or move across internal processes. From a supply chain perspective, the inability to preserve historical data behind a stable identifier weakens continuity: even when the physical material remains the same, the data trail may fragment. In practice, this limits end-to-end traceability and reduces the organization’s ability to build reliable reporting and governance routines around material-level information.

Third, inconsistencies in the material identification create process inefficiencies and manual work, particularly in procurement-related workflows. When material records are unclear or duplicated, operational steps such as request-for-quotation preparation, supplier communication, and internal alignment require additional clarification. Instead of executing standard processes based on shared master data, employees spend time validating what the material actually is, reconciling different entries, and ensuring that the correct information is communicated externally. These issues do not only slow down work; they also introduce variation in process execution, as different individuals may apply different interpretations or workarounds. Over time, this increases the likelihood of recurring errors and reinforces reliance on informal knowledge rather than standardized data structures.

Fourth, the problem extends beyond human effort to the organization’s ability to use the ERP system effectively. Interviewees explicitly framed the situation as a value realization issue: the organization has invested heavily in ERP capabilities, yet the benefit cannot be fully captured without disciplined master data foundations. The interviews suggested that “all roads lead” to financial and controlling processes, meaning that unreliable material identification does not remain an isolated master data problem but propagates into downstream areas that depend on consistent transactional logic. Where deliveries, transportation-related processes, and financial postings depend on correct material references, the existence of multiple inconsistent identifiers increases complexity and reduces automation potential. In this sense, the lack of standardized identification is not only a data quality issue but also a barrier to process integration across the end-to-end chain.

Fifth, the interviews raised concerns about organizational discipline and change management as a central motivation for the project. While technical implementation was viewed as feasible, several interviewees highlighted that the more difficult challenge is behavioral and organizational: adopting standardized identification requires a shift toward more disciplined process adherence, a data-driven mindset, and consistent governance routines. This shift was expected to take time, including multi-year transition period, and it was described as requiring visible sponsorship and direction from top management. Interviewees also noted that resistance toward ERP-related changes exists and that successful adoption depends on internal people, such as key users, who communicate positively and support the mindset shift. Therefore, the motivation for the Material ID project is not only to “fix data”, but to establish a foundation for sustained standardization where material creation and maintenance follow shared rules rather than localized workarounds.

Finally, the case context includes a broader question about the role of non-standard and locally developed systems in supply chain execution. Interviews referenced the existence of a tailored site management system and specialized logistics solutions and questioned whether these systems remain strategically justified when standard market solutions exist and technological development, including artificial intelligence capabilities, advances rapidly. This observation links the material identification problem to a larger architectural motivation: if the organization aims to progress toward a more standardized and scalable digital supply chain, the ERP environment and its master data become increasingly central. In this framing, Material ID is positioned as a prerequisite for moving away from fragmented system landscapes and toward integrated, data-driven operations.

In summary, the motivation for the Material ID project arises from a combination of interrelated challenges: inconsistent material identification undermines data continuity, limits traceability, increases manual work, reduces the ability to leverage ERP-enabled automation, and reinforces fragmented ways of working. Addressing these issues requires not only technical changes but also governance and change management mechanisms to sustain a standardized approach to material data over time. These empirically identified problems provide the basis for defining the objectives of the solution in the next section.

4.3 Definition of the Objectives for a Solution

Building on the empirically identified problems in Section 4.2, the objectives for the solution are defined with the DSR methodology. In DSRM, objectives should be inferred rationally from the problem definition and from knowledge of what is feasible in the organizational and technical context (Peffers et al., 2007, p. 55). Accordingly, the objectives below translate the key material identification challenges into clear requirements that guide the design of the study’s artifacts.

Objective O1: Establish standardized material identification and data consistency. The solution should support a harmonized approach to identifying and describing third-party materials so that material master data is consistent across functions and systems. This objective reflects the need for unified definitions and formats, which are commonly emphasized as prerequisites for “one master data” and reducing semantic inconsistencies across organizational silos (Silvola et al., 2011, pp. 150–151).

Objective O2: Strengthen traceability and lifecycle-relevant material metadata. The solution should enable clearer traceability of third-party materials across lifecycle stages and across organizational interfaces, supporting end-to-end visibility from engineering needs to sourcing and downstream lifecycle requirements. This objective responds to the observed limitations in current traceability and the reliance on person-dependent knowledge rather than structured, reusable data.

Objective O3: Reduce duplicate records and ambiguity in material understanding. The solution should contribute to minimizing duplicate or approximately duplicate material records and improving material clarity for operational decision-making. Prior research shows that a lack of unique identifiers and inconsistent naming practices can create approximately duplicate records in ERP databases, which may lead to confusion and errors across processes (Zong et al., 2017, pp. 434–435). In the case context, this objective directly supports more reliable purchasing and improved consistency in material-related decisions.

Objective O4: Enable automation and scalable digitalization through reliable master data. The solution should support the prerequisites for automation and digital enablement by improving the reliability and usability of material master data for integrations, workflows, and digital tools. This objective is consistent with the broader MDM literature emphasizing that sustainable improvements require not only technical solutions, but also defined processes and practices that support data usage across systems (Silvola et al., 2011, pp. 158–160).

Objective O5: Clarify governance, ownership, and control mechanisms for material data. The solution should define and reinforce governance requirements—specifically who is responsible for creating, approving, maintaining, and monitoring third-party material master data. Master data quality research highlights that unclear delegation of responsibilities is among the most significant barriers to achieving high-quality master data (Haug & Arlbjørn, 2011, pp. 297–300). Therefore, this objective emphasizes role clarity, decision rights, and control routines as necessary conditions for sustaining standardization and avoiding a return to local workarounds over time.

Together, these objectives provide the requirements baseline for the subsequent design and development of the artifacts in the next sections.

4.4 Design and Development

This section presents the two design science artifacts developed in this study as part of the DSRM "design and development" phase. In DSRM, the purpose of this phase is to create artifacts that address the identified problem and constitute the study's research contribution (Peffers et al., 2007, p. 55).

The artifacts were constructed by synthesizing the theoretical foundation presented in Chapter 2—particularly the ERP benefit dimensions proposed by Shang and Seddon (2002) and the KPI linkage logic developed in Section 2.4.2—and the empirical findings and solution objectives derived from the expert interviews.

The first artifact, the Benefit Identification Framework, structures the expected benefits of SAP Material ID project into a coherent benefit logic that supports communication and measurement readiness. The second artifact, Design Principles, provides prescriptive guidance on how the expected benefits can be achieved through standardization, traceability, process design, automation enablement, and governance. The framework is presented first because it defines what benefits are expected and how they relate to measurable outcomes, while Design Principles specify how the organization should implement and govern Material ID to realize those benefits.

4.4.1 Benefit Identification Framework

The framework consolidates (1) the theoretical benefit dimensions of ERP value outcomes (operational, managerial, strategic, IT infrastructure, and organizational) proposed by Shang and Seddon (2002) and discussed in Chapter 2, and (2) the empirical benefit expectations identified in the expert interviews. The interviews followed a systematic structure outlined in Appendix 1, guiding experts through current workflow pain points, specific benefit expectations, and the mechanisms required to achieve them.

To keep the artifact practically usable, the framework also links each benefit to representative KPIs, enabling the case organization to translate “expected value” into measurable targets during and after rollout.

Table 3. Benefit Identification Framework.

(Benefit number) Expected benefit identified from interviews	**Representative KPI(s) to operationalize the benefit**	**Shang and Seddon’s (2002) value dimension**	**Theoretical anchoring used in this thesis (benefit–KPI linkage)**
(B1) Faster and clearer purchasing execution (PR contains the right material and price → purchaser validates and buys; less “manual hunting”)	Procurement cycle time; order processing time; error rates	Operational	Operational efficiency → cycle time & error reduction

(B2) Reduced manual rework and exceptions (fewer invoice blocks caused by incorrect documentation requirements and mismatches)	Error rates; rework/exception handling volumes; order processing time	Operational / Managerial	Operational efficiency KPIs; measurement logic for making value visible
(B3) Improved master data quality and data consistency (single source of truth; fewer fragmented IDs/duplicates; consistent definitions)	Master data accuracy rate; duplicate elimination rate; data completeness	IT infrastructure / Organizational	Data governance → accuracy, duplicates, completeness
(B4) Reliable reporting and transparency (ability to filter by material and supplier; less spreadsheet/email-based analysis; better spend/price visibility)	Reporting efficiency; transparency scores; performance monitoring indicators	Managerial	KPIs as bridge from abstract benefits to measurable outcomes
(B5) Improved price analysis and negotiation leverage (historical prices and purchase volumes become trustworthy at material level)	Working capital days; inventory turnover (as downstream	Managerial / Strategic	Financial optimization metrics linked to SCM value outcomes

	financial effects)		
(B6) Compliance and sustainability readiness (HS code, weight, certificates, country of origin, CBAM-related requirements become maintainable and retrievable)	Material traceability rate; regulatory reporting efficiency; transparency scores	Strategic / Managerial	Compliance & sustainability → traceability and reporting KPIs
(B7) End-to-end traceability across lifecycle (auditable "path of a material"; ability to attach and retrieve certificates and quality-related evidence at material level)	Material traceability rate; reporting efficiency	Strategic	ERP benefits include strategic and organizational impacts through visibility and coordination
(B8) Quality and failure analytics enablement (quality notifications/failure history by material; earlier detection; potential forecasting)	Transparency scores; reporting efficiency (as early measurable proxies)	Managerial / IT infrastructure	IT infrastructure benefits include consistency + integration that enable analytics capabilities
(B9) Automation of transactional flows (automatic PR/PO creation, order confirmation, goods receipt—where master data is complete)	Automation readiness score; system integration	IT infrastructure / Operational	Digital enablement KPIs (integration completeness; automation readiness)

	completeness		
(B10) Reduced reliance on "shadow processes" and custom tools (less dependence on spreadsheets/emails; stronger use of ERP standard capabilities)	System integration completeness; data completeness	IT infrastructure	IT infrastructure benefits emphasize integration and data consistency
(B11) Improved cross-functional collaboration and a shared "material language" (less person-dependent knowledge; clearer coordination across functions)	Transparency scores; reporting efficiency (as early proxies)	Organizational	Organizational benefits include collaboration, knowledge sharing, unified vision
(B12) Lifecycle and services value potential (installed base visibility; proactive spare part opportunities once history accumulates)	Inventory turnover; working capital days (as later-stage financial effects)	Strategic	Strategic benefits include competitiveness and capability to support growth over time

The framework is intended to function as a bridge between early value expectations and measurable benefit realization. First, it consolidates "what value is expected" from SAP Material ID project as articulated by interviewees.

Second, each expected benefit is classified using Shang and Seddon (2002) five ERP benefit categories to ensure the artifact remains theoretically grounded and comparable to prior ERP value research. In this study's context, many of the early expectations naturally cluster around operational (cycle time, reduced manual work), managerial (reporting and spend/price/transparency), and IT infrastructure (integration, data consistency, automation readiness) dimension while strongest strategic outcomes (lifecycle and service value) are expected to accumulate as material history grows.

Third, KPI column operationalizes the framework by reusing the KPI logic already established in the thesis: KPIs act as the measurement layer that makes benefit realization observable. This is particularly important in a foundational initiative such as Material ID, because the project's value proposition is strongly dependent on whether consistent identifiers and metadata allow reliable aggregation and automation across processes and systems.

4.4.2 Design Principles

While the framework summarizes what value is expected from the SAP Material ID project, the interviews repeatedly emphasized that the identifier itself does not automatically resolve underlying issues. Instead, Material ID should be understood as an enabling capability: it creates the conditions for standardization, traceability, automation, and governance, but benefit realization depends on how the organization implements and uses the capability in daily processes.

To make this "how" explicit, this study proposes five design principles. In DSR, design principles function as prescriptive rules that translate objectives into actionable guidance for implementers in a specific context. In this thesis, each design principle is formulated using the design principle schema (see Figure 5) (Gregor et al., 2020, p. 1633) and linked back to the expected benefits and KPIs in the Benefit Identification Framework. The design principles therefore complement the framework by clarifying the mechanisms through which SAP Material ID can enable the identified operational, managerial, strategic, and IT infrastructure benefits (Shang & Seddon, 2002). Design principal sections marked with an asterisk (*) indicate those that were refined based on feedback from the expert review.

Table 4. Design Principle 1: Standardization & Data Consistency.

Design Principle 1: Standardization & Data Consistency	
Structure	**Components**
For Implementer I to achieve or allow Aim A for User U	**Implementer (I):** Material master data owners and process owners responsible for material creation and maintenance. **Aim (A):** Establish a single, governed source of truth for third-party material identification and associated metadata across the ERP and interfacing systems, thereby reducing duplicate and fragmented records and improving data consistency and usability. **User (U):** Procurement, engineering, project teams, logistics/site operations, and other SCM stakeholders who create, search, purchase, report, and collaborate based on material records.
In Context C	The case company's material-related workflows currently include reliance on free-text purchasing descriptions, dispersed documentation requirements, and "shadow processes" (emails, personal workbooks, and spreadsheets) to compensate for fragmented identifiers and inconsistent material information. Interviewees described both error risk (different functions "talking about different material") and substantial manual effort to retrieve or consolidate historical information, especially when material identification is not standardized across the end-to-end lifecycle.
Employ Mechanisms M1, M2, M3 Involving Enactors E1, E2, E3	**Mechanisms (M):** **M1:** Enforce unique identification and one-to-one mapping. Ensure each physical third-party material corresponds to one governed Material ID and one consistent material record; apply duplicate checks and standardized naming rules at creation.

	M2: Standardize minimum required attributes and documentation linkage. Define mandatory material attributes and structurally link documentation requirements to the material record to avoid copy-paste requirements across unrelated items. * **M3:** Reduce free-text dependency in procurement execution. Shift purchasing from long-text driven requests toward coded material selection and standardized record usage, so that searching, reporting, and collaboration occur primarily through the governed identifier rather than person-dependent descriptions. **Enactors:** **E1:** Master data owners and process owners (definition of standards, approvals, data model). **E2:** Operational users (procurement, engineering, project teams) who adopt the standardized identifier in everyday work. **E3:** Digitalization/IT stakeholders who implement validations, integrations, and usability support.
Because of Rationale R	**Rationale (theoretical and empirical justification):** Theoretical work on material master data highlights that inconsistent master data undermines decision-making and process performance; for example, Silvola et al. (2011, p. 147) emphasize that organizational decisions are constrained by the quality of the data used. Similarly, ERP-focused research shows that missing unique or global identifiers encourages multiple names and records for the same item, which creates process confusion and undermines procurement and inventory decisions (Zong et al., 2017, pp. 434–435)

Design Principle 1 operationalizes the idea of Material ID as a “single source of truth” by defining what must be standardized and how this standardization is embedded into everyday work. In the case context, the principle directly targets the interview identified mechanism behind fragmentation multiple identifiers, ad-hoc descriptions, and scattered knowledge and frames them as implementation requirements. Consistent with the framework, the expected early measurable outcomes primarily relate to master data quality and reporting, while longer term value depends on sustained adoption across functions.

Table 5. Design Principle 2: Process Efficiency & Duplicate Reduction.

Design Principle 2: Process Efficiency & Duplicate Reduction	
Structure	**Components**
For Implementer I to achieve or allow Aim A for User U	**Implementer (I):** Procurement and SCM process owners, master data governance roles, and Digitalization/IT responsible for ERP process controls and supporting data structures. **Aim (A):** Improve purchasing throughput and reduce avoidable manual work by shifting from free-text requisitions and ad-hoc ordering to codified purchasing based on governed Material IDs, while preventing duplicate creation and enabling reuse of historical purchasing information. **User (U):** Purchasers and strategic purchasing, project and engineering stakeholders, and suppliers benefiting from clearer, more consistent ordering requirements.
In Context C	Purchasing work in the case context is slowed by requisitions with insufficient structured material references and reliance on free-text descriptions, which requires manual searching, clarification, and price checking. Interview findings also indicate repeated duplicate or

	fragmented material representations (including cases where the same item appears under multiple identifiers), which drives additional effort and reduces confidence in historical price and purchasing visibility.
Employ Mechanisms M1, M2, M3 Involving Enactors E1, E2, E3	**Mechanisms (M):** **M1:** Codify requisitions and purchasing with Material IDs. Require that purchasing requests reference governed Material IDs (instead of free text), so procurement execution becomes validation and exception handling rather than investigative work. **M2:** Reuse governed purchasing information. Where applicable, link Material IDs to reusable purchasing knowledge to reduce repeated clarification and enable faster RFQ/PO creation. **M3:** Prevent and resolve duplicates systematically. Implement duplicate prevention checks at creation and define consolidation routines (including ownership and decision rules *) to maintain one consistent representation per material over time. **Enactors:** **E1:** Procurement and process owners (define how PR→RFQ→PO should use Material IDs). **E2:** Master data / governance roles (duplicate prevention rules, consolidation decisions). **E3:** Digitalization/IT (technical validations, usability support, integration logic).
Because of Rationale R	**Rationale (theoretical and empirical justification):**

	Duplicate and inconsistently described material records are a known ERP master data issue: without unique identifiers, the same material may exist under multiple names and records, increasing ambiguity and inefficiency in downstream processes (Zong et al., 2017, pp. 434–435). Also, Silvola et al. (2011, pp. 146–147) note that process performance is constrained by the quality and consistency of the underlying data. Empirically, the interviews align with this logic by highlighting that codified purchasing reduces manual work and cycle time, while systematic duplicate prevention is required to sustain these efficiency gains over time.

Design Principle 2 specifies how SAP Material ID enables operational and managerial benefits by shifting purchasing from free-text interpretation to codified execution: requisitions should reference governed Material IDs and reuse structured purchasing knowledge to reduce manual searching, clarification, and repeated work. At the same time, efficiency improvements will not sustain unless duplicate prevention and consolidation routines are embedded into the creation and maintenance process. Consistent with the framework, the most immediate measurable outcomes relate to reduced procurement processing time and fewer exceptions, while improved price visibility and negotiation leverage accumulate as governed historical purchasing data becomes reusable at the same material level.

Table 6. Design Principle 3: Governance & Ownership.

Design Principle 3: Governance & Ownership	
Structure	**Components**
For Implementer I to achieve or allow Aim A for User U	**Implementer (I):** Cross-functional process owners and master data governance roles (Product Management, SCM, and Digitalization/IT), supported by business leadership (sponsors) and key user network.

	Aim (A): Ensure sustained, enterprise-wide adoption of Material ID by defining clear ownership, disciplined ways of working, and a pragmatic rollout approach, so that Material ID becomes a compounding capability rather than “extra admin.” **User (U):** All functions that create, enrich, consume, and rely on material data, as well as suppliers interacting with purchasing and documentation requirements.
In Context C	The case context requires cross-functional adoption, but interviewees repeatedly highlighted risks related to unclear responsibility models, resource load in creation, maintenance, and change resistance, especially if adoption remains partial across functions. Interview evidence also suggests the need to balance standardization with flexibility through phased rollout, while recognizing that benefits compound only after sustained usage.
Employ Mechanisms M1, M2, M3 Involving Enactors E1, E2, E3	**Mechanisms (M):** **M1:** Establish explicit ownership and decision rights (governance model). Define who creates, approves, and maintains Material IDs and metadata and implement a consistent decision process for exceptions and prioritization. * **M2:** Run disciplined change management and capability building. Ensure leadership sponsorship, structured communication, key-user enablement, training cadence, and reinforcement practices to avoid “partial adoption” and person-dependent working methods. This includes continuous evaluation/feedback loops to refine practices during implementation and consolidation. **M3:** Execute a phased, pragmatic rollout with compliance controls. Start with standard materials and new projects to control workload

	and learning curve, expand coverage iteratively, and define process controls that require Material ID usage in day-to-day execution (to prevent falling back to old ways of working). **Enactors:** **E1:** Business leadership and process owners (sponsorship, prioritization, enforcement of ways of working). **E2:** Operational users and key users across functions (adoption, feedback, local support). **E3:** Digitalization/IT and master data governance stakeholders (workflow or system enforcement, integration enablement, monitoring).
Because of Rationale R	**Rationale (theoretical and empirical justification):** Empirically, interviewees emphasized that benefits depend on disciplined rollout, management involvement, and clear responsibility models; otherwise, Material ID risks becoming fragmented or underused, and the expected benefits do not compound over time. Theoretically, digital change requires focused attention not only on vision or strategy but also on implementation and consolidation; comprehensive change management practices (top management commitment, communication, training, employee engagement, and continuous evaluation) are highlighted as critical to successful execution and sustained adoption (Picado Argüello & González-Prida, 2024, p. 6).

Design Principle 3 clarifies that Material ID value realization is primarily a governance and adaptation challenge: the identifier enables standardization, traceability, and automation, but outcomes depend on whether organization establishes clear ownership, invest in continuous capability building, and avoids partial adoption across functions. In the case context, interviews suggest that phased rollout is a practical way to balance workload and flexibility while allowing benefits to compound as coverage and usage increase over time.

Table 7. Design Principle 4: Traceability & Lifecycle.

Design Principle 4: Traceability & Lifecycle	
Structure	**Components**
For Implementer I to achieve or allow Aim A for User U	**Implementer (I):** Master data governance roles, SCM process owners (procurement, logistics), quality compliance stakeholders, and Digitalization/IT responsible for data structures and integrations. **Aim (A):** Create a material-level auditable digital footprint by using Material ID as the stable primary key for compliance-relevant attributes, traceability evidence, and quality history, enabling practical regulatory reporting, faster root-cause analysis, and service/installed-base visibility over time. **User (U):** Procurement and supply management, logistics and site operations, project teams, and service-related stakeholders who need reliable material-level evidence and history across suppliers and projects.
In Context C	In the case context, material-related compliance evidence and history are difficult to maintain and retrieve consistently when identifiers are fragmented or documentation is handled through local workarounds. This weakens end-to-end traceability across suppliers and projects, slows quality investigations, and limits the ability to build reliable reporting routines around attributes such as country of origin, classification codes, weights, and certificate status.

Employ Mechanisms M1, M2, M3 Involving Enactors E1, E2, E3	**Mechanisms (M):** **M1:** Make compliance and traceability attributes auditable at Material ID level. Define and enforce a minimum set of material-level attributes (such as HS code or classification, country of origin, weight, and certificate status) and link relevant evidence to the Material ID record so reporting is based on governed, retrievable data rather than person-dependent interpretation. * **M2:** Link quality events and corrective actions to Material IDs. Ensure that quality notifications, test results, deviations, and failure history are recorded and retrievable through the Material ID, enabling faster root-cause analysis and reduced cost of poor quality through repeatability and pattern detection across suppliers and projects. **M3:** Preserve material continuity to enable services and installed-base visibility. Maintain lineage and change history through the Material ID so that material-related evidence and performance data accumulates over time even when suppliers, projects, or documentation flows change, supporting proactive service planning and spare-part opportunity identification as the data trail grows. **Enactors:** **E1:** SCM process owners and compliance stakeholders (define required attributes, evidence rules, reporting responsibilities). **E2:** Operational users in procurement, logistics, projects, and quality (capture evidence consistently and use the data in daily work and issue resolution).

	E3: Digitalization/IT and master data governance (implement validations, integrations to relevant systems).
Because of Rationale R	**Rationale (theoretical and empirical justification):** Traceability requires the ability to trace the history and origin of materials through processes and distribution, a capability that relies on creating identifiers for outputs and sharing reliable data (Germani et al., 2015, pp. 228–230). Compliance in master data management further depends on adherence to standards and regulations, requiring unified, retrievable repositories rather than disparate data sources (Gualo et al., 2023, pp. 796, 800). Empirically, the interviews emphasized that the expected value comes from making material attributes and evidence auditable and reusable at the material level, and from linking quality notifications and failure history to a consistent identifier to speed up investigations and reduce repeated issues across projects and suppliers.

Design Principle 4 clarifies how Material ID enables traceability and compliance in SCM by making material attributes and supporting evidence auditable at the material level rather than dispersed across documents and local parties. By linking quality events and material history to the same identifier, the organization can reduce manual investigation work, accelerate root-cause analysis, and allow material-level history to accumulate across suppliers and projects, which also strengthens service visibility as adaptation expands over time.

Table 8. Design Principle 5: Automation & Digital Enablement.

Design Principle 5: Automation & Digital Enablement	
Structure	**Components**
For Implementer I to achieve or	**Implementer (I):** ERP or process owners, enterprise architecture and integration teams, and master data governance roles responsible for rollout and adoption.

allow Aim A for User U	**Aim (A):** Enable scalable process automation, integration, and analytics by making Material ID the shared primary key across ERP and interfacing systems. **User (U):** Procurement, logistics, supply chain planning, quality, and supplier-facing roles that execute and monitor end-to-end transactional flows.
In Context C	The case company operates with several interfacing and locally optimized tools, and interviewees highlighted that end-to-end automation is difficult without a unified Material ID acting as the primary key across systems. In practice, benefits depend on high coverage of Material ID usage and sufficiently complete master data to support standard ERP process execution.
Employ Mechanisms M1, M2, M3 Involving Enactors E1, E2, E3	**Mechanisms (M):** **M1:** Establish Material ID as the non-negotiable primary key across ERP and partner systems by implementing consistent integration mappings, interface rules, and duplicate prevention controls, ensuring "one material, one identifier" across the landscape. **M2:** Configure master data gated process automation in procurement and logistics so that transactional steps can be automated only when required attributes are complete and validated (for example, PR/PO creation, order confirmation, and goods receipt), supported by standardized workflows and exception handling. **M3:** Reduce shadow processes by shifting reporting and operational follow-up into ERP-standard or governed analytics layers and enable advanced analytics and AI use cases (such as anomaly detection and

	failure analytics by material) once consistent data structures and identifiers are in place. **Enactors:** **E1:** Enterprise architects and integration developers responsible for interfaces, APIs, and data flows. **E2:** Process owners, key users, and master data governance roles responsible for process rules, data completeness requirements, and adoption support. **E3:** Suppliers and external partners (data provision and maintenance), and analytics stakeholders using governed data for reporting and decision-making.
Because of Rationale R	**Rationale (theoretical and empirical justification):** ERP benefit realization is contingent on consistent use and high-quality information (DeLone & McLean, 2003); therefore, automation and analytics cannot scale without governed master data and shared identifiers (Silvola et al., 2011). In Shang and Seddon's (2002) terms, this principle primarily targets IT infrastructure benefits, which provide the foundation that enables downstream operational and managerial benefits. Empirically, interviewees emphasized that a unified Material ID is a prerequisite for end-to-end automation and for reducing reliance on external tools built to compensate for missing identifiers and fragmented data.

Design Principle 5 positions Material ID as the “digital backbone” that allows ERP and interfacing systems to reference the same material consistently, which is a precondition for automation, integration, and analytics at scale. It operationalizes the expected automation-related benefits in the framework by translating them into implementation requirements: enforce Material ID as the shared primary key (M1), automate only when master data is complete and validated (M2), and shifts work from spreadsheets and local tools into governed ERP-standard processes and analytics capabilities (M3). This emphasis reflects the interview finding that Material ID enables automation but does not create value unless adopted across processes and supported by disciplined data completeness and integration practices.

4.5 Demonstration

In line with the DSR methodology, the demonstration phase aims to prove the artifact can solve specific instances of the problem, such as within a case study (Peffers et al., 2007, p. 56). This supports the methodology's broader goal of moving beyond purely explanatory research to create explicitly applicable solutions (Peffers et al., 2007, p. 47). In this study, the demonstration was conducted through email-based feedback from two digitalization experts: one with prior experience from a Material ID implementation in another company, and one familiar with the case company's ERP environment and end-to-end process development. The experts were asked to review the artifacts, with emphasis on clarity, completeness, and whether the artifacts credibly describe how benefits can be enabled and realized in practice.

Overall, the feedback supported the direction of the artifacts but highlighted that several formulations should more explicitly reflect the enabling nature of Material ID. First, the experts recommended broadening the "expected value" descriptions to better reflect that material master data is foundational for ERP to execute core processes such as planning and procurement, and that value therefore extends beyond individual local pain points into system-level process performance. Second, they noted that questions and wording that imply "Material ID solves" data quality issues should be replaced with language that clarifies the dependency on governance, compliant ways of working, and consistent execution. Without robust processes and ownership, the same problems can persist after implementation, for example through the creation of new parallel materials for similar items, unclear update rules, and inconsistent approval practices. This emphasis is consistent with the interview evidence that Material ID creates the conditions for improvement, while the realization of benefits depends on how organization operationalizes the capability through disciplined adoption across functions.

Based on the demonstration feedback, the artifacts were refined to improve accuracy and usability. The value statements were adjusted to capture both operational and system-level enablement, and the design principles were clarified to consistently frame Material ID as a technical enabler rather than an automatic solution. In addition, the experts' comments reinforced the importance of positioning governance and ownership as a foundational design principle that conditions the feasibility of standardization, process efficiency, traceability, and automation outcomes. The automation-related principle was also sharpened to emphasize that Material ID primarily enables the use of standard ERP capabilities and reliable integrations at scale, which may reduce the need for workaround automation rather than simply adding RPA on top. This demonstration therefore strengthens the plausibility and relevance of proposed artifacts in the case setting, while full evaluation of realized outcomes is left for post-implementation study in future research, consistent with the separation between demonstration and longer-term evaluation in DSRM (Peffers et al., 2007, p. 56).

To make the impact of the demonstration phase fully traceable, the specific refinements triggered by the expert review are explicitly marked with an asterisk (*) in the Design Principle tables, as introduced in Section 4.4.2. Concretely, the asterisk highlights the updated sections in DP1 Standardization & Data Consistency (Table 4, M2), DP2 Process Efficiency & Duplicate Reduction (Table 5, M3), DP3 Governance & Ownership (Table 6, M1), and DP4 Traceability & Lifecycle (Table 7, M1). These markings show exactly where the demonstration feedback led to clarified formulations—especially to emphasize Material ID as an enabling capability and to make the role of governance, disciplined ways of working, and process design explicit in achieving the expected benefits.

4.6 Communication

The results of this study are communicated through this thesis, which documents the supply chain problem context, its importance, and the expected value potential of SAP Material ID. This thesis presents two artifacts and explains their theoretical grounding and empirical basis to ensure transparency and rigor.

In addition to academic communication, the artifacts are intended for practical use in the case company. They provide a structured way to align stakeholders on expected benefits, clarify how benefits can be achieved, and support benefit planning and measurement readiness during the Material ID project rollout.

5 Concluding Remarks and Discussion

This thesis investigated early value expectations related to the implementation of SAP Material ID for third-party materials in the supply chain management context of the case company. The study was motivated by the observation that inconsistent identifiers constrain efficient material management, limit traceability, and hinder the utilization of advanced digital tools. To address this, the study applied Design Science Research (DSR) to produce two artifacts: a Benefit Identification Framework and a set of Design Principles.

A central finding is that Material ID should not be viewed as a standalone solution that automatically resolves process issues. Instead, it functions as an enabling capability that creates the necessary conditions for standardization, traceability, and automation. This aligns with recent findings by Merwe et al. (2024, pp. 573, 575) who argue that while material master data is critical for supply chain performance, its value is only realized when actively managed. The results further demonstrate that benefit realization depends heavily on governance, ownership, and consistent adoption—supporting the view of Silvola et al. (2011, p. 160) that technology alone does not create "one master data" without defined processes and organizational discipline.

5.1 Theoretical Contributions and Addressing Research Gaps

This thesis makes three specific theoretical contributions that directly address the research gaps identified in Section 2.5.

First, the study addresses the lack of pre-implementation benefit identification guidance. Prior ERP research has predominantly focused on post-implementation assessments, classifying benefits that have already occurred. This study fills the identified gap by adapting Shang and Seddon’s (2002) taxonomy into a prospective Benefit Identification Framework. This contribution demonstrates that ERP value dimensions can be used ex-ante to align stakeholder expectations, offering a structured approach for organizations struggling to justify master data investments, a challenge noted by Nour (2023, p. 2).

Second, the thesis clarifies the mechanisms of value creation in material data initiatives. While existing literature acknowledges that poor data quality leads to operational failure, there has been limited research on how standardized identification specifically enables value. The Design Principles developed in this study address this gap by specifying the mechanisms—such as one-to-one mapping and auditable attributes—required to translate data quality into business value. This extends the work of Haug and Arlbjørn (2011) by moving beyond barrier analysis to prescriptive design guidance.

Third, the study bridges the gap between ERP benefits and SCM performance measurement. Previous research has often treated ERP success models and supply chain KPIs as separate domains. By explicitly mapping expected benefits to specific KPIs (e.g., linking Operational Efficiency to Procurement Cycle Time), this thesis responds to the call by Gunasekaran et al. (2004, p. 335) for metrics that capture the essence of organizational performance. It demonstrates that in data-centric projects, KPIs must measure not only process speed but also the governance readiness (e.g., duplicate rates) that Gualo et al. (2023) identify as a prerequisite for performance.

5.2 Practical Implications and Answers to Research Questions

The artifacts developed in this study provide direct answers to the research questions set out in Chapter 1.

Addressing RQ1: What benefits are expected from the implementation of SAP Material ID? The Benefit Identification Framework (Table 3) answers this question by consolidating twelve specific benefits. It identifies that while immediate expectations focus on Operational Efficiency (faster purchasing, reduced manual rework), the long-term value lies in Strategic and IT Infrastructure dimensions (lifecycle traceability, automation readiness). This distinction allows the case company to manage expectations realistically: operational gains may appear quickly, but strategic value, such as installed-base visibility, requires the accumulation of governed history over time.

Addressing RQ2: How can expected benefits be linked to KPIs to support value realization? The study answers this by integrating a measurement layer into the framework. By linking abstract benefits (e.g., "Compliance Readiness") to concrete indicators (e.g., "Traceability Rate," "Master Data Accuracy"), the study provides a method for the case company to transition from "hoping for value" to "managing value." This approach aligns with DeLone and McLean's (1992, 2003) argument that system quality must translate into net benefits. Furthermore, the Design Principles serve as the practical "instruction manual" for RQ2, clarifying that reaching these KPI targets requires the implementation of strict governance and ownership models—mechanisms that Helo and Hao (2022) and Tufano (2023) highlight as critical for ensuring data remains fit for advanced digital uses like AI.

5.3 Limitations and Future Research

A central limitation of this study is its pre-implementation setting. The benefit identification and the KPI linkages represent expected value outcomes derived from expert views and the case context, rather than empirically observed changes after go-live. Consequently, the artifacts do not provide evidence of realized performance improvements, nor can they fully capture implementation-side dynamics such as user adoption patterns, data-quality degradation over time, or unexpected process bottlenecks. This boundary is especially relevant in a DSR approach: while the study demonstrates the artifacts’ relevance and plausibility, the evaluation phase could not be conducted in a post-implementation environment due to the project timeline and the scope of the thesis.

A second limitation relates to generalizability. The study is based on a single case in a specific industrial context, where SAP Material ID is embedded in complex engineering-to-SCM interfaces, supplier interactions, and governance constraints typical of large-scale manufacturing and energy-related supply chains. The identified benefit set and the design principles are therefore strongly shaped by the realities of this environment. While the artifacts are conceptually transferable to other organizations implementing material identification or master data governance, the expected benefits and their prioritization may differ in other industries and operating models, such as high-volume retail or purely digital supply chains.

A third limitation concerns the validation method. The study's demonstration relied on expert feedback and review of the artifacts, which provides a credible but primarily "static" form of validation. This approach supports assessing coherence, completeness, and perceived usefulness, but it cannot replace "dynamic" validation through live system testing, pilot deployments, or longitudinal observation of KPI trends. As a result, the study cannot empirically verify causal links between Material ID implementation practices and KPI improvements, nor can it test how the proposed design principles perform under real constraints such as partial adoption, integration delays, or changing organizational ownership decisions.

The most direct continuation of this thesis is a post-implementation evaluation study that completes the DSR cycle by assessing how the proposed artifacts perform in practice. A longitudinal design would be particularly valuable: after go-live, future research could track the KPIs linked to the twelve expected benefits over a defined period, establish baselines, and examine whether improvement patterns align with the benefit logic proposed in the framework (Table 3). This would allow researchers to move from expected benefits to realized benefits, and to test whether the "pre-implementation governance layer" suggested by this thesis explains observed outcomes, especially the extent to which data quality, duplicate prevention, and ownership routines mediate operational performance improvements.

A second promising direction is to test and refine the design principles through comparative and process-oriented studies. Future research could investigate whether the five principles (Tables 4–8) predict implementation success across different organizational units, plants, or comparable firms, and which principles have the highest leverage under varying conditions. Methodologically, this could be achieved through multiple-case research or through embedded case comparisons within the same company, combining qualitative analysis (adoption barriers, ownership conflicts, workarounds) with KPI outcomes. Such studies would strengthen external validity and contribute more generalizable prescriptive knowledge about how master data and identification initiatives create value beyond a single industrial setting.

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Appendices

Appendix 1. Interview Structure and Questions

Interview Structure and Questions

Intro

- Introducing topic.

Section 1 — Current Workflow

1. Can you walk me through your current workflow related to materials or data in your role?

Probes:

- What steps consume most of the time? Where does manual work occur? Where does uncertainty or rework happen?

Section 2 — Current Pain Points

2. Where do you see inefficiencies, manual work, or unclear steps in the current process?

Probes:

- Can you give an example? How often does this occur? Who else is impacted?

3. How does the current material identification or classification practice affect your daily work?

Probes:

- Do you face issues with duplicates, missing data, long texts, etc.? How does it affect process flow or decision-making?

Section 3 — Expected Benefits

4. What benefits do you expect the Material ID to bring for your work or your team?

Probes:

- Process efficiency? Data quality? Automation? Traceability? Reporting?

5. Which areas, in your view, would gain the most value from Material ID?

Probes:

- Procurement? Planning? Sustainability? Product management?

Section 4 — Value Mechanisms

6. What would need to change for these benefits to actually be realized in practice?

Probes:

- Clear ownership? Better data governance? Integration across systems? Training? Change Management?

7. Through which mechanisms do you believe Material ID will generate value?

Probes:

- Standardization? Automation / RPA readiness? Better metadata? Eliminating duplicate processes?

Section 5 — Risks & Challenges

8. Do you see any risks, drawbacks, or new manual tasks that Material ID might introduce?

Probes:

- Data maintenance? Change resistance? Confusion at implementation? Extra governance workload?

Section 6 — Digitalization & End-to-End Perspective

9. How should Material ID integrate with digital systems and end-to-end process flow?

Probes:

- ERP–PLM integration? Data quality checks? API / automation readiness? Future scalability? More standardized data structure?

Section 7 — Closing Reflection

10. Is there anything else you believe is important for understanding expected benefits or value creation?

Appendix 2. Clarification of Artificial Intelligence Use

Artificial intelligence-based language models have been utilized in this master's thesis to refine the linguistic structure, enhance the fluency of the text, and perform grammatical checks. All scientific content, argumentation, source selection, and analysis remain entirely the author’s own work.

All linguistic corrections and suggestions generated by artificial intelligence were critically reviewed and approved by the author before inclusion in the final manuscript. The author bears full responsibility for the accuracy, integrity, and originality of the thesis. The specific models used in this process were OpenAI’s ChatGPT versions 5, 5.1, and 5.2.