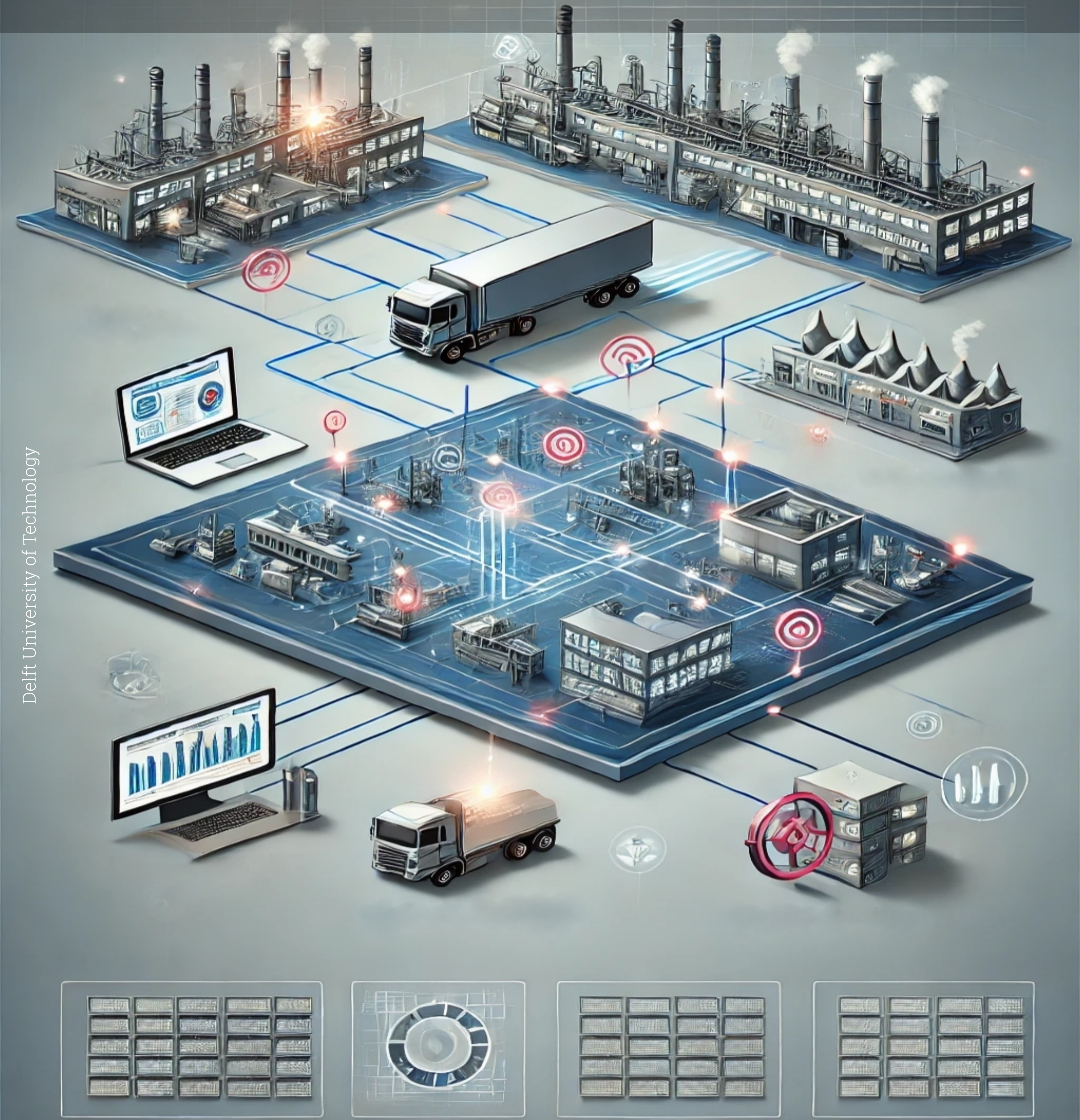
MOT2910: MSc Thesis Project

Information System driven Process Standardization for High Impact Issues in Reverse Logistics



Delft University of Technology

TU Delft Delft University of Technology

ASML

MOT2910: MSc Thesis Project

Information System driven Process Standardization for High Impact Issues in Reverse Logistics

by

Student Name	Student Number	Email ID
Nikhil Shitole	5825164	

in partial fulfillment of the requirements for the degree of

Master of Science
in Management of Technology
Faculty of Technology, Policy and Management
at the Delft University of Technology

To be defended in public on 26 August 2024 at 10:00 AM

Graduation Committee:	
Chairperson:	Dr. Jafar Rezaei
First Supervisor:	Dr. Yousef Maknoon
Second Supervisor:	Dr. Sander Smit
Company Supervisor:	Duane Walker
Company Mentor:	Dennis Prince

Preface

The past two years have been a transformative journey for me. After spending over four years in the corporate world, I made the bold decision to return to academia and relocate from the familiarity of my home country to the Netherlands. This transition was a significant change, and it presented numerous challenges. However, I embraced these challenges with respect, dedication, and hard work, particularly during the course of my thesis. This period has not only enhanced my professional skills but also contributed significantly to my personal growth. Despite the hurdles I faced along the way, I have now successfully completed this chapter of my life and academic journey, becoming more responsible and resilient.

I would like to express my heartfelt gratitude to TU Delft and the Faculty of Technology, Policy, and Management for providing me with this incredible opportunity and for their support throughout my academic journey. My sincere thanks go to Professor Dr. Jafar Rezaei for chairing my graduation committee and offering invaluable insights and suggestions during the thesis writing process. I am deeply grateful to Professor Dr. Yousef Maknoon, my first supervisor, for his continuous encouragement, insightful and constructive feedback, and unwavering motivation throughout my thesis journey. Additionally, I extend my thanks to Professor Dr. Sander Smit, my second supervisor, for his thoughtful feedback during our thesis meetings and for providing perspectives that have significantly enriched my research, making it more comprehensive and holistic.

I would like to express my heartfelt thanks to my company supervisor, Duane Walker, and my mentor, Dennis Prince, along with the entire Reverse Logistics and Supply Chain Team at ASML. Your guidance, expertise, and unwavering support have been instrumental in shaping the direction and quality of this thesis. I am truly grateful for the opportunity to work with such remarkable professionals in the field, whose insights and encouragement have significantly contributed to the success of this endeavor.

I would like to extend my profound thanks to my parents, whose sacrifices and unwavering support have been the cornerstone of my journey. Their blessings and encouragement have given me the ability and opportunity to pursue my dreams, for which I am eternally grateful. I would like to extend my heartfelt thanks to my friend Aditi for her continuous motivation, understanding, and unwavering support which have greatly contributed to my success. I would also like to express my deep appreciation to my friend Shreya for her valuable advice and encouragement throughout this academic journey.

Last but certainly not least, I would like to express my heartfelt gratitude to everyone I met at TU Delft. Being surrounded by such intelligent, vibrant, and ambitious individuals has been an extraordinary experience, one that I will cherish and remember for the rest of my life.

Nikhil Shitole,
Delft, Netherlands

Executive Summary

In today's fast-paced global environment, the primary challenge for high-tech companies is maintaining a consistent supply of raw materials in the form of specialized parts from their suppliers. This is essential to sustain manufacturing operations and meet performance targets, ultimately ensuring customer satisfaction. The specialized parts used as raw materials are often technically intricate and costly, which contributes to lengthy lead times for manufacturing and sourcing. Consequently, these parts are generally maintained at low inventory levels. If received incorrectly or found defective during use and if the nature of the defect is such that they are unserviceable, they require immediate intervention such as repair, reconditioning, remanufacturing, or quality analysis to ensure operational continuity. Direct replacement of these parts with new, fault-free parts is often not feasible within the required timelines due to their lengthy sourcing durations. In this context, the emerging field of Reverse Logistics becomes critical, facilitating the efficient handling of these defective parts by shipping them to their respective suppliers to take the appropriate action and ensure that they are swiftly returned to operational status, thereby minimizing downtime and maintaining the supply chain's integrity. These are termed as high-impact issues in Reverse Logistics.

Any delay in shipping defective parts or products to their suppliers extends the time required to perform necessary actions such as repairs or quality checks. These delays result in downtime and can halt the manufacturing operations of high-tech companies until the corrected parts are received back and reintegrated into the production process.

To achieve these objectives, it is essential to have a robust standardized information-sharing and communication process flow throughout the organization. This will ensure timely and accurate management of these defective parts as requested by various stakeholders within high-tech companies. The unavailability of such a process flow leads to significant delays and operational inefficiencies, undermining the company's ability to respond quickly to critical situations and maintain consistent manufacturing outputs.

Stakeholders throughout the organization, responsible for the supply and demand planning of critical and low-inventory parts, initiate requests to the Reverse Logistics Team for shipping defective parts to the supplier when they are deemed as unserviceable or incorrectly received and there is no new inventory to replace them. For the Reverse Logistics Team to achieve timely shipments, they require access to relevant information that is timely, accurate, and centralized through a platform or interface that offers transparency, traceability, and accountability. This system must also be scalable to accommodate an increasing volume of requests in the foreseeable future.

Due to the lack of a standardized process flow, stakeholders currently employ fragmented and inconsistent methods for communicating and sharing information about defective parts with the Reverse Logistics team. These methods are highly unreliable and risky, lacking traceability and visibility in a centralized interface where all incoming and processed requests can be monitored. The existing methods need continuous monitoring by the RL team to ensure they do not miss any requests. Furthermore, when these existing communication practices are deployed, necessary preliminary steps required before sending requests to the Reverse Logistics team get bypassed, creating bottlenecks and hindering their ability to efficiently manage and expedite the shipment of defective parts. Therefore, the necessity of developing and integrating a standardized process with an advanced Information System like ERP, and adopting it organization-wide, will significantly streamline the defect-handling process. This strategic integration enhances transparency, traceability, and accountability, ensuring that requests from various stakeholders to ship defective parts from high-tech companies to suppliers are managed efficiently and effectively. The Reverse Logistics Team is pivotal in ensuring that these defective parts are promptly shipped to suppliers upon notification.

The literature underscores the necessity for a process flow that expedites the shipment of unserviceable and incorrectly received parts to suppliers for necessary corrective actions. It highlights a notable deficiency in the standardization and formalization of process flows within Reverse Logistics.

This leads to the research question of the thesis which is *"How can high-tech companies standardize their information-sharing and communication processes to effectively manage high-impact issues in reverse logistics?"* To address this research question, the research methodology used in this research draws on the Information Systems Research Framework, integrating aspects of people, organization, and technology, both current and prospective. A comprehensive qualitative analysis was conducted, involving 22 semi-structured interviews for thematic analysis complemented by document analysis to delve into the challenges and impacts arising from the absence of standardized information-sharing and communication processes. Utilizing the Technology-Organization-Environment (TOE) framework, this research explores the technological, organizational, and external environmental contexts that influence technology adoption, specifically Information Systems in an organization. Additionally, it incorporates business process management and standardization theories to elucidate the standardization of business processes and the role of information systems therein. This provides foundational insights for developing an Information Systems based process flow, while also emphasizing the importance of change management theories and models for ensuring its successful adoption. This comprehensive approach facilitates a deep understanding of the factors necessary for successfully developing and adopting information systems as a standard process flow within high-tech companies to manage high-impact issues.

This rigorous qualitative analysis based on the literature framework and theories reveals that high-tech companies seeking to develop and standardize their information-sharing and communication processes to manage issues related to the shipment of unserviceable and incorrect parts in Reverse Logistics require a comprehensive approach. This approach incorporates technological, organizational, and environmental factors that significantly influence the development and successful adoption of such standardized process flows.

This research, therefore, by studying the challenges and impacts resulting from the lack of a standardized information sharing and communication process flow identifies key technological, organizational, and external environmental factors, along with their inter-dependencies, that influence the development and successful adoption of such an Information System-based standardized process flow. A framework called IS-PSF is developed which consists of these factors and inter-dependencies identified which are further spread across the phase of change management (transition from an existing state which in this case is the unavailability to the future state which is post-adoption of the to be Information System based process flow). The research methodology employed to develop the IS-PSF framework is distinctive, integrating the TOE framework with theories of business process standardization and change management models.

There are many relevant academic and practical insights derived from this research. The research demonstrated that while documentation of agreed procedures, rules, and guidelines can contribute to standardization, true standardization is unachievable without the integration of information systems alongside these formalization efforts based on the nature of the business processes used. The research highlighted that high-tech companies should deploy a proactive strategy for understanding the need for standardization by monitoring the performance of the business processes using performance indicators or metrics. The research showcased that having a robust and matured IT infrastructure alone is not sufficient but the role of human factors and how the stakeholders make sense of a technology (information systems in this case) are crucial for selecting an appropriate IS on which the standardized process can be developed and successfully adopted.

The research highlights the role of effective change management communication and strategy is vital to ensure a successful transition from the existing non-standardized fragmented information-sharing and communication practices to the standardized Information System process flow. An effective change management strategy decides whether the change management will be successful or a failure. The research also points out the importance of periodic reviews of the process flow by the process owners for continuous improvements. The research highlights that at times, owing to customer requirements, market volatility, environmental regulations, and the aim to set industry standards, high-tech companies standardize their processes in Reverse logistics.

From a practical perspective, the framework developed in the research helps managers make informed decisions on technology investments and change management strategies, allowing for seamless adoption of new systems across organizational boundaries. The study's practical application of the conceptual framework bridges the gap between theory and practice, providing actionable insights for improving process performance and stakeholder satisfaction in high-tech industries.

Overall, this study contributes to the development and successful adoption of an Information Systems Standard Process Flow. This framework is designed to efficiently and effectively manage issues related to unserviceable and incorrectly received parts, aiming to expedite their shipment to suppliers for necessary actions. The goal is to minimize delays in the process flow through the development and successful implementation of a standardized information system-based process flow.

Nomenclature

BPM	Business Process Management
BPS	Business Process Standardization
DN	Delivery Note
DOA	Dead on Arrival
DSR	Design Science Research
ERP	Enterprise Resource Planning
HANA	High-Performance Analytic Appliance
IP	Input Processing
IRC	Integral Repair Cycle
IS	Information Systems
IS-PSF	Information Systems Based Process Standardization Framework
IT	Information Technology
KPI	Key Performance Indicator
MN	Material Notification
MRB	Material Review Board
OPIT	Organizational Information Processing Theory
PO	Purchase Order
PR	Purchase Requisition
RCA	Root Cause Analysis
RL	Revese Logistics
RMA	Return Material Authorization
RSC	Revese Supply Chain
RSCM	Revese Supply Chain Management
SAP	System Applications and Products
SC	Supply Chain
SCM	Supply Chain Management
SI	System Integration
SLA	Service Level Agreements
SLR	Systematic Literature Review
SP	System Performance
TOE	Technology-Organization-Environment

Contents

List of Figures

List of Tables

Chapter-1: Introduction

1.1 Research Background:

Environmental concerns and global competitiveness are driving manufacturing companies to integrate "Green Initiatives" into their Supply Chain (SC) practices. A sustainable RSC within a manufacturing entity offers numerous advantages for the business's finances, its customers, and the environment. Its benefits encompass a higher return on investment, decreased losses and unexpected revenue, better environmental sustainability, and fostering competition in manufacturing through reuse which eventually, leads to customer satisfaction (Ravichandran et al., 2023).

Thus, to achieve a balance between business efficiency and sustainability, organizations must recognize the adverse effects of their SC practices and restructure their operations to minimize environmental damage and promote social betterment throughout the entire SC network (Mathiyazhagan et al., 2021). The RSC represents a shared obligation between producers and consumers to diminish waste through recycling, remanufacturing, reusing, reconditioning, and the proper disposal of products or items deemed unacceptable, thereby improving environmental sustainability (Mathiyazhagan et al., 2021).

Reverse Supply Chain Management (RSCM) plays an important role in a circular economy, especially in "closing parts or product loops" (Yamaguchi, 2022). This is because it encompasses the series of activities required to collect used products from customers or end users and either dispose of them or recover value from the returned products through processes such as reuse, refurbishment, remanufacturing, reconditioning or recycling (Prahinski & Kocabasoglu, 2006; Ravichandran et al., 2023).

RSCM has a strategic view, including data analysis, value recovery planning, stakeholder (suppliers, internal stakeholders, end customers) collaboration, and innovation for reuse and remanufacturing (Prahinski & Kocabasoglu, 2006; Blackburn et al., 2004). Reverse Logistics (RL) is a part of RSCM that focuses on the physical movement and handling of parts or products, like transportation, warehousing, and sorting from the end customer to the manufacturer who is the supplier of those parts or products (Prahinski & Kocabasoglu, 2006). Sellitto (2018) defined RL as the strategy of organizing, executing, and overseeing the movement of raw parts or products, inventory, finished goods, and information from the point where goods are consumed or disposed of, back to their starting point, to reclaim residual value or ensure proper disposal. When a product or part is damaged, defective, or at the end of its life, different disposition activities are performed to recover value from them such as repair and reconditioning. remanufacturing, recycling (Prahinski & Kocabasoglu, 2006), which are briefly explained in the "Defects Management in Reverse Supply Chains" in subsection 2.1.3. This is often done by sending the defective part or product back to the supplier (manufacturer) of that material who based on the identified cause of the defect or requirement proposed by the customer performs the repair, recondition, and remanufacture processes on them. After the repair, recondition, and remanufacture processes of the defective material, it can be used again in the manufacturing operations.

According to R. Huscroft et al. (2013), high-tech companies may need to expedite parts through the RL process when they have received an unserviceable part and therefore need to be replaced or repaired, or when an incorrect order of parts is received. This helps minimize disruptions to customer demand and avoid significant cost implications. Boykin (2001) states that in the high-tech manufacturing industry, the performance and reliability of parts and products used by them as well as the machines or output generated by them are crucial to the financial success and operational efficiency of the organization. This necessitates the availability of an RL process that enables the immediate return of defective parts or products from the customer, a high-tech company to the supplier or manufacturer of those parts for taking appropriate action in the form of repair, recondition, remanufactured, or analysis, ensuring rapid resolution and continuity in production (Boykin, 2001). Therefore, these types of defective parts which need expedited shipment to the suppliers for rapid resolution in the form of repair actions and performing quality analysis can be considered high-impact issues in RL

Therefore an efficient RL process is crucial for high-tech companies to maintain smooth operations and customer satisfaction, by enabling timely shipping of unserviceable or incorrect parts to their

suppliers for repair and other reuse solutions. This ensures the reliability and performance of their parts or products.

The main risk factors in Supply Chain Management (SCM) include managing customer relationships and delivering extensive customer service, managing demand effectively, executing logistics processes efficiently, smooth operation of logistics subsystems, product development, managing technology appropriately, implementing sustainable supply chain management strategies optimally, and managing relationships with competitors and external stakeholders (Zimon & Madzík, 2020). The unserviceable and incorrectly received parts are thus closely connected to these supply chain risks as they directly impact several critical aspects of supply chain operations, including customer satisfaction, inventory management, and the overall efficiency of logistics processes. These types of parts or products can cause disruptions resulting in delayed deliveries to the customers by the high-tech companies as the manufacturing lead time increases due to the time needed to get the unserviceable or incorrectly received parts with an appropriate action performed and sourced back to the high-tech companies.

As per Ravichandran et al. (2023), the importance of a sustainable RSC becomes especially evident for high-tech companies when there is a risk associated with obtaining essential raw materials in the form of parts or products necessary for manufacturing operations continuity of the high-tech companies from their suppliers. In such situations, if the inventory at hand in high-tech companies becomes defective and unserviceable, or if an incorrect order of raw parts is received, the only viable option is to immediately ship them back to the suppliers. These parts then undergo repair, reconditioning, remanufacturing, or analysis based on the nature of the defect. After this, they are sourced back to the high-tech companies and used in the manufacturing operations. This aligns with R. Huscroft et al. (2013), who notes that high-tech companies may need to expedite parts through the RL process when they require an unserviceable part to be replaced or repaired, or when an incorrect order is received. Lamba et al. (2020) mentions that the high-tech industry has historically leveraged RL to manage end-of-life products, and parts requiring transformation for utilizing them back into production activities. Therefore, the various SC risks can be mitigated by efficiently repairing, reconditioning, and remanufacturing defective products, which can then be reutilized in the manufacturing process. This ensures that manufacturing operations resume without any downtime due to the unavailability of necessary parts or products, thus avoiding any business implications. Additionally, by reducing the need to procure new parts or products to replace defective ones, this approach promotes sustainability and a circular economy through the process of reutilization, waste reduction, and extending the life of the parts or products (Kazancoglu et al., 2021; Govindan & Hasanagic, 2018).

Since the activities of the RL process involve multiple relationships between different stakeholders both internal and external to the companies, it is important to understand and emphasize the role different stakeholders have in the RL systems implementation (Álvarez-Gil et al., 2007). The stakeholders can also be various functional departments within an organization. Morgan et al. (2016) states that RL handling problems may differ based on the characteristics of the products being returned. Thus, each company in the high-tech sector will face different problems based on the characteristics of the products they manufacture and the parts or products they use as raw parts or products for them. As per Prahinski & Kocabasoglu (2006) various challenges for the successful implementation of RSCM are:

- The delay in material returns for getting them repaired/ reconditioned/ remanufactured/ recycled which especially impacts technologically critical and time-sensitive products.
- The variation in the quantity of returned parts or products.
- The extent and variety of defects in returned parts or products.
- The lack of visibility into the quality of parts or products due to insufficient communication of information from the stakeholders or departments back through the supply chain.

The planning of RL activities (customer to supplier) in RSCM presents greater challenges compared to forward logistics (supplier to customer) in SCM due to increased uncertainty regarding the quantity, timing, and quality of returned products (Agrawal et al., 2015). The inherent unpredictability and variability associated with the RSCM, as highlighted by Ravichandran et al. (2023); Agrawal et al. (2015), underscore the significant challenges in planning and managing the RL activities of parts or products needing repair, reconditioning, or recycling. This uncertainty significantly complicates the tasks of business managers and RL teams responsible for RL activities with the RSCM, necessitating the presence of a reliable process for capturing and processing information regarding defective parts that need expedited shipment to the suppliers. In addition to these challenges, RL also suffers from issues related to information transparency across the supply chain, visibility of defective parts information, and efficiency impacts due to a lack of timely and accurate data (Lambert et al., 2011; Genchev et al., 2011; R. Huscroft et al., 2013; Alarcón et al., 2021). Ineffective communication, insufficient information sharing, and the absence of formalization and process standardization further exacerbate these problems (Lambert et al., 2011; Genchev et al., 2011; R. Huscroft et al., 2013; Alarcón et al., 2021).

According to R. Huscroft et al. (2013), promptly and accurately communicating the status of a part within the RL process to all affected stakeholders is crucial. Effective communication and information sharing relevant to the RL process help prevent or mitigate customer service issues and meet customer needs. This enables a more effective response to customer service problems and ensures timely resolution of such issues (R. Huscroft et al., 2013). The critical role of information integration, as outlined by Wong et al. (2011), comes into play here, emphasizing the need for an Information Technology (IT) infrastructure that facilitates seamless information sharing and coordination across various business functions. Due to the complexities of the RL process, effective communication and information sharing play a significant role in influencing RL performance. Accurate and timely communication is important for attaining operational efficiency and maintaining customer satisfaction R. Huscroft et al. (2013).

Zhou & Benton Jr (2007) state that standardization of SC business processes tends to help organizations better leverage the information shared among SC stakeholders. It increases the effectiveness and responsiveness of the supply chain. This, therefore, can reduce the delay in getting the defective parts or products repaired, reconditioned, or remanufactured without delays.

As per Badenhorst (2016), standardization of business processes involved in RL has certain benefits. Firstly, standardization will help to increase the visibility of returns (Genchev et al., 2011). Secondly, it can improve operating flexibility and operating efficiency. The efficiency is improved because formal rules and procedures eliminate the need to treat every event as a new decision (Tiwari, 2013). Finally, standardized procedures can help to reduce conflict and confusion in RL operations (C. K. M. Lee & Lam, 2012; Huang & Yang, 2014). Therefore, the usage of non-standard communication and information-sharing business processes if employed in RL for managing the defective parts that needed expedited movements towards the suppliers for repair and analysis purposes can introduce inefficiencies, leading to delays, reduced transparency and visibility, and challenges in prioritization of the defective parts that need expedited delivery towards the suppliers. **Standardizing business processes helps organizations avoid redundancies (Tregear, 2015), reduce costs and improve product and service quality (Münstermann et al., 2010; Goel et al., 2023), improve process transparency (Kettenbohrer et al., 2013), and reduce processing time for value-added activities (Münstermann et al., 2010). Standardizing processes improves coordination and compliance across organizational boundaries (Davenport, 2005; Mahmoodzadeh et al., 2009; Goel et al., 2023).**

The necessity to minimize losses from improperly managed defective parts or products underscores the importance for companies to optimize their RL operations by systematically formalizing their procedures (Genchev et al., 2011). Formalization is defined as the degree to which rules, procedures, instructions, and communications are clearly defined and documented, ensuring that expectations are understood by all involved stakeholders (Alarcón et al., 2021; Pugh et al., 1968). It can be established through the use of clearly defined and standardization of workflows, and structured communication channels within and between firms (Genchev et al., 2011). Alarcón et al. (2021) states that an important aspect that makes RL processes implementation and management difficult is the lack of formalization.

Information support in the form of assistance provided to the decision-makers in the RL through readily available and accurate information to facilitate various business processes and decision-making is critical for achieving efficient RL operations (Daugherty et al., 2002). RL is frequently defined by uncertainty and the need for quick timing or processing (Daugherty et al., 2002). Managers must be prepared to process and handle the products on demand, even if they are uncertain about their return date. In such situations, information coordination is complicated because of the multiple parties involved (Daugherty et al., 2002).

The approach for overcoming the various challenges mentioned and achieving standardization necessitates a platform like Information Systems (IS) for information sharing and communication required for decision makers for managing unserviceable and incorrectly received products (Daugherty et al., 2002). Within the scope of RL, the capabilities of IS are characterized by the facility to transmit and receive information both internally within an organization and externally between different organizations (Hazen et al., 2015). As per Matende & Ogao (2013), IS are social systems that involve the interaction between people and technology. Laudon & Laudon (2014), describe IS as interrelated components working together to collect, process, store, and disseminate information to support decision-making, coordination, control, analysis, and visualization in an organization. They also highlight the role of IS in integrating the organization's business processes and enabling the flow of information among various functions and stakeholders. Lambert et al. (2011) states that IS plays a pivotal role in managing returns, facilitating effective communication among involved stakeholders, and assisting in the identification of products and determining their handling. Thus, this provides an opportunity to create a standard business process flow using the IS platform that can help organizations tackle the challenges related to communication and information flow and sharing due to non-standardized processes in the management of critical activities issues like the unserviceable and incorrectly received parts while improving transparency in terms of information visibility, scalability, and efficiency of the RL operations. However, the successful integration of an IS for RL activities poses the greatest challenge, demanding significant effort and time (Lambert et al., 2011). Along with this, as per Oltra-Badenes et al. (2019), limitations persist in developing and utilizing IS tailored to efficiently manage the distinct processes unique to RL within RL. J. Hall et al. (2013) points out that enhancing product visibility can help to resolve communication issues.

To develop a well-defined and standardized RL process flow through the adoption of IS for managing issues such as unserviceable and incorrectly received parts to ensure timely return of defective parts to the supplier is essential for effective RL management, it is crucial to identify the factors and inter-dependencies that impact the development and successful adoption of such a process.

By highlighting the necessity for a standardized business process and addressing the factors and inter-dependencies that impact its adoption to act as a standard process for RL activities, this study seeks to offer practical insights and theoretical advancements required for the adoption of IS as a standardized platform for communication and information flow within RL in high-tech manufacturing contexts when dealing with high-impact issues related to impacts and necessity of the unserviceable or incorrectly received parts which have to ship in an expedited manner towards the suppliers.

1.2 Problem Definition

As mentioned in the chapter 1, the high-tech manufacturing sector critically relies on RL for managing the return of defective products, especially those deemed unserviceable and incorrectly defective, to ensure their utilization back into manufacturing activities without impacting business operations in the form of financial loss, and customer dissatisfaction. The reutilization ensures the operational continuity. Despite recognizing the importance of these RL activities for sustainability and cost-effectiveness, businesses often face operational challenges that impede efficient management. **These challenges are often due to a lack of formalization and standardization in information sharing and communication processes within RL (Genchev et al., 2011; J. Hall et al., 2013; R. Huscroft et al., 2013; J. Hall et al., 2013). These challenges impact the performance of the RL process which affects the efficiency, transparency in terms of information visibility, and responsiveness towards handling defective products.**

To thoroughly investigate the challenges high-tech companies face in RL, particularly in managing high-impact issues due to the lack of standardized processes, this research focuses on ASML Netherlands B.V. as a case study. The study explores the factors that can influence the adoption of IS to standardize these processes for efficient and effective information flow and communication aimed at enhancing RL performance and thereby the overall organizational performance.

1.3 Case Study- ASML Netherlands

ASML Netherlands is an innovation leader in the semiconductor industry. They provide their customers, the chipmakers with everything they need from hardware, software, and services – to mass-produce patterns on silicon through lithography. Founded in Eindhoven in 1984, they are a global team of more than 40,000 people of 144 different nationalities and counting. ASML's operations are spread across more than 60 locations in Europe, Asia, the Middle East, and the US (ASML, 2023).

The largest problem that ASML faces is keeping up with the customer demand (ASML, 2024c). As a leader in EUV lithography systems, pivotal to technological advancements, the company is experiencing growing demand. This presents an opportunity to enhance capabilities and meet customer demand, reinforcing its industry leadership (ASML, 2023). This forces not only ASML to speed up their manufacturing operations but also their suppliers to meet the demands of parts or products that will be used in the machines placed by ASML (ASML, 2024c). The Reverse Logistics team managing the Reverse Supply Chain Operations within the Reuse Department to focus on circularity was established at ASML in 2022 and it aims to deliver on ASML's ambition to maximize circularity by 2030 (ASML, 2024a). The cross-departmental Re-use team at ASML focuses on several design principles, including the repairability and upgradeability of parts (ASML, 2024b). This helps the suppliers as they are not able to supply parts as per the demand by providing an alternative stream of refurbished and upgraded parts that can be quickly integrated into production (ASML, 2024b). This strategic initiative not only alleviates

Figure 1.1: ASML Netherlands B.V. (ASML, 2024h)

the pressure on suppliers but also enhances the overall efficiency of ASML's supply chain by ensuring a steadier and more reliable flow of necessary components.

Through the establishment of the RL team within the Reuse Department, ASML effectively addresses potential bottlenecks in production by decreasing dependency on new part production timelines. This proactive approach allows ASML to meet soaring customer demand more effectively by utilizing an integrated supply strategy that incorporates both new and refurbished parts.

Ultimately, ASML's commitment to circularity and sustainable practices not only positions the company as a leader in environmental responsibility but also secures its competitive edge in the fast-paced high-tech industry, ensuring its ability to meet future demands and maintain its leadership in EUV lithography systems.

The Reverse Logistics team managing the Reverse Supply Chain Operations within the Reuse Department of ASML is tasked with ensuring that any defective material encountered in the factory while manufacturing a machine (modules) or set of machines (system) or in the field (customer), is sent to the respective supplier of that material to perform actions like repair/recondition/remanufacture or root cause analysis depending on the nature of the defect. Once the defective part or product is repaired, reconditioned, remanufactured or its analysis is done based on the requirements, the part or product is received back at ASML and used in the manufacturing of the machines (systems) as intended. The ultimate goal is to ensure the re-utilization of those defective products back into the manufacturing operations, which eventually helps in achieving the targeted lead times on the production of the machines as promised to the customer. This approach not only streamlines the reutilization of defective materials but also alleviates the pressure on suppliers who are striving to meet ASML's demands as mentioned earlier. Thus, the RL Department plays a vital role in enhancing operational efficiency and sustainability by effectively managing the lifecycle of materials and supporting continuous supply.

The RL team in the Reuse Department of ASML is currently encountering challenges managing the RL activities for urgent defective parts or products processing for shipping them out of ASML towards the respective suppliers for performing repair, recondition, remanufacture, and root cause analysis (RCA) activities due to:

1. Unavailability of a standard process flow to manage these urgent defective parts or products.

2. Usage of disparate communication tools like emails, Microsoft Excels, Microsoft Teams Messages and Calls, and Phone Calls for information flow and communication about urgent defective parts or products.

Of the various defective parts or products, urgent defective parts or products are the categories for which a quick resolution is expected due to their critical role in maintaining manufacturing operations continuity and ensuring that ASML timely delivers its machines to customers, thereby upholding the company's service quality and position of market leader.

For ASML to manufacture its machines and deliver them to its customers, a constant supply of raw materials in the form of parts or products is essential. Some of these parts used as raw materials are often technically intricate and costly, which contributes to lengthy lead times for manufacturing and sourcing them from the suppliers. Consequently, these parts are generally maintained at low inventory levels. When these parts are in low stock and suppliers cannot deliver them on time, any defects or faults that arise in them must be addressed immediately. This is because, due to the unavailability of fresh, new parts to replace the defective ones, the manufacturing operations stop until a solution is made available. In such cases, the only viable option to ensure manufacturing operations continuity is to repair, recondition, remanufacture, or analyze these defective parts or products. To achieve this, it is crucial to urgently ship these parts to their original supplier (the manufacturer who produced and sold them to ASML). After the supplier repairs the parts and provides the necessary analysis, they are returned to ASML. These parts are then reutilized in the manufacturing process, allowing production to continue without significant delays, preventing disruptions, and maintaining productivity. These parts are referred to as urgent defective parts.

The management of urgent defective parts at ASML aligns with the concepts discussed by R. Huscroft et al. (2013) and Boykin (2001) in section 1.1. High-tech companies often need to expedite parts through the RL process when they require an unserviceable part to be replaced or repaired, or when an incorrect order is received, minimizing disruptions and cost implications. Additionally, the performance and reliability of parts are critical for business success and operational efficiency, necessitating an RL process that enables immediate return and repair of defective parts. Thus, ASML's approach to handling urgent defective parts supports the rapid resolution and continuity in production as highlighted in the literature.

The defective parts or products that have incoming new parts or products to replace them within the expected time frame are defined as non-urgent or regular repairs. The definitions of urgent defects and non-urgent or regular defects are as per the statements of the participants during the qualitative analysis done for this research and are discussed in section 4.2

It is observed that in the RL process flow of ASML, there is an absence of a well-established standard process flow along with gaps in the existing IS, which significantly hinders the effective management of RL, particularly in accurately identifying, prioritizing (separating them from the regular non-urgent repair and analysis required defective parts or products), and communicating these urgent defects to the RL team. The issues at hand are not only impairing the effectiveness of RL performance but also have broader implications for the organization's business performance.

At ASML, when parts or products to be used in a machine are identified as urgent defective, either discovered in the factory or reported by customers in the field, they are directed to the ASML's RL team for further processing of RL administrative activities which can be seen in subsection 4.1.1. The stakeholders across multiple departments responsible for overseeing urgent defective parts or products use varied, fragmented processes and tools to notify and communicate these urgencies to the RL team. The detailed description of the existing way of working and process flow can be seen in subsection 4.1.2.

This lack of standardization affects the efficiency and responsiveness of the RL team in addressing urgent defects that require immediate attention. The absence of a standardized process leads to ambiguity in the tasks to be performed by the RL team, resulting in delayed responses, miscommunication, and the unavailability of accurate information promptly. Consequently, this delays the shipment of urgent defective parts or products to the supplier, increasing the repair lead time and ultimately delaying their return to ASML. The delayed return of repaired or analyzed parts causes stoppages in manufacturing operations, extending the lead time for machine production and delaying deliveries to customers. This results in customer dissatisfaction and negatively impacts ASML's business performance.

The current disparate, fragmented, and non-standardized information sharing and communication processes involve the use of emails, Excel sheets, Microsoft Teams messages, and phone calls to notify the RL team about urgent defects. Although these methods are employed for communicating and sharing information about urgent defect repairs, there is an opportunity to improve the process. Stakeholders who initiate these requests can enhance their effectiveness by following the necessary steps and sequence of activities before communicating with the RL team about the urgent defect request. This proactive approach ensures that defective parts are efficiently shipped to the supplier, fostering smoother collaboration and timely resolution of issues. Additionally, the manual nature of these methods results in a lack of integration and standardization, leading to issues with traceability, consistency, visibility, and the potential for critical information loss. Such disorganized communication and information sharing can cause miscommunication, errors, and inefficiencies, which are particularly problematic in environments where timely and accurate responses are crucial.

Urgent defect requests require immediate attention. Upon receiving a request, the RL team needs to perform a series of administrative activities necessary to ship the defective part. However, the use of fragmented methods and tools in the process flows, coupled with non-adherence to the required sequence of activities before submitting a request, hinders the RL team's ability to perform their tasks efficiently. This ultimately delays the shipment of defective parts, undermining the effectiveness of the urgent defect repair process.

Due to this, there are delays in addressing urgent defects, as critical information may not be shared promptly or efficiently across relevant stakeholders. This delay in turn increases the lead time required for these items to get repaired and returned to ASML to get reintegrated into their respective machines. Such additional and unwanted delays have a direct impact on business operations, as the machines awaiting reintegrated parts or repaired products experience extended downtime, disrupting production schedules and affecting overall business efficiency. This eventually impacts the demand and supply planning for the organization.

The reintegration of defective parts or products into manufacturing operations not only contributes to the sustainability goals of the company by reducing waste but also helps in managing costs and maintaining product quality. However, the effectiveness of the reintegration process is significantly undermined by these various fragmented processes currently employed by departments.

Interestingly, ASML uses an Enterprise Resource Planning (ERP) system based IS of System Applications and Products (SAP) for processing various activities within RL and SCM. However, despite its extensive use for managing standard RL operations and overall SCM activities, SAP is not currently completely utilized for managing urgent defects. The detailed flow of how ERP of SAP is used for other non-urgent defects and urgent defects along with the use of disparate communication methods can be seen in subsection 4.1.2. This gap highlights the potential for integrating urgent defect management into the existing SAP ERP framework to streamline processes and enhance efficiency. All the departments across the organization have access to this system. However, it is not used for the management of urgent defects. This represents a significant potential opportunity to enhance the RL process effectiveness for urgent defects. The research, therefore, aims to study and identify the technological, organizational, and external environmental factors, along with various process standardization theories, that influence the development and adoption of an IS-based standardized process flow for managing these high-impact issues in RL. The objective is to understand how these factors affect the utilization of IS as a primary standardized process flow for information sharing and communication regarding urgent defective products throughout the organization.

The identification of these factors and inter-dependencies is critical for the RL, as this will lay a foundation for the development of a standard process flow that will allow the RL team to manage the inventory of urgent defects. This process flow needs to be efficient (improves performance and response of RL), transparent (clear and everyone involved can see it and thus easy to trace), visible (Clear picture of reasons for urgency, incoming requests, accountability), and scalable (capable of notifying large requests about urgent defects). This will not only increase the responsiveness and efficiency of the RL but also lead to scalable, and transparent RL at ASML, reducing any delays in the repair and analysis of the defective products. This will ensure that the management of urgent defective parts aligns with the company's standards for operational excellence and sustainability. While urgent defective parts repairs and analysis are not a frequent occurrence at ASML, their time-sensitive, critical, and high-impact nature makes them a high-priority issue. Addressing these urgent defects promptly not only mitigates operational disruptions at ASML but also supports suppliers who are striving to meet ASML's stringent demands as mentioned earlier. Effective management and expedited repair of these defects are crucial for maintaining the supply chain's resilience, and integrity and ensuring the continuous availability of essential components.

The RL in ASML has three major flows:

- **Service Flow:** Parts or Products (can be the entire machine or machines) returned from the customer (field) to the RL Department of ASML. These also can be defective parts that need to be repaired or are to be upgraded (from a performance point of view) as per the customer feedback. There can be some urgent defects coming from the end customer(field) as well. These defective products are usually stored at the warehouse location of ASML and the Customer Quality Management System

(QMS) team takes care of it. The urgent defects from service flow are not in the scope of this thesis research.

- **Factory Flow:** Raw material in the form of parts or products used in the factory can also be returned to the RL team of ASML from the factory upon detection of a defect. These defective parts can be both urgent and non-urgent types. The defective parts or products can need repair, recondition, remanufacture, or analysis. Out of these the urgent defective parts or products belonging to this category are mainly distinguished into the following categories:
  - **Dead On Arrival (DOA)-** These are the parts or products that are defective when received at the ASML factory from the suppliers. The damage can also occur during the transportation of products from the supplier to ASML. This belongs to the incorrectly received parts defined by R. Huscroft et al. (2013).
  - **Stock Purge-** When the entire batch of parts or products to be used is defective, this is treated as urgent defective parts. This also belongs to the incorrectly received parts defined by R. Huscroft et al. (2013).
  - **In-process failures-** The parts or products received from the suppliers fail while they are being assembled into the machines at ASML. This belongs to the unserviceable parts as defined by R. Huscroft et al. (2013). This can happen in two stages:
    1. **Individual modules (machines/ cabinets):** In this stage, individual modules are being built which are part of a bigger system. The raw parts or products can get defective in this stage.
    2. **System Integration (SI) & System Performance (SP):** In this stage, different modules (machines/ cabinets) of a system are assembled to form a system and tested. The raw parts or products or the entire module can get defective in this stage.

    These at times require a RCA as they might also impact and affect the performance or functioning of other parts of the machine.
- **Warehouse Flow:** Some defective parts or products are stored in the Warehouse of ASML at the Weert location in the Netherlands. These defective parts or products are stored there as there is no demand for them at the given time. But at times when a defect arises at a customer site, and if a similar part is available at the Warehouse located in Weert, Netherlands, it is economical to ship this part to the supplier get it repaired, and send it back to the customer.

The definitions of different types of flows and occurrences of the urgent defects are as per the statements of the participants during the qualitative analysis done for this research and are discussed in section 4.2

For both the factory and Warehouse flows, information and communication about the defective products are provided to the RL team of ASML. This is done through the various disparate tools in the processes mentioned earlier. The RL team performs some critical administrative that are required to ship the defective parts or products to the supplier for the required repair, reconditioning, and remanufacturing activities and get them back at ASML. A detailed explanation of these activities is mentioned in subsection 4.1.1 and in subsection 4.1.2. The completion of these critical activities is hindered by a lack of cohesion and standardization of processes among various departments, leading to an unpredictable and inconsistent information flow of defective products. **This thesis research has its scope focused only on factory flow.**

Also, at times there is no notification about urgent defects raised to the RL team. The RL team, acknowledging the critical nature of urgent defects, must respond swiftly and effectively to address these issues. The resolution of urgent defects can be in terms of repairs, reconditioning, or remanufacturing. If these defective parts or products are not urgently repaired, reconditioned, or remanufactured, the challenges mentioned in chapter 1 not only impact the environmental and economic benefits associated with RL but also affect customer satisfaction. Therefore, it is of utmost importance to correctly process the information about the urgency to business managers who make critical decisions about processing defective products to get them ready for use back into manufacturing operations after the requested or required changes like repair, reconditioning, remanufacturing is done on them. The current approach of managing reverse flow inventory exacerbates the issues mentioned, undermining efforts to establish a scalable and information-transparent reverse flow for the RL Department.

1.4 Importance of research problem

The urgent defective parts repairs, reconditioning, and remanufacturing at ASML, is critical for several reasons:

1. **High-Tech Industry:** ASML specializes in high-tech precision equipment rather than mass manufacturing products, making the urgency and precision of repairs particularly crucial to their operations. The performance of each component used is integral to the whole machine or system of machines, so prompt and exacting repair work is essential to maintain the stringent standards required for their technology to function optimally.
2. **Technological Leadership & Competitive Advantage:** Currently, ASML is a leader and the only manufacturer of the Extreme UltraViolet (EUV) technology of lithography machines (ASML, 2023)). The semiconductor industry is highly competitive, with constant pressure to innovate and improve. ASML being a leader and the only manufacturer of the EUV technology of lithography machines, the faster repair processes especially for for urgent defects can provide ASML with a competitive edge, demonstrating its responsiveness and technical capability.
3. **High-Stakes Production Environments:** Any downtime or delay in meeting the demands of the respective customers can cause significant disruptions not only for ASML but for the semiconductor manufacturing process as well as for its end customers, leading to substantial financial losses and delays in the production of electronic devices which are produced using the machines and systems from ASML.
4. **Product Quality and Reliability:** Given the precision required in semiconductor fabrication, the performance of ASML's machines directly impacts the quality and yield of semiconductors. Furthermore, in case of urgent defects, the reliability of the defective parts or products that will be used in other machines also raises doubts, this demands a rapid resolution. The urgent repairs ensure that equipment maintains the highest levels of accuracy and reliability.
5. **Supply Chain Continuity:** ASML's machines form a critical part of the semiconductor supply chain. Therefore, rapid repair and turnaround times are necessary to ensure continuous operations and prevent bottlenecks that can affect the entire industry. Streamlining and standardizing return and repair processes is a key focus area for ASML to facilitate the scaling of operations (ASML, 2023, 2024c).

The Table 1.1, shows the number of urgent defective parts or product repair/recondition/ remanufacture requests that the RL team at ASML received from the factory for four months received by emails and other disparate channels. On average, the RL team has to ship 15 defective parts or products on an urgent basis with an unknown level of technicality involved depending on the nature of the defect and the criticality and impact of the part or product. When a part or product is found to be defective, it casts concerns about the reliability of similar parts or products used in other machines. A detailed analysis of the response time taken by the RL team to ship these defective parts out of ASML can be seen in Figure 1.3 and in Figure 1.2. This time is only the time taken by ASML to perform the administrative activities needed to get the urgent defective part or product ready to be shipped out of ASML. This does not include the time by the defective part or product to reach the supplier.

Consequently, there's an expectation for a quick resolution of the defective items. The repair of urgent defective products thus plays a very vital role, as these defective products directly impact the ongoing manufacturing activities at ASML. Although the frequency and the number of requests received might be low and rare compared to the other non-urgent requests, these are high-impact issues that can halt the manufacturing operations at ASML as mentioned in section 1.4

Months	Total Repair Requests	Total Urgent Defect Requests	% of Urgent Defect Requests
January	267	16	6%
February	342	11	3%
March	364	15	4%
April	273	16	6%
Average	**338**	**15**	**4%**

Table 1.1: Summary of the number of Urgent Defect Flow Requests per month(ASML Netherlands B.V., 2024b)

The estimated monetary impact for ASML caused by the delays in shipping the urgent defective parts due to existing processes of usage of fragmented communication processes as mentioned earlier

can be seen in Table 1.2. Table 1.2, illustrates the estimated financial impact on ASML resulting from disruptions in the factory's work-in-progress, attributed to delays while awaiting replacement parts for urgently defective items.

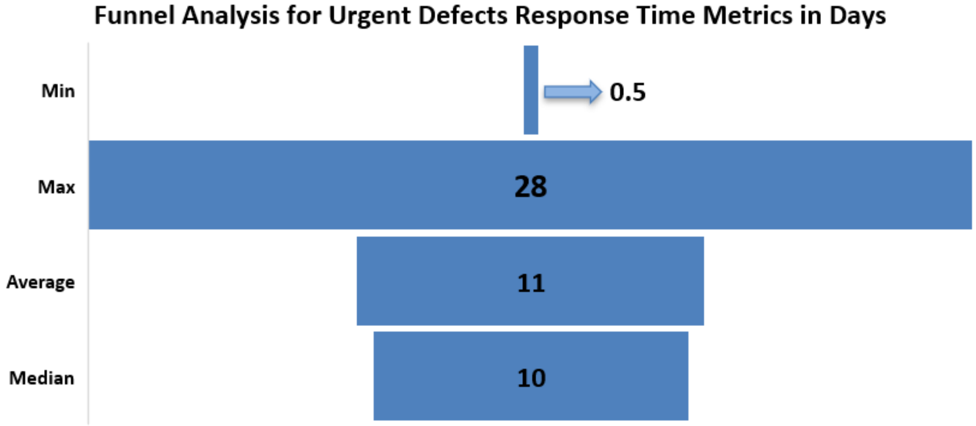


Figure 1.2: Funnel Analysis of Resolution Time for Urgent Defect Flow requests (ASML Netherlands B.V., 2024e)

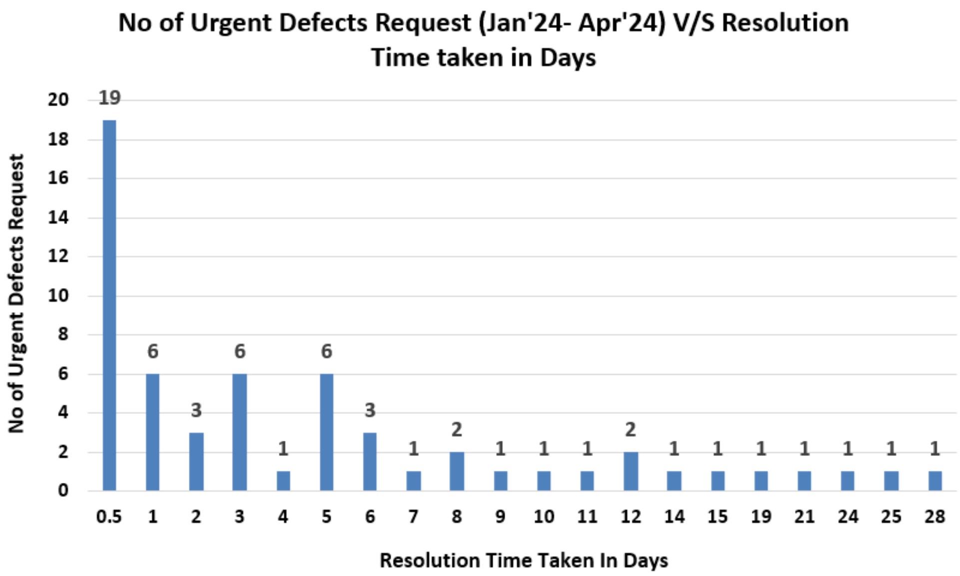


Figure 1.3: Response Time for Urgent Defect flow requests resolution by RL team (ASML Netherlands B.V., 2024d)

Type of Manufacturing Process in the factory	Average Impact (SI & SP + Module Building)/ Day (€)	Average Number of days for each Urgent Defect resolution	Average Urgent Defects per Month	Urgent Defects per Year	Average Impact per Year (€)
Individual Modules and System Integration (SI) with System Performance (SP)	[redacted]	11	15	180	[redacted]

Table 1.2: Estimated Monetary Impact due to delays in UDF Resolution (ASML Netherlands B.V., 2024a)

In ASML, urgent defects can occur at two stages, namely while individual modules (machines/

cabinets) are being built or when the different modules (machines/ cabinets) of a system are assembled and tested. The latter is called System Integration (SI) with System Performance (SP). This monetary impact is due to the urgent defect products as they by their nature halt the entire production process. It serves as a critical indicator for evaluating the efficiency of the urgent defect management process in minimizing financial risk within RL operations. **The qualitative analysis conducted in subsection 4.2.5 highlighted that the monetary impact ASML faces is due to delays in shipping urgent defective parts or products to the supplier. These delays were attributed to the challenges posed by the unavailability of standardized processes and the use of disparate communication methods.**

The estimated monetary impact is aligned with the business needs to address the research problem caused by the usage of fragmented communication processes as mentioned in section 1.2 which is further aligned with the research framework proposed by section 3.2 and in subsection 2.1.1.

The repair of the urgent defective parts needs an immediate response of shipping them out of ASML to the supplier. Each additional day or time that the factory has to wait to get this defective part or product repaired and returned to ASML from the supplier after the required repair is completed to be reutilized leads to potential financial implications. The financial implications that can be incurred by the ASML are from the delays due to a disturbance caused in the work in progress or the halt of the factory operations due to waiting for a replacement part or product. The average impact of any product or part that goes defective in these two stages leads to a halt or disturbance in the manufacturing operations at ASML and it is around € [redacted] per day. This estimated monetary impact is due to the urgent defect products as they by their nature can halt the entire production process. **Considering 15 average Urgent defect repair requests a month, as seen in Table 1.2, the number of urgent defect repair requests in the year is expected to be 180. This can therefore lead to a potential impact of € [redacted] on ASML.** This analysis is a part of the business needs observed as per the Hevner et al. (2004) design science for research framework which is mentioned in section 3.2 and in detail in subsection 2.1.1. The actual amounts are not made available (redacted) for confidential reasons.

As mentioned earlier, the high-tech industry environment in which ASML delves is a very competitive and time-sensitive industry. The delays in shipping the urgent defective parts and receiving them back lead to delays in the manufacturing processes and product delivery schedules of the high-tech companies. These prolonged resolution times for urgent defects can erode customer trust and satisfaction. Furthermore, defective parts can pose safety risks, which can have serious implications in a stringent and highly regulated industry like semiconductor manufacturing.

In conclusion, the imperative for urgent repairs and service at ASML transcends beyond operational efficiency as it reflects the company's broader strategic dedication to quality, customer satisfaction, regulatory adherence, and maintaining its position at the forefront of the industry. Consequently, this emphasis highlights the need to refine and strengthen the processes surrounding urgent defect handling, mandating the implementation of a standardized and reliable process through an IS platform. Thus, the problem statement for the case study can be summarized as follows:

The lack of formalization and standardization for information sharing and communication processes within Reverse Logistics for managing high-impact issues in high-tech companies adversely affects their supply chain performance and, ultimately, their overall business performance. At ASML, the management of high-impact issues like urgent defects within RL processes flow is compromised by the unavailability of a standardized process flow along with the use of disparate and fragmented communication approaches. This disjointed approach results in miscommunications, delays in response times, inaccuracies in data, and challenges in efficiently maintaining traceability of urgent defects. These inefficiencies hinder the organization's ability to swiftly and scalable management of urgent defects, adversely affecting the company's operational transparency, cost-effectiveness, and customer satisfaction. Consequently, ASML requires the development and implementation of a unified and standardized information system-based process flow to streamline these processes, ensuring improved performance in terms of shipping the defective parts faster to the supplier. Therefore, to develop such a flow it is important to identify the factors and inter-dependencies that will impact its development and adoption in a high-tech organization

1.5 Research Objective

The research objective is to develop a strategic approach in the form of a comprehensive framework that enables high-tech companies to identify and overcome challenges associated with fragmented, non-standardized communication and information-sharing processes in RL operations. These challenges pertain to managing time-sensitive, critical, and high-impact issues. **The focus is on identifying and understanding the factors and inter-dependencies that influence the development and adoption of a standardized process flow facilitated by an IS in a high-tech organization. This research will develop a comprehensive framework detailing the technological, organizational, and external environmental factors that affect the adoption and effective implementation of such systems within a high-tech company.** The framework will address different phases of change management for IS-based process flow development and adoption in the organization, identifying relevant factors for each phase.

The novel framework developed, referred to as IS-PSF, is detailed in chapter 5 and illustrated in Table 5.1. This framework aims to serve as an overview and guiding map for high-tech companies, clarifying the considerations necessary for standardizing processes that handle high-impact and critical operational issues through IS functionalities. This framework will act as an overview for developing and adopting an IS-based standard process flow across the organization

ASML Netherlands B.V. has been selected as a case study for this research to probe into the current practices and challenges of managing high-impact issues like urgent defects. This case study will offer insights that apply broadly to other high-tech companies grappling with similar issues. The developed framework will address the pervasive challenges due to the unavailability of a standard process flow by identifying the factors necessary to develop and adopt a standard process flow, described in section 1.1 and section 1.3. It will propose solutions for more efficient and effective communication and information-sharing flow to manage urgent defects and related concerns. This investigation into the challenges and barriers faced by the adoption of IS will showcase how standardized versus non-standardized processes impact operational performance across high-tech industries.

1.6 Research Questions and Scope

1.6.1 Main Research Question:

The main research question of the research is as follows:

Main Research Question: How can high-tech companies standardize their information-sharing and communication processes to address the challenges and impacts of managing high-impact issues in Reverse Logistics?

Explanation: The main research question addresses the challenges of lacking a standardized process for managing information sharing and communication flow, particularly for the high-impact issues (urgent defective parts in this case) in high-tech companies. This study focuses on developing a single, standardized process for managing these issues, replacing the existing fragmented methods. The question examines how this strategic approach can address inefficiencies and communication gaps caused by unavailability of a standardized processes and use of fragmented communication methods. By analyzing current inefficiencies and their impact on the business process performance, and the benefits of an integrated information system, the study aims to create a comprehensive framework for business process standardization and effective IS adoption to manage the high-impact issues. Through stakeholder perspectives and information flow requirements, considering technological, organizational, and external contexts, along with process standardization theories and change management strategies, this study provides actionable recommendations for high-tech companies to optimize RL operations. The goal is to enhance visibility, improve responsiveness, and boost customer satisfaction by efficiently managing these high-impact issues.

1.6.2 Sub-Research Questions:

Sub-research question: 1 What are the current challenges in managing high-impact issues in reverse logistics for high-tech companies?

- This sub-question examines the business need for process standardization by analyzing the impacts and challenges of non-standardized information flows.
- This sub-question explores the current process flow for managing high-impact issues (urgent defective parts in this case) and distinguishes them from other issues.
- This sub-question identifies the challenges and impacts of non-standardized flows for managing high-impact issues, highlighting improvement areas

and opportunities for IS-based standardization.

Sub-research question: 2 What are the technological, organizational, and environmental factors and inter-dependencies that influence the adoption and implementation of IS-based standardized process flow for managing high-impact issues in reverse logistics for high-tech companies?

- This sub-research question identifies the factors and inter-dependencies from technological, organizational, and external contexts for successful IS implementation for managing high-impact issues in RL.
- This identification is based on literature review and semi-structured interviews conducted.
- This sub-research question aims to integrate the learning's from item **Sub-research question: 1** that influence the development of the IS-based standardized process flow.

Sub-research question: 3 What are the potential benefits and impacts of adopting an IS system-based standard process flow for managing high-impact issues in reverse logistics for high-tech companies?

- This sub-question explores the anticipated benefits and positive impacts due to the adoption of an IS system as a standard for the management of high-impact issues.
- The negative impacts of standardization is also explored in this sub-research question

Sub-research question: 4 What strategies can be employed to enhance the adoption and effective implementation of IS-based standardized process flow for managing high-impact issues in reverse logistics for high-tech companies?

- This sub-research question aims to derive strategies that can be recommended for high-tech companies to successfully implement and utilize IS for high-impact issues management.
- Furthermore, this sub-research question seeks to uncover best practices, implementation strategies, change management approaches, and user adoption techniques that are crucial for ensuring the effective utilization and long-term success of the proposed IS-based standard process.
- This sub-research question will also help explore how to standardize process flows for critical activities within RL. This is important for high-tech companies that might face challenges due to uanvailability of standardized processes in RL.
- As per Pan & Jang (2008), understanding the dynamics of IS implementation as a standard process flow is crucial, as a well-executed adoption hinges on selecting an appropriate strategy. Furthermore, as per Pan & Jang (2008), the research suggests that a deliberate and methodical approach to IS roll-out, supported by thorough change management, strong network relationships, and a culture primed for change, is key to ensuring a successful deployment.
- The change management needs to be effective as it ensures that the transition to the selected IS is smooth, with department buy-in and minimal disruption to operations. This overarching strategy supports the implementation of all the previous steps, ensuring that the transition not only occurs but is sustained with continuous improvement.

1.6.3 Research Contribution

Theoretical Contribution

This research adds significant academic value to the field of business process standardization by utilizing the technology of information systems in the emerging and highly uncertain field of reverse logistics in the supply chain management for high-tech companies. The study identifies essential factors and interdependencies necessary for the development and successful adoption of standardized business processes using information systems by developing a novel conceptual framework known as IS-PSF mentioned in Table 5.1. It builds on the Technology-Organization-Environment (TOE) framework, providing a dynamic and novel framework that combines business process management with change management phases. This approach not only addresses inefficiencies caused by the unavailability of standardized processes, but it also improves understanding of the critical role that information systems, formalization, and lateral relations play in organizational performance effectiveness. The research showcases that formalization alone is not sufficient but needs an Information System to achieve standardization. The research showcases that process standardization using IS has a positive impact on business process performance provided that processes are highly routine and transactional. The research also showcases that having a mature and robust IT infrastructure is not enough but also also the role of human factors and effective change management strategy is equally crucial. The framework introduces a new methodology derived from the IS research framework by Hevner et al. (2004) for analyzing complex IS-based process implementations, emphasizing the importance of strategic management support, proactive adaptation, and ongoing monitoring of business processes.

Practical Contribution

The research offers a practical guide for high-tech companies to design, implement, and manage standardized process flows using information systems, particularly in the context of reverse logistics in the form of the overview provided by the framework developed known as IS-PSF mentioned in Table 5.1. It explains how to overcome challenges due to the unavailability of standardized communication practices by implementing a systematic approach to information sharing, which is critical for increasing operational efficiency and ensuring sustainability. The framework assists managers in making informed decisions about technology investments in the form of information systems and change management strategies, thereby facilitating the seamless adoption of new systems across organizational boundaries. By emphasizing the practical application of the conceptual framework, the study bridges the gap between theory and practice, providing actionable insights for improving process performance and stakeholder satisfaction in high-tech industries.

1.6.4 Report Structure

The chapter 1 provides an overview of the background information of the research problem, the case study chosen to effectively study the research problem, the research objectives, and questions. The chapter 2 reviews the existing literature for the research problem and research objectives focusing on Design Science in Information systems research, RSCM and RL, Information sharing and communication challenges, high-impact issues management, information systems and their use in RL, TOE framework, process standardization and management theories and finally the change management theories and model. The chapter 3 focuses on the research methodology, data collection, data analysis methods, and validation. The chapter 4 summarises qualitative analysis focused on the research findings, including some noteworthy discoveries. The chapter 5 presents the framework for IS-based process standardization development and adoption. The chapter 6 validates the framework developed using semi-structured interviews. The chapter 7 discusses the research findings by answering the sub-research questions, followed by the academic and practical implications of the research, and concludes the research by answering the main research question of this thesis research.

Chapter-2: Literature Review

In the dynamic field of RL for high-tech manufacturing environments, understanding the factors that influence the adoption of standardized processes and IS is critical for enhancing operational efficiency and overall business performance. This chapter reviews existing literature to provide a comprehensive overview of current knowledge, theories, frameworks, and empirical findings related to process standardization, IS adoption and implementation, and change management for IS adoption within high-tech environments. This literature review establishes a solid foundation for the research methodology employed in this study, directly aligning with the research objective of developing the framework of IS based standard process flow development and adoption and also for performing detailed qualitative analysis.

2.1 Literature Review Approach

While a full-scale systematic literature review (SLR) is not conducted in this research, a targeted literature review approach, drawing from the principles of SLR, is employed to explore the existing body of knowledge related to the research problem and objectives. This approach leverages the strengths of SLR in providing a structured and transparent process for identifying, selecting, and synthesizing relevant literature while focusing specifically on the key areas of interest.

The preference for an SLR approach stems from its ability to offer comprehensive details on search and selection methodologies, criteria for inclusion and exclusion, and techniques for validation, making it particularly suitable for a technical audience (King et al., 2020). This targeted literature review follows a systematic process of defining the search strategy, establishing inclusion and exclusion criteria, and applying techniques for validation, ensuring the reliability and relevance of the selected literature.

By concentrating on the specific aspects of the research problem, such as the challenges of managing time-sensitive, critical, and high-impact issues in reverse logistics, the standardization of communication and information-sharing processes, and the role of Information Systems (IS) in enabling process standardization, the literature review provides a comprehensive understanding of the current state of knowledge and identifies potential gaps for further investigation. The SLR approach as per Armitage & Keeble-Allen (2008) is as follows:

Consideration	Systematic Reviews
Review Question Formulation	Begin with a specific research question, followed by the sub-research questions that will guide in answering the main research question
Literature Search	Aim to include all pertinent literature to minimize bias.
Study Selection	Clearly state inclusion/exclusion criteria to avoid reviewer bias.
Quality Assessment	Systematically scrutinize methods and potential biases of studies.
Synthesis of Findings	Draw conclusions from methodologically robust studies.

Table 2.1: Systematic Literature Review Approach (Armitage & Keeble-Allen, 2008)

This targeted literature review approach allows for a more efficient and focused examination of the literature while maintaining the rigor and transparency associated with SLR. The insights gained from this targeted literature review contribute to the development of a robust conceptual framework and inform the research design and methodology, ensuring that the study builds upon existing knowledge and addresses the key challenges and opportunities identified in the literature.

For conducting the targeted literature review for the IS to act as a standard process flow in RL within a high-tech manufacturing context, identifying search terms, their synonyms, and their relevance is crucial for effectively navigating academic literature databases. A structured approach to formulating the search strategy for the literature review can be seen in Table 2.2.

Search Term	**Synonyms**	**Relevance**
Reverse Supply Chain Management	Reverse Logistics, Returns Management, circular supply chain, product recovery process, and closed-loop supply chain	Essential for understanding the theoretical and practical aspects of managing the flow of products from the point of consumption back to the point of origin.
Information Systems	Integrated information systems, Information Technologies for communication and information exchange	Crucial for exploring how information systems are used to streamline communication and information sharing RL.
High-Tech Manufacturing Defects	Defect Management	Relevant for identifying challenges and strategies related to defect identification, reporting, and resolution in high-tech industries.
Urgent Defect Management	Critical defect resolution and expedited defect handling strategies, Unserviceable and incorrectly received parts	Focuses on the management and prioritization of defects that require immediate attention to prevent significant disruptions in manufacturing and SC processes.
Challenges and Risks in SC	Information sharing challenges, Multiple Processes, Information Accuracy Risks, Non-standard process flows, Process standardization, Formalization, Stakeholder collaboration, and Communication inefficiencies	Highlight the obstacles in effective communication within RL processes, essential for identifying areas for optimization and standardization through the Information system.
Supply Chain Transparency and Visibility	Visibility in supply chain/ Reverse Logistics, traceability in Supply Chain/ Reverse Logistics, open supply chains	Important for understanding how increased transparency through optimized information systems can improve defect management and stakeholder communication.
Enterprise Resources Planning Systems in Supply Chain	ERP role in Supply Chain/ Reverse Logistics, ERP Infrastructure	Specific focus on the role of ERP systems in SCM, including the handling of defects and reverse logistics operations. The scalability of operations through ERP will also be investigated here.
Technology, Organization, and Environment Framework	TOE	To examine the technological, organizational, and environmental factors that influence the adoption and implementation of the tailored IS for managing urgent defects in the high-tech company's RSC operations.
Business Process Standardization	Process Management, Formalization, Standardization of business processes	Specific theories for understanding the impact of process standardization.
Change Management	Change Management strategies and Models	Understand the role of change management in technology deployment and adoption.

Table 2.2: Search Description for Literature Review

The literature review for this research was conducted using a comprehensive set of search terms to ensure a broad and relevant scope. The following combinations of search terms were employed:

- ("Reverse Supply Chain Management" OR "Reverse Logistics" OR "Circular Supply Chain")
- AND ("Information Systems" OR "ERP Systems")
- AND ("High-Tech Manufacturing Defects" OR "Quality Issues in Manufacturing")
- AND ("Urgent Defect Management" OR "Unserviceable OR Incorrect Parts")
- AND ("Circular Economy" OR "Sustainability in Supply Chain")
- AND ("Communication Challenges in SCM" OR "Communication Inefficiencies")
- AND ("ERP Systems in SCM")
- AND ("Supply Chain Transparency" OR "Visibility in Supply Chain")
- AND ("ERP")
- AND ("Technology, Organization, and Environment" OR "TOE")
- AND ("Business Process Standardization")
- AND ("Change Management")

This combination of search terms was designed to capture the multidisciplinary aspects of the research, focusing on reverse logistics, information systems, high-tech manufacturing defects, process standardization theories, change management strategies and the various factors influencing the development adn adoption of IS based standardized processes in the context of RL.

For the literature review, a targeted SLR was conducted by searching bibliographic databases, which included Web of Science, Scopus, and Google Scholar.

This strategy balances specificity with breadth, ensuring that the research captures a wide range of relevant literature while remaining focused on the core aspects of the research problem.

2.1.1 Design Science in Information systems research

The design-science paradigm is essentially a problem-solving paradigm (Hevner et al., 2004). The goal of this paradigm is to develop innovative ideas, practices, technical capabilities, and products for effectively and efficiently analyzing, designing, implementing, managing, and using Information Systems (IS) in an organization (Hevner et al., 2004). IS are implemented in an organization to improve its effectiveness and efficiency by aligning IT capabilities with business strategies and needs (Hevner et al., 2004). The extent to which that purpose is achieved is determined by the capabilities of the IS and the characteristics of the organization, including its work systems, people, and development and implementation methodologies Hevner et al. (2004). IS research focuses on creating purposeful artifacts in the form of constructs, to solve previously unsolved problems, ensuring that these solutions are practical and useful in real-world scenarios (Hevner et al., 2004). **IS research is crucial for understanding the interplay between business strategy, IT strategy, and organizational infrastructure, which helps organizations adapt to new technologies and change the way they operate (Hevner et al., 2004).**

As per Hevner et al. (2004), IS research combines human, organizational, and technological aspects. IT artifacts include vocabulary and symbols, models and abstractions, algorithms and practices, and implemented and prototype systems. These concrete prescriptions help IT researchers and practitioners address the challenges of developing and implementing IS within organizations. IS behavioral science research frequently focuses on IT artifacts in organizational contexts. Theories aim to predict or explain artifact use, perceived usefulness, and impact on individuals and organizations (net benefits) based on system, service, and information quality Hevner et al. (2004).

Furthermore, Hevner et al. (2004) states that design science is the process of creating and evaluating IT artifacts to address organizational problems. Evaluating a new artifact in an organizational context allows for the use of both quantitative and qualitative methods. To develop theories or solve problems, it's important to qualitatively assess the complex interactions between people, organizations, and technology to be adopted (Hevner et al., 2004). Field studies help behavioral scientists understand organizational phenomena in context while constructing and testing innovative IT artifacts helps design scientists understand the problem and feasibility of their solution. An IT artifact can be a model, method, framework, or instantiation that enables researchers to develop and successfully implement (Hevner et al., 2004). **The IT artifact to be developed for this research is a framework designed to identify and analyze the factors and inter-dependencies critical for achieving IS-based standardized process development and adoption. This framework will serve as the instantiation tailored specifically for a**

high-tech company, providing a structured approach to guide the integration and optimization of information systems within organizational processes. This systematic framework aims to enhance the understanding and implementation of standardized practices in high-tech environments, aligning technological solutions with organizational goals.

IS and the organizations they support are complex, artificial, and purposefully designed and are composed of people, structures, technologies, and work systems Hevner et al. (2004). **According to Hevner et al. (2004) IS design research Framework, the design of IS research lies in the intersection of people, organizations, technology, and existing knowledge-based foundations and methodologies. The conceptual framework for understanding, executing, and evaluating IS the research combines behavioral science and design-science paradigms are presented in Figure 2.1.**

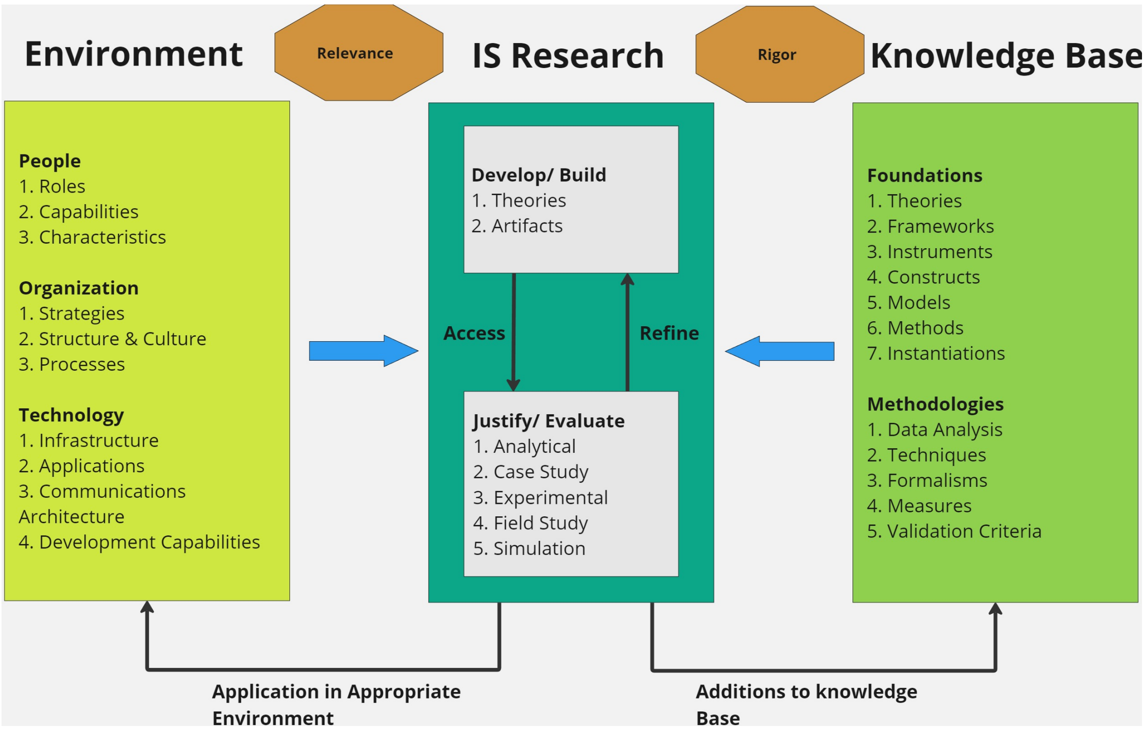


Figure 2.1: Information Systems Research Framework (Hevner et al., 2004)

Hevner et al. (2004), delineate three intertwined components in Design Science Research: the environment, IS research, and the knowledge base. The environment encompasses the business needs OF adoption of IS and forms the context wherein the research phenomenon is situated, comprising the people, organizations, and the technology being utilized or planned to be used. The knowledge base provides the foundational knowledge necessary for advancing IS research and methodologies. IS research itself involves the activities required to create and assess artifacts designed to satisfy business needs. This includes the development of theories and artifacts, followed by their evaluation through various methodologies. Further, Hevner et al. (2004) proposes five evaluation methods: analytical, case study, experimental, field study, and simulations. **In this research, given the nature of research problem, a case study is chosen as a suitable justification and evaluation method. This method will be the validated in validation phase of the research framework as mentioned in subsection 3.2.5**.

The environment in IS research encompasses people, business organizations, and their current or prospective technologies (Hevner et al., 2004). It includes the goals, tasks, challenges, and opportunities that define the business needs as perceived by organizational members. These perceptions are influenced by the roles, capabilities, and attributes of the individuals within the organization (Hevner et al., 2004). **Business needs of IS adoption are assessed and appraised within the framework of the organization's strategies, structure, culture, and existing business processes (Hevner et al., 2004).** These are considered concerning the existing technological infrastructure, applications, communication architectures, and developmental capabilities of the organization. This comprehensive context shapes what the researcher identifies as the business problem or need (Hevner et al., 2004). The research that aims to address these business needs ensures the relevance of the research (Hevner et al., 2004).

Design Science Research (DSR), in particular, involves creating and evaluating artifacts designed to address these identified business needs. These artifacts may demonstrate utility through the discovery of new truths (Hevner et al., 2004). The knowledge base, consisting of foundations and methodologies, supplies the essential literature for IS research. This base includes foundational theories, frameworks, instruments, constructs, models, methods, and instantiations from previous IS research and relevant disciplines, which are utilized during the development phase of research. Methodologies guide the evaluation phase to ensure rigor by applying existing foundations and methodologies appropriately (Hevner et al., 2004). In design science, computational and mathematical methods are predominantly used to assess the quality and effectiveness of artifacts, though empirical techniques can also be used (Hevner et al., 2004). **In this research, the business needs to overcome the challenges due to unavailability of standardized business processes to manage the high-impact issues are addressed by designing an IT artifact. This IT artifact is a framework that identifies the factors and inter-dependencies that influence the development and adoption of IS based standardized process flow aimed to overcome the challenges presented and ensure organizational effectiveness and efficiency.** The different theories and frameworks used for the knowledge base of this research can be found in the following sections.

Hevner et al. (2004) points out that design science research artifacts are often not fully functional IS for practical use. Artifacts are innovations that define the ideas, practices, technical capabilities, and products needed to analyze, design, implement, and use IS efficiently (Hevner et al., 2004). This justifies the research objective of this thesis research of designing a framework that will serve as an overview and guiding map to identify the factors and inter-dependencies influencing the development and adoption of IS-based standardized process flows when the high-tech companies looking to develop and implement such process flows effectively.

2.1.2 Reverse Supply Chain Management (RSCM) and Reverse Logistics (RL):

The return of products is becoming inevitable across all industries, and returns can occur at any time during the product life cycle. As mentioned in chapter 1 and by Badenhorst (2016), in comparison to forward logistics flows, RL is characterized by significantly higher levels of uncertainty. This uncertainty manifests in variations in the quantity, quality, and timing of returns making RL a predominantly reactive process. Organizations typically do not undertake RL activities as part of proactive planning, instead, these activities are often initiated in reaction to demands or requirements from downstream partners or customers Badenhorst (2016).

As explained in chapter 1, RSCM involves reusing defective materials after they are repaired/ reconditioned or remanufactured. Many companies have integrated RL into their SC planning to meet compliance requirements. This approach aligns with environmental regulations and sustainability expectations, while also providing a business advantage through recovered products (Ardeshirilajimi & Azadivar, 2015). RL is part of the RSCM that focuses on the physical movement and handling of materials, like transportation, warehousing, and sorting. RSCM takes a broader strategic view, including data analysis, value recovery planning, stakeholder collaboration, and innovation for reuse and remanufacturing (Prahinski & Kocabasoglu, 2006). RL plays a crucial role in sustainability by ensuring that recovered resources are reintegrated into the supply cycle, transforming old products into raw materials, as per Boronoos et al. (2021). Thus, the potential for enhanced performance is a significant factor motivating companies to improve quality by developing their RL capabilities (Morgan et al., 2016).

The global population increase and the escalating consumption of technology is intensifying pressures on the high-tech sector (Coronado Mondragon et al., 2015). Additionally, this industry contributes significantly to carbon emissions, generating about two to three percent of the world's total, which is on par with the global aviation sector, due to the surging demand for technological products (B. Xu & Lin, 2018). Furthermore, B. Xu & Lin (2018) discovered that decreasing CO_2 emissions is advantageous for the high-tech industry. Taking part in reuse activities, including repairs, has been financially rewarding for the industry, and suppliers are increasingly expected to enhance their sustainability practices (Coronado Mondragon et al., 2015).

The high-tech manufacturing sector is characterized by its reliance on intricate supply chains and the critical need for maintaining high-quality standards (Team, 2019). The aim of incorporating RL processes in manufacturing businesses is to recapture value from these subpar defective products (Starostka-Patyk, 2017). As mentioned in chapter 1, RSCM consists of various activities like repair, reconditioning, remanufacturing, recycle. Amini et al. (2005) states that effective RL operations play a crucial role in executing repair services, increasing profitability and competitive advantage for companies in highly competitive environments. Minner (2001) further states that there is significant potential for cost reduction and service enhancement which serves as a motivating factor for developing planning techniques and coordinating the various stakeholders involved in the logistics chain. As per R. Huscroft et al. (2013), parts in the RL pipeline may need to be expedited, such as when a customer needs an unserviceable asset replaced or repaired, or when an incorrect order is received. This can result in higher shipping, transportation, and handling costs for the RL process owner (R. Huscroft et al., 2013).

For companies, management of RL can be a challenge, as it requires a high level of coordination and communication across departments, as well as a thorough understanding of the product lifecycle (Alexwells, 2023). While organizations often possess sophisticated information and technology systems for forward logistics, reverse logistics systems require further enhancement (C. K. M. Lee & Lam, 2012). Product returns for remanufacturing through the reverse supply chain enhance customer satisfaction, as observed by Mishra et al. (2022). While returns are often seen as a setback, being equated to negative sales and affecting an organization's accountability as noted by W. Xu et al. (2018), effectively managing the RSC and logistics can reduce unnecessary expenditures and material consumption. This, in turn, lessens the financial strain returns and recalls have on an organization's performance, as discussed by Vlachos (2016). Garg & Sharma (2020) suggest that long-term success necessitates acknowledging RSC's value for profitability through significant raw material cost savings.

The control and tracking of returned material plays a significant role in the high-tech manufacturing industry and thus the ability to manage these returned parts is very crucial (Boykin, 2001). In high-tech industry the parts cost varies from several dollars to hundreds of thousands of dollars, making the management of returns both economically significant and strategically critical (Boykin, 2001). To manage this efficiently, a return material authorization (RMA) process is established. RMA involves both the physical flow of the defective part as well as the flow of information concerning the part (Boykin, 2001). RMA begins with the high-tech company contacts the parts supplier for when a defect arises to ask for the analysis and repair activities. The RMA process is tracked using a unique number assigned to each request (Boykin, 2001). All the communications related to the defective part between the high-tech company who is the customer of the defective part while the supplier who is the manufacturer of the defective parts happens with RMA number as an identifier and reference (Boykin, 2001).

According to Alarcón et al. (2021), one significant challenge in implementing and managing RL processes is the absence of formalization. This concept is essential for guiding and managing activities both internally within an organization and throughout its supply chain, as emphasized by Richey et al. (2005). The establishment of a formalized plan is critical for improving the oversight of RL processes, providing a methodical and regulated framework for operation (Hartline et al., 2000). Thus, the degree of formalization within RL processes can indicate the extent of a company's control over its RL operations, as noted by Genchev et al. (2011). Alarcón et al. (2021), further highlights that while existing studies extensively describe the problems associated with the lack of RL processes formalization, they fail to provide practical tools or solutions for companies to address this issue. Furthermore, establishing formalized RL processes enables companies to effectively set and manage customer expectations regarding returns. This formalization not only benefits organizations but, combined with the enhancement of skills among personnel engaged in recovery activities, serves as a crucial facilitator for the development of the RL system Alarcón et al. (2021). Furthermore, as per Genchev et al. (2011) when a new business activity is introduced for formalization, that requires a change in the firm's operations, the adoption of a process-oriented approach is recommended.

According to Badenhorst (2016), RL presents a compelling case for the use of standardized processes, particularly as product returns increase across industries. Companies are actively working to standardize their RL processes to create unique procedures and standards that improve the efficiency of returns handling. Implementing standardized and uniform processes throughout the supply chain can enhance the consistency of results. By standardizing operations, variations, and errors can be significantly reduced (FasterCapital, 2024). The advantages of standardization in RL are numerous as mentioned in chapter 1 and by Badenhorst (2016) like it makes returns much more visible, making them easier to track and manage. Furthermore, standardization improves operational flexibility and efficiency by establishing formal rules and procedures, reducing the need to treat each return as an individual case. As product returns increase, many organizations aim to standardize the reverse logistics process (Huang & Yang, 2014; Badenhorst, 2016). Thus standardization supports the scalability of RL operations. Finally, standardizing processes can significantly reduce conflicts and confusion in RL operations, thereby clarifying return flow management and reducing uncertainties. Overall, the adoption of standardized processes in RL is crucial for streamlining operations, improving efficiency, and reducing operational ambiguity. R. Huscroft et al. (2013) mentions that the timing of operations is a factor that impacts the RL performance. It deals with concerns related to on-time delivery requirements, service requirements, cycle time, and effective use of transportation opportunities. R. Huscroft et al. (2013) further emphasizes that the aspect of timing in

RL operations, while initially receiving less attention, is increasingly recognized for its importance as organizations begin to integrate RL management more thoroughly into their system-wide operations. The emphasis on timing highlights the necessity for precise coordination among stakeholders involved to ensure efficient product returns, repairs, and recycling processes. This eventually impacts customer satisfaction. Standardization also enhances data handling. Utilizing uniform data formats across all stakeholders in various cross-functional departments simplifies data sharing and analysis, fostering better decision-making, minimizing mistakes, and increasing the transparency of the supply chain (FasterCapital, 2024).

Olorunniwo & Li (2010) emphasizes that to make more commitment to RL and build a better control system, particularly in measuring performance, the KPIs play a vital role. As per J. Hall et al. (2013), the top management team in an organization sets meaningful goals and communicates the organization's priorities to its constituents. Constituents determine how their work processes contribute to the organization's priorities, which are then implemented throughout the organization. This prepares managers to establish performance metrics for their employees and processes. When developing performance metrics, it's crucial to ensure that they accurately reflect desired outcomes (J. Hall et al., 2013). The goal-setting theory posits that well-defined and conscious objectives can significantly influence actions. These actions directly impact performance, whether at the individual, group, or organizational levels (J. Hall et al., 2013). Metrics serve as an essential aspect of goal-setting and achievement by measuring performance and determining the extent to which objectives are met. Nonetheless, for performance metrics to be truly valuable and provide an accurate assessment of performance, they must be correctly aligned with the organization's goals (J. Hall et al., 2013). Melnyk et al. (2004) states that the main goal of performance metrics is to showcase how a certain process generates value for the organization. Research conducted by Nunes et al. (2023) the assessment of business performance is linked to decision-making. Effective decision-making involves gathering quantitative or qualitative information to evaluate the system's state Nunes et al. (2023). Performance indicators are then used to monitor, control, and manage the process (Nunes et al., 2023). The performance metrics therefore help managers and executives make informed decisions about the current and future state of operations and highlight areas in need of improvement (Melnyk et al., 2004). According to Butt (2020), KPIs and metrics go hand-in-hand to reflect strategic drivers and align with the organization's vision and goals.

According to J. Hall et al. (2013), RL is segmented into two primary operations. Initially, the operation that involves accepting a product that a customer has sent back, is referred to as the "inbound" operation. Subsequently, the operation that deals with sending a product back to the original provider, is called an "outbound" operation. The factor of Communication was the top-rated challenge for outbound operations and the second most frequently cited challenge for inbound operations. The high costs and risks associated with RL processes in the high-tech sector necessitate top managers who are receptive to these processes and actively advocate for them. These managers should intensely focus on the utilization and implementation of new technologies to ensure their successful acceptance and seamless integration within the organization García-Sánchez et al. (2018).

For the outbound logistics, as per J. Hall et al. (2013), the performance metrics can be focussed on the level of service provided by the supplier in terms of quality performance index to evaluate both the product quality and effectiveness of processes that underwent to repair the parts. Furthermore, the metric of wait time was highlighted which relates the service delays such as the time taken to repair, receive credits or any other general delays.

Furthermore, J. Hall et al. (2013) states that outbound organizations may aim for quick inventory replenishment, but inefficiencies in returning products to suppliers can impede this goal. Outbound-focused companies can prioritize internal processing time to prepare products for shipment as a key performance metric and is therefore necessary to view each process separately. As per J. Hall et al. (2013), the internal processing time until shipped is a key performance metric for RL outbound operations. This is further supported by Hazen et al. (2015) who states that one of the most relevant measures of operational performance is processing effectiveness, which entails how quickly and easily a return transaction can be processed by an organization (Hazen et al., 2015). The commonly assessed outcomes of an organization's processes and programs that reduce organizational costs are customer satisfaction, operational effectiveness which is primarily operational, and cost-effectiveness which is primarily financial.

Olorunniwo & Li (2010) further states that on-time shipping of parts to be returned should be an indicator to assess the effectiveness and efficiency of RL activities. Hazen et al. (2015) highlights that appropriate metrics can help shape communication and coordination across functions.

Olorunniwo & Li (2010); Ravi & Shankar (2005) further state that as per their research, many high-tech companies have not established any performance indicators for RL which acts as one of the major barriers to a successful reverse logistics processes.

RL relies more heavily on innovation compared to other processes because reverse flows differ significantly from forward flows, necessitating distinct handling and greater resource investment. Organizations that dedicate focused attention to RL processes and stay up-to-date with technological advancements will be better equipped to adopt new technologies that enable them to excel in RL activities. Consequently, this will enhance their overall market performance (García-Sánchez et al., 2018).

According to the Morgan et al. (2016), logistics performance is defined by the efficiency, effectiveness, and distinctiveness of a company's logistics operations. Several companies strive to set themselves apart through their RL and return management activities, highlighting the sustainability advantages of these processes. RL initiatives are recognized not only for their financial benefits but also for their contribution to environmental sustainability.

2.1.3 Defects Management in Reverse Supply Chains

As per Starostka-Patyk & Nitkiewicz (2014), returns are often labeled as waste in many descriptions. These are usually products that are defective or have reached the end of their life cycle. Lambert et al. (2011), states that gatekeeping, a critical process in RL is initiated when a customer expresses the intention to return a product to the supplier company. At this stage, the supplier company conducts an initial screening to determine which products are eligible to enter the RL system and which are to be excluded due to being non-functional. This process may involve offering technical assistance to the customer, as part of the supplier company's efforts to diagnose the problem. The various activities for defect management involved in RL can be visualized in Figure 2.2 and are explained (Khor et al., 2016):

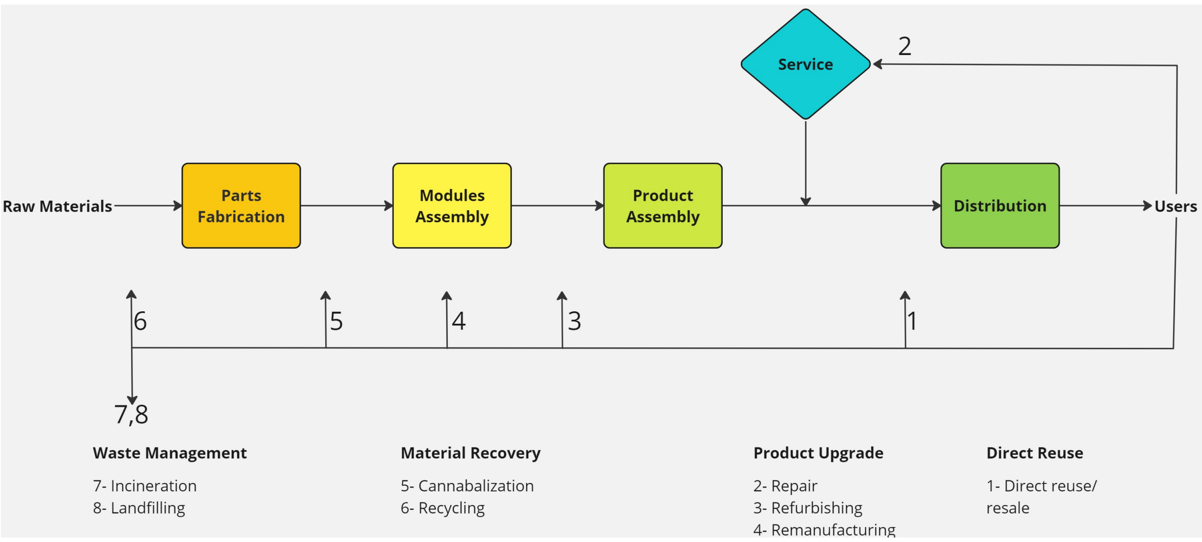


Figure 2.2: Disposition alternatives on the reverse supply chain (Prahinski & Kocabasoglu, 2006)

- Repair involves the process of mending or substituting faulty components or modules to return the product to its operational state.
- Reconditioning, a more comprehensive process than repair, involves partial disassembly of the product to bring it back to specified operational standards. This process includes testing and fixing or substituting components or modules that are failing or likely to fail.
- Remanufacturing, a step above reconditioning, entails returning used products to meet or exceed the specifications set by the original equipment manufacturer (OEM). This process requires full disassembly, followed by thorough testing, and updating or replacing outdated or worn components.
- Recycling involves a sequence of actions designed to recover usable materials from end-of-life products or components. This includes collection, shredding, sorting, and processing materials to be repurposed into new products, effectively stripping the original product or component of its identity and function.

As per Amini et al. (2005), managing reverse logistics operations, particularly for repair services, presents distinct challenges. Some of the challenges mentioned by Amini et al. (2005) are as follows:

- Fluctuating and inconsistent demand for repair parts, leading to inefficient inventory turnover.
- Variation in repair processing demands specific to each customer's operational needs. This is very crucial in high-tech companies whose products are complex and often specialized types.
- The necessity of shorter repair cycles.
- The importance of coordination among the multiple stakeholders involved in repair services.

2.1.4 Information Sharing Challenges in Reverse Supply Chains

Managing successful coordination of RL in the supply chain requires collaboration (Prakash & Barua, 2015). The ability to collaborate with various players in the reverse chain is as important as in the forward chain. What makes a forward supply chain successful is the collaboration, visibility, and trust of the various entities in the chain. This is also true for the reverse chain (Olorunniwo & Li, 2010).

As per the study done by R. Huscroft et al. (2013), coordination amongst the stakeholders in RL was ranked as an important factor along with customer support and top management support for the successful adoption of RL. Within the context of RL, this factor primarily concerns the ability to accurately communicate the status of a product to be returned for repairs or others within the RL process promptly to all affected stakeholders. In the context of a global market, organizations must synchronize their activities across the entire value chain. This type of coordination is key to preserving value and achieving customer satisfaction. The effectiveness of vertical coordination is determined by the structure and operation of the RL network (R. Huscroft et al., 2013). R. Huscroft et al. (2013) defines communication as a crucial factor for vertical coordination, which entails the readiness and capability to share strategic and tactical data and information with stakeholders in the process, whether within or external to the organization. According to Lambert et al. (2011), information transparency in an RL information system improves information sharing throughout the entire SCM. Furthermore, Kembro et al. (2014) states that information sharing improves and facilitates the coordination of processes.

Information sharing among supply chain stakeholders is a fundamental requirement for successful SCM. Recent advances in information technology make it easier to share information (H. L. Lee & Whang, 2000). The array of technologies designed to bolster Supply Chain Management (SCM) efforts is broad and continuously evolving. Regrettably, there isn't a one-size-fits-all Information Technology (IT) solution for SCM challenges. Organizations must investigate multiple options to identify a solution that meets the specific needs of their SCM projects.

Without the right information systems and supporting technology, SCM initiatives are likely to face significant challenges in achieving success (Prasad et al., 2010). As per Prasad et al. (2010), the existing literature primarily focuses on individual aspects of IT in the context of SCM, such as the adoption of inter-organizational information systems, Electronic Data Interchange (EDI), the design of Collaborative Planning, Forecasting, and Replenishment (CPFR) systems, the utilization of network technologies, the implementation and usage of Enterprise Resource Planning (ERP) systems, applications of Radio Frequency Identification (RFID) in the supply chain, and the impacts of electronic marketplaces or learning outcomes from online ordering. However, these studies rarely explore the trade-offs between various IT solutions and other methods of information exchange in SCM. Furthermore, Prasad et al. (2010) emphasizes that for a supply chain to be managed effectively, it's crucial to handle visibility, coordination, information sharing, and communication both within the enterprise and among the network of supply chain partners. Organizations have thus recognized that achieving efficient and effective supply chains is unattainable without a solid, well-integrated information system that spans the entire enterprise. Thus, as per R. Huscroft et al. (2013), investigating the impact of communication on RL performance has been and will continue to be a valuable topic for academic research.

R. Huscroft et al. (2013) states that formalization encompasses defining clear responsibilities, standardizing processes and procedures, and equipping individuals with the necessary information for process implementation is an important factor that affects RL. Formalizing the RL process is critical for managing both internal and external stakeholders' expectations regarding returns. This clarity and structure are essential for operational success. However, the absence of formalization can lead to inefficiencies and diminished faith in the process, particularly if tasks are delegated without clear guidance or follow-up, resulting in delays and adjustments that disrupt the entire operation (R. Huscroft et al., 2013).

Furthermore, according to R. Huscroft et al. (2013) standardized performance metrics aligned with the firm's RL goals are crucial for monitoring and ensuring process efficiency. This need for formalization and standardization underscores a significant gap in the literature and presents a potential area for future research, including exploring the impact of formalization on cost reduction, uncertainty, vertical coordination, customer satisfaction, and the effectiveness of incentive systems. Thus, formalization can be achieved by standardization of processes (R. Huscroft et al., 2013). Formalization is initially described as the degree to which rules, procedures, instructions, and communications are documented (Alarcón et al., 2021). Genchev et al. (2011)s provides a succinct explanation, describing formalization as the documentation of rules and procedures that are collectively agreed upon for a specific business activity. Further elaboration by other scholars indicates that formalization can be executed through various methods such as defined and documented policies, job descriptions and roles, charts detailing organizational responsibilities, strategic and operational planning, systems for setting objectives, process standardization, and formalized systems of communication both within and between firms (Alarcón et al., 2021). Thus, Genchev et al. (2011), investigated formalization as a way of improving RL flows.

Furthermore, Genchev et al. (2011) states that formalization can reduce costs, simplify operations, and improve logistics efficiency and effectiveness. Although formalization can reduce operational flexibility, hinder innovation, and make knowledge transfer more difficult it is found that formalization in logistics has more benefits than drawbacks. The same is true in RL, formalization has a significant potential to help managers "make order out of chaos" in return and it can be a useful tool in streamlining RL operations (Genchev et al., 2011).

To conclude, as per Badenhorst (2016), there are a few studies that focus on specific practices or issues to improve reverse logistics processes and thus clearly illustrate the need for research into how RL processes can be improved and made efficient.

Risk is broadly defined as any possible event or circumstance that can have a negative influence on the enterprise (Bai et al., 2013). As per Bai et al. (2013), risk arises from the potential negative consequences caused by data errors in the information flow. Risk takes the form of monetary costs, legal penalties, or operational inefficiencies. The information flow in a business process is the flow of informational units passing through a sequence of tasks in a process. Errors may be introduced into the data contained in an information unit because of mistakes, omissions, software glitches, or fraud. The incorrect, missing, or spurious data in an information unit is referred to as an error. The data accuracy required for defect processing can be connected to errors in information flow (Bai et al., 2013). Business processes utilize various control procedures to prevent, detect, and correct errors in information flow. Each control procedure detects and corrects specific error types at task locations (Bai et al., 2013). By placing control procedures at different tasks or activity locations in the process can reduce errors and risks (Bai et al., 2013).

To address issues such as a lack of control and information about the return flow, organizations can invest in technologies (Li et al., 2015). As per New (2010, 2015); Doorey (2011), supply chain transparency is a concept gaining traction within supply chain management, spotlighting the importance of visibility across reverse logistics operations. The visibility problems can be mitigated by adopting a web-based approach (Badenhorst, 2016). A web-based approach allows organizations to capture the reasons for product returns, assess product quality, and evaluate customers' return habits (Badenhorst, 2016). Furthermore, to overcome human error and inconsistency in manual data recording, organizations can utilize technological solutions based on various technologies to enable item tracing and real-time data management, ensuring improved reverse logistics operations (Awasthi & Chauhan, 2012). Sodhi & Tang (2019), states that visibility serves the requirements of stakeholders within the company (or its supply chain), such as managers, direct suppliers, or immediate customers. Furthermore, Sodhi & Tang (2019) suggests that increasing visibility adds value to an organization by not only facilitating transparency but also by minimizing risk exposure and enhancing efficiency simultaneously. Traceability refers to a company's ability to determine the origin of its products. This aspect of visibility allows a company to track the provenance of items within its supply chain (Sodhi & Tang, 2019).

Thus, several key factors have been identified as paramount for enhancing the performance of RL are efficiency of RL operations, transparency and visibility of processes, scalability of RL processes, and the necessity for standardization of processes through formalization.

2.1.5 Information Systems (IS) in Reverse Supply Chains

RL heavily relies on IT to enhance and maintain visibility across the reverse supply chain, tracking the movement of goods effectively (Olorunniwo & Li, 2010). In the context of RL, the Information Systems plays a crucial role in managing returns, facilitating effective communication among involved parties, and assisting in the identification of products as well as determining the appropriate actions for them (Lambert et al., 2011). RL and RSCM operations face numerous obstacles, as identified by various researchers, and are typically categorized into operational, financial, legal regulatory, and environmental issues. A deeper analysis of the root causes of these barriers often reveals that poor information flow, along with fragmented and inconsistent operations, are significant issues (Jayasinghe et al., 2019). Therefore, as per Jayasinghe et al. (2019) to effectively manage and streamline RLSC operations, a robust approach to sound information flow/ information management (IM) is essential for regulating information related to inputs, outputs, and processes. In modern times, Information Technology (IT) plays a pivotal role for managers in storing data, communicating data, sharing information, and making informed decisions. The essence of supply chain management thus lies in information sharing and collaboration (Olorunniwo & Li, 2010). As per Wong et al. (2011), previous research in Supply Chain Management (SCM) has identified two critical levels of integration to support the coordination of business processes essential for SCM. These are intra-organizational Information, which crosses internal departmental boundaries, and inter-organizational Information, aimed at enhancing communication with supply chain partners. Intra-organizational information involves connecting a company's IT applications with data gathering and storage systems, ensuring the swift and accurate exchange of information to aid cross-departmental processes. On the other hand, inter-organizational information focuses on standardizing and digitizing the exchange of information across the business activities of different organizations. This type of integration facilitates the availability of information for quick distribution to supply chain partners, enabling them to make timely decisions and take action in the market (Wong et al., 2011).

Due to the significant asset value of the products to be repaired and the distinctive features of RL processes, it is essential for companies to cultivate specific RL capabilities, including managing return operations, utilizing IT, sharing information, and partnering collaboratively. In the current business environment, managers universally depend on IT for data storage, communication, information dissemination, and to facilitate data-driven decision-making. The sharing of information and effective collaboration are fundamental principles within SCM (Olorunniwo & Li, 2010). This is particularly vital for urgent defective products that demand prompt attention and resolution from the key stakeholders involved. This will help in enhancing the visibility of upcoming inflow to build a scalable and transparent returns management process. Thus, Olorunniwo & Li (2010) investigated how information technology, information sharing, and collaboration in the supply chain can impact an organization's performance in reverse logistics

As per Lambert et al. (2011), the IM system is a critical element of RL that oversees the handling of returns and facilitates clear communication among all the relevant parties. It also plays a key role in recognizing each product and determining the appropriate course of action for it.

Badenhorst (2016) states that most logistical information systems (IS) are not designed to accommodate the reverse flow of material, presenting a significant challenge for organizations attempting to execute reverse logistics (RL) processes effectively. The lack of robust IS means that effective decision-making in RL critically depends on strong information support (Mai et al., 2012). Consequently, RL frequently relies on manual data recording, which introduces the potential for human error or inconsistencies due to task duplication, insufficient technological tools, and a lack of IT resources (Awasthi & Chauhan, 2012). According to Cheng & Ma (2013), manual handling of information is inconvenient during RL operations. Risk, broadly defined as any possible event or circumstance that can negatively influence the enterprise (Bai et al., 2013), arises from the potential negative consequences caused by data errors in the information flow. Manual errors, such as mistakes, omissions, and inconsistencies, introduce risks that manifest as monetary costs, legal penalties, or operational inefficiencies (Bai et al., 2013).

Furthermore, the absence of efficient, accurate information support for authorizing, tracking, and managing returns can lead to costly errors and inefficiencies (Mai et al., 2012). Hence, the absence of suitable technological advancements impedes the effectiveness of reverse logistics operations, as information technology, along with software and hardware solutions, are vital for comprehensive management and transparency throughout the RL operations (Badenhorst, 2016).

According to Gordon (2012), to improve any process in the RSCM we need to define the RL process. The reason for this is that the definitions of RL are all-encompassing and cannot be adopted by each organization, leading to a need to redefine the RL. Furthermore, a concept of double-looping learning can be introduced which states that it is not just about correcting errors in the process, but also about examining the fundamental causes behind those errors, which often involves questioning and modifying the governing values or policies that lead to the errors (Gordon, 2012). Senior management should define what to include in RL at a minimum, typically encompassing the returns process, repair function, after-sales customer service, and logistics processes (Gordon, 2012). One of the necessary steps in this process is that the technology in the context of RL has to be flexible to accommodate any changes (Gordon, 2012). Thus, for the research, we can conclude that the IS should also be flexible to accommodate the changes needed. Also, it is important to develop a process to capture knowledge of how past situations were handled, which is crucial for organizational learning. The use of tracking software or some other data repository is considered essential to support this kind of organizational learning, ensuring that RL remains flexible and can adapt to changes over time and new product requirements (Gordon, 2012).

J. Hall et al. (2013) stresses the critical importance of establishing clear and conscious goals to enhance RL performance. Supporting this, Hazen et al. (2015) suggests that effective RL management requires organizations to set well-defined goals and utilize robust information systems for monitoring and measuring success. This approach is vital for both inbound and outbound firms. However, as reverse logistics is a comparatively recent aspect of supply chain management, many firms still lack well-defined goals and formalized RL processes.

When the different ERP systems were reviewed by Oltra-Badenes et al. (2019), including SAP, Microsoft, SAGE, Infor, Oracle, CCS Agresso, Odoo, OpenBravo, and Compiere, alongside an examination of specialized literature, it became evident that ERP solutions tailored specifically for RL management are insufficient. This analysis further highlighted the paucity of research on integrating RL management within ERP systems. Consequently, there is a clear need for the development of an ERP solution adept at facilitating RL operations (Oltra-Badenes et al., 2019). One of the most significant challenges in the RL chain is effectively integrating an information system. This task demands considerable effort and time to accomplish as it plays a pivotal role in the success of RL (Lambert et al., 2011).

Currently, IS based on ERP systems is the global standard solution for organizations IS (Oltra-Badenes et al., 2019). ERP is a unified information system designed to consolidate the working processes of an enterprise's internal functions. These systems can significantly transform organizations by altering both the IS landscape and the overall corporate business processes, enabling organizations to optimize their performance (Oltra-Badenes et al., 2019). ERP systems can standardize the procedures for processing internal information and integrate operational information produced by various functions (Adaileh & Abu-Alganam, 2010).

Enterprise Resource Planning (ERP) system is SCM

For this research, the case study deployed discusses as adoption of IS based on the Enterprise Resource Planning (ERP) system, and thus literature review is conducted on ERP as discussed in subsection 3.2.1 and in subsection 4.2.7. ERP is an IS that brings about dramatic changes in organizations by changing both the IS environment and the corporate business process in general by also allowing organizations to maximize their performance (Oltra-Badenes et al., 2019).

ERP systems enhance the flow of information within a supply chain and foster integration with SCM practices. These systems by serving as comprehensive application programs for business organization, management, and supervision, consolidate fragmented information within a business entity and bridge it with both internal and external supply chain information (Starostka-Patyk, 2021). Adaileh & Abu-Alganam (2010), defined ERP as a comprehensive IS that unifies the internal functioning processes of an enterprise. IS like an ERP system, is user-interfaced and designed to provide information useful to support strategy, operations, management analysis, and decision-making functions in an organization. It standardizes procedures for processing data internally and consolidates operational data from diverse functions within the organization (Adaileh & Abu-Alganam, 2010).

The significance of integrating information within organizations is also recognized in research on the adoption of enterprise resource planning systems to facilitate operations across different functions within companies. ERP systems are further known for collecting and disseminating integrated data in real time (Chang, 2020). While the literature on SCM has highlighted the necessity of combining both internal and external processes, previous studies often overlook the critical need to consider both intra- and inter-organizational information integration in SCM (Wong et al., 2011). Information integration serves the purpose of achieving real-time transmission and processing of information required for supply chain decision-making (). These systems act as an extensive IS-based innovation that integrates functions, operations, and processes (intra) as well as external stakeholders (inter) into one complete system that streamlines and supports activities and encourages alignment, information sharing, and cost reduction (H. O. Awa et al., 2017).

As per Prasad et al. (2010), implementing an ERP system within an organization should be viewed as a significant asset for SCM solutions. It enhances both visibility and transparency within the organization. Additionally, ERP systems can streamline and expedite existing business processes. ERP systems bring a diverse range of advantages, as they not only enhance operational performance but also financial outcomes, investor interests, and user contentment. Often, the mere announcement of an ERP initiative can positively influence market perceptions (Moon, 2007). ERP systems enhance efficiency by preventing data redundancy and offering visibility of data across the entire company (Starostka-Patyk, 2021). Pan &

Jang (2008) states that an ERP system allows companies to replace their existing information systems while helping them standardize the flow of management information

As per the research done by Oltra-Badenes et al. (2019), there is a lack of research analyzing the implications of RL management on IS. This gap is noteworthy, especially considering that one of the most critical challenges identified in RL management is the shortage of IS that can adequately manage RL processes. For this reason, Oltra-Badenes et al. (2019) work focuses on analyzing the requirements that RL entails in IS as a first step to developing suitable ERP to manage RL.

2.1.6 Technology-Organization-Environment Framework:

The Technology-Organization-Environment (TOE) framework is a theoretical model that explains the process of technological innovation adoption and implementation by firms. It was developed by Tornatzky and Fleischer in 1990 and is widely used to analyze how three aspects of a firm's context can influence its decision to adopt and implement innovative technologies Baker (2012). This can be seen in

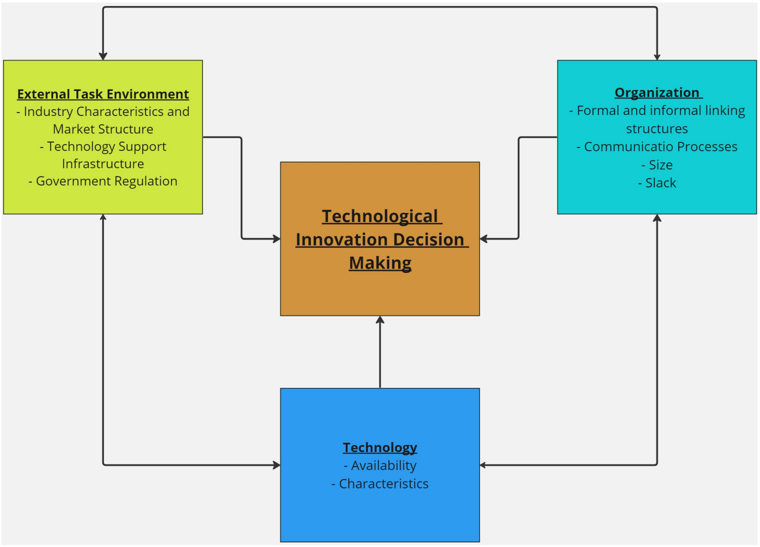


Figure 2.3: The Context of Technological Innovation (Tornatzky & Fleischer, 1990)

Technology adoption models like the Technology Acceptance Model (TAM), Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), and Unified Theory of Acceptance and Use of Technology (UTAUT) have been criticized for several shortcomings. Oliveira & Martins (2011) suggest that while models like TAM, TRA, TPB, and UTAUT are primarily focused on predicting individual adoption behaviors, the TOE framework is employed to examine technology adoption from an organizational perspective. These models have been further critiqued for their focus on the illusion of tradition, technological determinism, and techno-centric views that prioritize technology over the user, often neglecting the influence of individual, social, and psychological factors in the adoption process (H. O. Awa et al., 2017). As per H. O. Awa et al. (2017) TOE framework addresses these limitations, as it offers a more comprehensive and industry-friendly approach (Wen & Chen, 2010). The TOE framework has robust empirical support in the IS domain (Henriksen, 2006; Hong et al., 2006; Kuan & Chau, 2001; Yoon & George, 2013; Zheng et al., 2000; K. Zhu et al., 2003) and aligns with contemporary scholarly demands for socially interactive systems (Barrett et al., 2006; Jacobsson & Linderoth, 2010; Savoy & Salvendy, 2016; Venkatesh & Bala, 2008).

Therefore, the TOE framework is ideal for this research study due to its holistic view that incorporates technological, organizational, and environmental contexts to assess technology adoption within organizations. It extends beyond individual-focused models like TAM, TPB, TRA, or UTAUT by considering organizational attributes and external influences, making it highly relevant for the development and adoption of standardized IS-based processes in high-tech companies. This approach ensures a comprehensive evaluation of factors affecting technology integration and process standardization, supported by its strong empirical backing in the IS domain.

According to Baker (2012), the TOE framework is an organization-level theory that explains how the three different elements of a firm's context influence adoption decisions. The three elements are the technological, organizational, and environmental contexts and are believed to influence technological innovations within the firm. The technological context includes all of the technologies that are relevant to the firm including both technologies that are already in use at the firm as well as those that are available in the marketplace but not currently in use (Baker, 2012; Pan & Jang, 2008). The organizational context refers to the organizational structure, management, resources, and processes, and how they affect innovation adoption in organizations (Saghafian et al., 2021). It is described by various measures about the company, including its size and scope, managerial structure, and available internal resources (Baker, 2012; Pan & Jang, 2008). Additionally, the environmental context refers to the broader landscape where the firm operates, encompassing industry dynamics, competitive interactions, and governmental engagements (Baker, 2012; Pan & Jang, 2008). The TOE framework has been widely applied in various contexts, including the adoption of Information Systems like Enterprise Systems like ERP (Pan & Jang, 2008; Y. Zhu et al., 2010; Chang, 2020). The T-O-E framework has garnered significant theoretical and empirical support along with a validated inventory of psychometric measurements, making it a preferred model in the IS domain. It stands out as a prevalent theory, particularly within the IS field, and its variables have been rigorously tested across the adoption of various technologies (H. O. Awa et al., 2017). As per Tornatzky & Fleischer (1990), for the TOE framework application there is a need to define the primary focus of analysis which can be the organizational unit that can undertake adoption and implementation. In the case of this research, ASML B.V. is the primary focus of the analysis. Furthermore, it is important to set a boundary between the organization and the environment (Tornatzky & Fleischer, 1990).

Mesgari & Okoli (2019), represents the concept of technology sensemaking which is a process through which stakeholders in an organization understand and give meaning to new technology within the organization, focusing on how they interpret and use it based on their experiences and social context. It involves both cognitive aspects, like how stakeholders mentally process and rationalize the technology, and social aspects, such as how group interactions and organizational culture influence their understanding. This process is crucial because it affects how effectively technology is adopted and integrated into daily work routines, impacting overall organizational performance and success. Technology sensemaking also includes discovering existing meanings in the environment and adapting to the technological setting, rather than just creating new meanings to rationalize experiences (Mesgari & Okoli, 2019).

Technological Context:

Tornatzky & Fleischer (1990) considers technological context separate from the rest of the environment to focus attention on how the features of the technology themselves can influence the adoption process and implementation. Technological contexts refer to technological characteristics that enhance the perceived benefits of technology itself (Chang, 2020). As per H. O. Awa et al. (2017) three critical technological factors extensively examined in the literature include technological complexity, technological compatibility, and technical know-how. These elements are considered pivotal in understanding and analyzing the adoption of technology within organizations.

- Technological Complexity: Technological complexity refers to the degree of difficulty encountered by users when transitioning to a new software for performing the same or similar tasks as before, often requiring the user to manage more tasks simultaneously. ERP systems, like many management information systems, are typically seen as challenging to implement, possibly due to complex and bureaucratic organizational processes. The intricacy of ERP systems can restrict the amount of knowledge users can acquire before their actual use, as higher complexity necessitates greater mental effort, workload, and stress. Research indicates that technological complexity can heighten uncertainties and risks associated with adoption, suggesting that systems perceived as overly sophisticated may significantly deter adoption intentions (H. O. Awa et al., 2017). It's common for not all companies to fully capitalize on the potential benefits of ERP implementation. Two of the primary reasons for this lack of success are the intricate technical nature of ERP solutions and the absence of alignment among people, processes, and the new technology (Pan & Jang, 2008). However, it's crucial to recognize that without ERP, companies will likely lack a competitive edge. To ensure successful ERP implementation, firms need to carefully choose standalone or partially integrated functional ERP software products that align with their business goals and strategies (Pan & Jang, 2008).
- Technological Compatibility: Technological compatibility refers to the degree of alignment between the new technology and existing structures, processes, infrastructures, procedures, values, norms, experiences, and information-sharing requirements within social systems (H. O. Awa et al., 2017).

It is further stated by H. O. Awa et al. (2017), that technology compatibility is not a significant factor for the adoption of ERP systems. This is because although they use internet-based infrastructure and operations to some extent, they are not as dependent on it for their fundamental functionality. Incompatibility hinders the smooth exchange of information both within the company (intra-firm) and with external partners (inter-firm) (H. O. Awa et al., 2017). In today's age of information technology, there is a necessity for an integrated information system to monitor ongoing activities comprehensively. This system should encompass all components and ideally provide visibility through a web portal. Of utmost importance is the coordinating system, which oversees the overall performance and management of the reverse logistics system (Lambert et al., 2011).

- Technical Know-How: Technical know-how assesses the accessibility of installation and maintenance resources, particularly skilled ICT professionals and consultants capable of leveraging their knowledge and expertise to advance the organization's objectives (H. O. Awa et al., 2017). ICT infrastructures provide the platforms for real-time interaction, internet skills offer technical know-how, and ICT know-how provides the business and managerial skills to effectively develop and operate the systems. According to research done by Badenhorst (2016), RL has become a significant concern for professionals, as the necessary tools for systematically exploring this area have not been fully identified or described. Consequently, many organizations struggle with inefficient handling of their RL processes and have yet to establish optimal processes for effective management. Therefore, it is crucial to comprehend the primary forces governing RL and to gain insights into the challenges and opportunities for enhancing efficiency and effectiveness. Proficient expertise comprehends the utility of the technology and leverages experiences to simplify the complexity of the technology effortlessly (H. O. Awa et al., 2017).

  Furthermore, When introducing information systems, organizations must consider human factors as well as integration with business processes. This includes focusing on the management and technical capabilities needed by IT department staff to improve information technology capabilities, which is critical for IT human resource development (Yeh et al., 2015). Yeh et al. (2015) pointed out the importance of the IT team staying up to date on the latest IT developments and being capable of addressing organizational challenges. They should also be able to train stakeholders on how to use technology to solve work-related problems by offering integrated solutions (Yeh et al., 2015).

When IS systems like ERP systems are to be introduced organizations must establish substantial IT infrastructure whether engaging in process reengineering or rationalization (Yeh et al., 2015). IT infrastructure can help plan information strategies based on requirements (Yeh et al., 2015; H. O. Awa et al., 2017). IT infrastructure is the underlying framework that supports an organization's IT services and activities (Yeh et al., 2015). It includes components like hardware, software, networking equipment, data centers, and cloud services that are required for the operation of IT systems within a business (Yeh et al., 2015; Laudon & Laudon, 2014). Organizations use information platforms, networks, communication technology, and core applications to share information with internal departments, external suppliers, and customers during digitalization efforts (Yeh et al., 2015). IT infrastructure plays a crucial role in reengineering processes, creating long-term value, and implementing enterprise digitalization (Yeh et al., 2015). IT maturity refers to the level of development and readiness of an organization's IT capabilities. Organizations must assess their IT maturity to achieve strategic goals and meet market demands (Yeh et al., 2015). An organization's IT maturity influences its ability to use technology to achieve strategic goals and improve overall performance via IT investments and configuration (Yeh et al., 2015). IT maturity is positively correlated with e-business IT capability, emphasizing its significance in shaping digital transformation initiatives and long-term value creation within organizations (Yeh et al., 2015). External resources, such as knowledge-sharing networks, can reduce knowledge absorption costs over time (Saghafian et al., 2021). This network can include professional network groups, consultants, and technical support teams to assist with technology implementation and use (Saghafian et al., 2021)

Organization Context:

The organizational context as mentioned in subsection 2.1.6, consists of the various descriptive measures of an organization like organizational size, centralization, formalization, the complexity of its management structure, the quality of human resources, and the amount of slack resources available (Tornatzky & Fleischer, 1990). Apart from these different characteristics, characteristics like informal linkages between stakeholders, transactions carried out through them in the form of decision-making, and internal communication can also be included in the organization context (Tornatzky & Fleischer, 1990). The organization inherently offers a diverse range of structures and processes that either hinder or support the adoption and implementation of innovations. These include both formal mechanisms, which outline how tasks are divided and coordinated within the organization, and informal methods such as mutual adjustment, direct supervision, and standardization of processes, outputs, and skills among stakeholders (Tornatzky & Fleischer, 1990). Informal linking agents, such as product champions, boundary spanners, and gatekeepers, are linked to adoption (Tornatzky & Fleischer, 1990). Cross-functional teams and stakeholders may have formal or informal connections to other departments or value chain partners are further examples of such mechanisms (Baker, 2012). The study examined the relationship between organizational structure and innovation adoption processes. As per Tornatzky & Fleischer (1990), the organizational structure of organic and mechanistic influences the adoption of IS in an organization. Organizations with organic structures prioritize teamwork, allow for flexibility in stakeholder responsibilities, and encourage lateral communication beyond reporting lines. Research suggests that organic and decentralized structures are best suited for the adoption phase of innovation, while mechanistic structures, which prioritize formal reporting relationships, centralized decision-making, and clearly defined roles for employees, may be better suited for implementation (Baker, 2012). Organizational communication can either facilitate or hinder innovation. According to Baker (2012), top management can promote innovation by creating an organizational culture that encourages change and supports innovations that align with the firm's mission and vision. Organizational support is viewed as top management support. Top management's support provides the necessary resources, authority, and power to encourage the adoption of technology within the organization(H. O. Awa et al., 2017). According to H. Awa et al. (2015), the top management is responsible for the organization's norms, cultures, values, visions, and missions which shape the regulations, policies, routines, and procedures that guide individual and organizational behavior. According to Jackson (2011), organizational culture has a significant impact on the adoption of information systems within an organization. A mismatch between the introduced IS and the organizational culture can lead to adoption failure, emphasizing the significance of understanding cultural influences on adoption practices (Jackson, 2011). Managers must understand and account for the various cultural factions that exist within an organization (Jackson, 2011). Managers can also consider the usage of cultural tools, for example, metaphorical analysis to gain rich insight into understanding the organizational milieu (Jackson, 2011).

Among the most frequently discussed factors within the organizational context that affect innovation, however, are slack and size (Baker, 2012). Larger entities are often noted for their increased propensity to embrace innovations, primarily attributed to their enhanced flexibility and capacity to manage higher levels of risk (Pan & Jang, 2008). Furthermore, Baker (2012), states that while slack is desirable and helpful, it is neither necessary nor sufficient for innovations to occur. In the context of the adoption of the IS system of ERP, as per Pan & Jang (2008), resistance from users may emerge during the ERP adoption process due to its inherent complexity and challenges. This connects with the technological context and its influence on technological adoption and implementation as explained in Figure 2.1.6.

Environmental Context:

The environmental context encompasses industry structure, the availability of technology service providers, and regulatory frameworks (Baker, 2012). Industry structure, including factors like competition intensity, plays a crucial role in driving innovation adoption. Additionally, dominant firms within a value chain can influence other partners to innovate. Moreover, in rapidly growing industries, firms are inclined to innovate more rapidly, reflecting the dynamics of the industry life cycle (Baker, 2012). The support infrastructure for technology also impacts innovation and government regulation can exert both positive and negative influences on innovation. For instance, when governments introduce new industry constraints, such as mandating pollution-control devices for energy firms, innovation becomes a necessity for compliance Baker (2012). In competitive environments with rapid changes, companies prioritize establishing strategic connections between business operations and IT to gain competitive advantages. This in turn necessitates the importance of adopting innovations While the technical installation specifically in the case of ERP systems is crucial, their strategic implications can have an even greater impact on competitiveness (Pan & Jang, 2008). Also, the research done by Pan & Jang (2008) emphasizes internal needs and external strategies of an organization are important factors that affect the adoption of IT. Organizations must continuously evolve and develop to remain competitive and meet clients' ever-increasing expectations. This need for change is often driven by external factors, such as heightened competition (Price & Chahal, 2006). The competitive threats from the external environment are major factors that influence the adoption of new information technology (Yeh et al., 2015).

As per Baker (2012), in every empirical study examining the TOE framework, researchers have employed slightly varied factors within the technological, organizational, and environmental contexts. While acknowledging **Tornatzky & Fleischer (1990) assertion that these three contexts influence adoption, researchers have proceeded under the assumption that each specific technology or context under scrutiny entails a distinct set of factors or measures (Baker, 2012). Baker (2012), further emphasizes that different types of technologies exhibit distinct factors influencing their adoption. Similarly, disparate national or cultural contexts and industries will entail differing factors. Consequently, other research endeavors utilize varied factors within the technological, organizational, and environmental contexts.**

R. Huscroft et al. (2013) states that organizations are increasingly taking responsibility for the disposal of their products. This strong involuntary push toward environmental awareness has caused more firms to focus on their reverse process and seek out avenues to attain value from the products they must take back. This can be in the form of recycling, remanufacturing, or even reuse. RL is positioned well to directly impact the environmental consciousness of the firm, and the results of this impact can have profound monetary and environmental impacts. Furthermore, as the world becomes more modern, customers expect products to have minimal negative impact on the environment.

2.1.7 Business Process Standardization

Business Process Management (BPM) is a set of methods, techniques, and tools used to design, manage, and analyze operational business processes (Schäfermeyer et al., 2012). Business process standardization (BPS) as an instrument of BPM is defined as the unification of business processes and the related actions within an organization to facilitate communications about how the business operates, to enable handoffs across process boundaries in terms of information, and to improve collaboration and develop comparative measures of process performance Schäfermeyer et al. (2012); Davenport (2005).

According to Davenport et al. (1990), a business process is a series of tasks that work together to achieve a specific goal. A business process involves multiple events and activities, carried out by actors or information technology (IT), by which organizations transform inputs into output Schäfermeyer et al. (2012). Events trigger the execution of a process. The stakeholders can perform business process activities manually or using information systems (Goel et al., 2023). **Business process standardization involves using standard parts and procedures for process activities, reducing operator discretion, ambiguity, and mistakes (Wüllenweber et al., 2009). The objective of standardization is to provide transparency and uniform process activities across the organization or value chain which helps organizations reduce process cycle times, lower inventories, and increase throughput (Wüllenweber et al., 2009). Benefits of this approach include cost savings, increased profits, reduced risks, and improved transparency, controllability, and quality of the product as well as the service provided (Münstermann et al., 2010; Wüllenweber et al., 2009).** As per Romero et al. (2015), process standardization is recognized in the literature as a driver of performance improvements in terms of cost, time, efficiency, effectiveness, quality, and responsiveness. Romero et al. (2015), further states that process standardization provides transparency with better documentation of processes. Standardizing business processes can be time-consuming, costly, and resource-intensive. Organizations face growing complexity in business processes due to diverse elements and interconnections, including customer-tailored products, global procurement and distribution, and multiple value chain stakeholders (Wüllenweber et al., 2009). **Therefore, BPS significantly impacts business process performance, especially in service firms, with a strong influence on time, cost, and quality.** The level of performance that a business process attains is a function of the efficiency and effectiveness of the actions it undertakes (Romero et al., 2015). The potential benefits of business process standardization can be seen in Figure 2.4 as defined by Münstermann & Weitzel (2008).

Goel et al. (2023) defines 'Business Process Standardization' (BPS) as a practice intended to achieve consistency across underlying organizational processes, in support of service-delivery excellence and optimization of costs and benefits. Münstermann et al. (2010); Wüllenweber et al. (2009); Wurm & Mendling (2020) defines process standardization as the unification of business process variants and their underlying actions. Tregear (2015)defines process standardization means the development of a standard or best-practice process to be used as a template for all instances of the process throughout the organization. As per Seethamraju & Seethamraju (2009), the primary goal of standardizing business processes is to control variability and diversity in processes, terminology, definitions, data formats, and technology platforms across various organizational units, thereby achieving efficiency and consistency in execution.

As per Wüllenweber et al. (2009), the main challenge during standardization initiatives is to turn existing process variants into standard operating procedures that are obligatory to all stakeholders in

Benefits of Business ProcessStandardization	Description
Improved process performance	• Reduced end-to-end time (cycle-time) • Reduced process costs • Improved process quality
Improved customer confidence	• Standardized processes reduce probability for process-driven mistakes • Standardized processes allow to cope with continuously increasing process complexity • Consequently, the overall quality and thereby customer confidence improves
Enhanced readiness	• To outsource business processes • To merge with or buy other companies • To react to regulatory changes • To react to changing compliance needs • To react to market and external change and trends by increased process flexibility
Simplified and increased communication/ transparency/measurability	• Make process activities transparent • Allow for benchmarking due to common key performance indicators • Employees can move more easily from one location to another or one product to another due to standardized processes • Simplified communication among departments and locations within organizations

Figure 2.4: Benefits of Business Process Standardization (Münstermann & Weitzel, 2008)

an organization. This is an organizational effort directed towards standardizing appropriate business processes Wüllenweber et al. (2009). Business process models or diagrams are commonly used to create and document uniform specifications for such initiatives. Implement IT to support standardized processes, such as ERP systems that eliminate transportation and waiting times between activities, or workflow management systems that provide detailed control over work assignments to participants. In BPM, standardization effort refers to the resources spent (time, people, or money) to standardize a business process within an organization.

Narayanan et al. (2011), defined process integration as the coordination of all business processes and activities. The focus is on integrating systems and services and securely sharing data across business areas to create interconnected processes. Integrating processes can help standardize a business process. The term process compliance is the adherence of business processes to established norms while Process compliance is a result of BPS and Process harmonization aligns or homogenizes variants with a standard process (Goel et al., 2023).

Strategic alignment between business process management and corporate strategy is a fundamental principle of BPM. Prioritizing process standardization is primarily a matter of strategic focus (Wurm & Mendling, 2020). Clear roles and responsibilities for all process stakeholders should be defined while process standardization is carried out (Wurm & Mendling, 2020). Periodic process audits should be conducted to check whether defined practices are followed (Wurm & Mendling, 2020). Standardized processes rely on documentation to guide employees. Documenting business processes without ambiguity promotes consistent performance. However, it should not overburden employees (Wurm & Mendling, 2020). To ensure process standardization, a single set of documentation should be available, regularly updated, and easily accessible to employees. IT and business processes are highly interrelated and should not be treated independently, instead, a tight integration should be pursued which is especially important in the context of BPS (Wurm & Mendling, 2020). In fragmented systems, manual workarounds using tools like Excel are often required to connect various applications, which can lead to errors and process variation (Wurm & Mendling, 2020). IT systems in highly standardized processes are not only well integrated, but they also guide employees through the process (Wurm & Mendling, 2020). The centralization of IT governance may result in increased standardization. IT plays an important role in meeting business objectives. Standardizing in IT landscapes with diverse systems, decentralized departments, or insufficient service levels can significantly improve performance (Romero et al., 2015). Ultimately, BPS lays the foundation for and significantly contributes to process automation. With process standardization, IS can be more standardized and proactive rather than just recording data (Wurm & Mendling, 2020). This aligns with (Awasthi & Chauhan, 2012), which mentions that to overcome human error and inconsistency in manual data recording, organizations can utilize technological solutions based on various technologies to enable item tracing and real-time data management, ensuring improved reverse logistics operations.

The structure of an organization, such as hierarchical vs. flat, can impact the ease of standardizing processes. Hierarchical structures may face more challenges in achieving uniformity compared to flat structures (Romero et al., 2015). Organizations with successful standardization initiatives typically have a moderate level of process maturity and there is a positive correlation between maturity level and standardization potential (Romero et al., 2015). A highly transactional process involves a single business transaction between a provider and a consumer, emphasizing a clear flow of activities. A highly routine process handles most cases in the same manner, which means they have a high level of structure (Romero et al., 2015). The repetitive and predictable nature of routine processes makes them highly amenable to standardization (Romero et al., 2015). By contrast, creative processes, which require a high degree of flexibility and judgment, do not lend themselves easily to standardization because each instance might be handled differently based on unique requirements or creative input Romero et al. (2015).

According to the analysis by Goel et al. (2023), achieving BPS is a staged process that involves completing a series of activities. These activities are necessary for successfully implementing standardization across business processes. The different stages involved as proposed by Goel et al. (2023) can be seen in Figure E.1 and is explained in detail in Appendix E.

Role of Enterprise System Software in Standardization

Standardization of processes, information, and technology platforms is typically carried out before implementing enterprise systems software (Seethamraju & Seethamraju, 2009). Inadequate standardization limits a firm's ability to access and utilize information for decision-making, hindering the identification and reconfiguration of process components to adapt to changes (Seethamraju & Seethamraju, 2009). Higher standardization enhances agility, particularly for global organizations with repetitive, transaction-based processes like procure-to-pay and order-to-cash. However, standardizing unique, location-specific processes that offer a competitive advantage may reduce agility, especially in inter-enterprise supply chain contexts (Seethamraju & Seethamraju, 2009). On the technological front, consolidating platforms can improve integration, reduce costs, and enhance process flexibility. Nonetheless, tight coupling of technology with processes and systems may restrict agility by making it difficult and costly to implement quick changes (Seethamraju & Seethamraju, 2009). Thus, while higher standardization of technology platforms can streamline operations, it may also limit process agility (Seethamraju & Seethamraju, 2009). Therefore, it is important to consider the type of process if they are repetitive or unique before aiming for standardization. Furthermore, to maximize the benefits of an ERP system, business processes must align with the software's inherent practices (Seethamraju & Seethamraju, 2009).

2.1.8 A Theory of Contingent Business Process Management

Business process management (BPM) aims to improve quality, customer satisfaction, and financial performance, and reduce the production time and costs of an organization (Zelt et al., 2019). BPM is an evolution of workflow management that automates and improves business processes (Kodhelaj et al., 2019). Kodhelaj et al. (2019) further highlights BPM as "supporting business processes using methods, techniques, and software to design, enact, control, and analyze operational processes involving humans, organizations, applications, documents, and other sources of information." The systems supporting BPM must be process-aware. Examples of various software tools for BPM and workflow automation include IBM 1 Business Process Manager, SAP ERP, Oracle BPM Suite, and Appian Intelligent BPM Suite (Kodhelaj et al., 2019).

As per Zelt et al. (2019), Galbraith (1973) introduced Organizational Information Processing Theory (OIPT), an organizational-level theory that aims to improve performance through system design. OIPT is based on contingency theories, which state that an organization's structure should accommodate both internal and external variables.

OIPT assumes that organizations are open social systems that manage work-related uncertainty (Zelt et al., 2019). Uncertainty refers to the gap between the amount of information needed to complete an organization's basic tasks and what is already known. OIPT classifies organizations as IP systems that collect, process, and distribute information based on their uncertainty-management mechanisms Zelt et al. (2019).

Zelt et al. (2019) proposes a new theory based on OIPT for managing business processes according to their specific characteristics. This approach suggests that, rather than using a one-size-fits-all strategy, process performance can be improved by adapting management mechanisms such as documentation, standardization, and performance monitoring to the nature of each process. By aligning these mechanisms with process-specific characteristics, organizations can enhance efficiency and effectiveness, using tailored performance indicators to track and optimize process outcomes.

According to Zelt et al. (2019), while OIPT is primarily a theory of organizational design, it can also be used to analyze business processes and management mechanisms through an IP lens for which Zelt et al. (2019) presents four arguments to support this assertion:

1. Zelt et al. (2019) believe that similar to OIPT, there is no one-size-fits-all approach to process management. The optimal approach is determined by the nature of the process.
2. Processes can be objectively described and measured with available information. Processes, similar to organizations, are open social systems that process information.
3. Processes involve multiple actors completing tasks in a logical and time-dependent manner, using various tools and equipment. This situation involves a significant amount of information being processed, distributed, and created. Everyone involved must cope with uncertainty and ambiguity.
4. Processes are similar to organizations, and involve tasks across multiple groups or departments. They thus require specific coordination mechanisms to process information. IP is crucial for connecting individual tasks to a more efficient and effective workflow.

Based on this Zelt et al. (2019) proposes a new theory, which is shown in Figure 2.5.

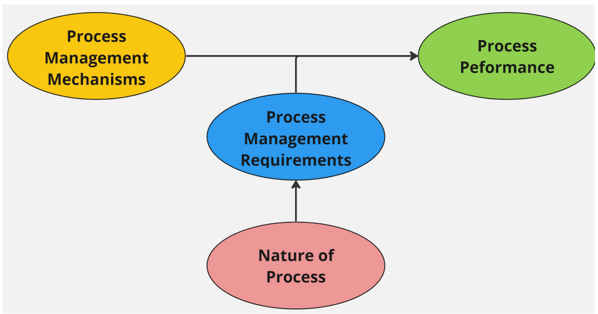


Figure 2.5: Simplied Theoretical model for contingent process management (Zelt et al., 2019)

The central thesis of theory proposed by Zelt et al. (2019) is as follows:

The positive effects of business process management mechanisms on business process performance are moderated by process management requirements, which vary depending on the nature of the business processes (Zelt et al., 2019). Process management mechanisms, including documentation, standardization, and monitoring, enable management to control and coordinate operations. The goal of these management mechanisms is to improve process performance (Zelt et al., 2019).

The core concepts of the theory are:

1. The nature of a process refers to its distinct characteristics that set it apart from other processes (Zelt et al., 2019).
2. Process management requirements stem from the process's nature and outline the extent to which participants must gather and interpret information (Zelt et al., 2019).
3. Process management mechanisms encompass the strategies and methods used by managers to define, coordinate, and control processes effectively (Zelt et al., 2019).
4. Process performance is measured by the operational efficiency and effectiveness of a process, considering factors such as cost, time, quality, and customer satisfaction (Zelt et al., 2019).

Nature of Process

The characteristics of a process can be described using 5 process dimensions process variability, analysability, interdependence, differentiation, and importance. A detailed explanation of these is as follows (Zelt et al., 2019; Wüllenweber et al., 2009):

1. Process variability: Processes can exhibit significant variability, as the inputs, steps, and outputs may fluctuate and be challenging to predict in advance. This means the extend to which process inputs/steps/outputs are variable and difficult to predict beforehand.
2. Process analyzability: Processes differ from computational procedures in that they require personal judgment and knowledge to execute. In process management research, these types of processes are called knowledge-intensive business processes as they rely on personal judgment or knowledge. Haußmann et al. (2012) refers to analyzability as how well stakeholders can complete a task by following clear, objective, and step-by-step procedures.
3. Process interdependence: Some organizational processes require collaboration, while others can be completed independently. Thus, interdependence plays a vital role in characterizing organizational processes as one of the frequently discussed process characteristics in process management literature.
4. Process differentiation: This refers to the level of involvement of stakeholders with diverse backgrounds, experiences, goals, and priorities in executing a process.
5. Process importance: This refers to the extend to which a process impacts an organization's competitiveness. This is a critical process characteristic influencing business process visibility.

Process management requirements: process uncertainty and equivocality

As per Zelt et al. (2019), process characteristics determine process management requirements, which we conceptualize as the degree of process uncertainty and equivocality. Uncertainty refers to the amount of information required to complete a process. It measures how much more information is needed to make informed decisions and take appropriate actions. High variability in processes makes it difficult for stakeholders to predict steps, outcomes, and potential problems, leading to uncertainty (Zelt et al., 2019). Furthermore, when stakeholders rely heavily on one another to complete tasks, the process becomes more uncertain. As a result, more information needs to be shared among process participants (Zelt et al., 2019).

The concept of equivocality refers to situations where there are multiple, potentially conflicting interpretations (Zelt et al., 2019). Organizational Information Processing Theory (OIPT) emphasizes that effective decision-making relies on both the quantity and quality of information (Zelt et al., 2019). In knowledge-intensive processes, which have low analyzability, tasks are complex and require significant personal judgment. This inherent complexity increases equivocality because different individuals may interpret the same situation in various ways (Zelt et al., 2019). High differentiation among process stakeholders, such as differences in roles, expertise, and perspectives, further contributes to these divergent interpretations (Zelt et al., 2019).

As a result, the information in these business processes becomes more ambiguous and requires additional effort to interpret and assign meaning. This necessity for interpretation underscores the importance of communication and collaboration to reach a shared understanding and make informed decisions (Zelt et al., 2019).

Process management mechanisms

Process management consists of various mechanisms that are applied to improve the business process performance in terms of its efficiency and effectiveness (Kohlbacher, 2010). The potential process management mechanisms are process documentation, process standardization, process monitoring, and process execution through coordination mechanisms such as information systems or lateral relations between process stakeholders (Zelt et al., 2019) which are explained as follows:

1. Process documentation and standardization: According to OIPT, increasing information processing capacity can be achieved through rules, control mechanisms, and coordination strategies (Zelt et al., 2019). In low-uncertainty situations, fixed standards and formal procedures are effective (Zelt et al., 2019). However, as uncertainty rises, a shift towards less formal, more participative, and network-based "organismic" structures is necessary (Zelt et al., 2019). At the process level, formalization and standardization work well for low-uncertainty processes but are less applicable to high-uncertainty, non-routine processes (Schäfermeyer et al., 2012)

2. Process monitoring: Process documentation and standardization vary based on process uncertainty. Low-uncertainty processes require minimal monitoring and feedback due to their predictability and low information processing needs (Zelt et al., 2019). Conversely, as uncertainty increases, so does the need for continual monitoring and feedback to handle the higher information processing demands Zelt et al. (2019). Processes with low uncertainty require minimal monitoring and feedback. The definition of process performance indicators (PPIs) becomes more important as the degree of uncertainty increases. Continuous monitoring is recommended to provide ongoing feedback to process participants (Zelt et al., 2019).
3. Process execution through IS or lateral relations: Coordination mechanisms, such as IS and lateral relations, enhance information processing capacity. IS are effective in situations of high uncertainty, aiding in managing increased information flow (Zelt et al., 2019). However, in high equivocality scenarios, where information interpretation is crucial, lateral relations are more effective. While ERP systems support interdependent activities, they may not be suitable for high equivocality processes due to higher customization and design costs (Zelt et al., 2019). Lateral relations are bilateral relations that facilitate better coordination and interpretation efforts in these cases (Zelt et al., 2019). Bilateral relationships connect stakeholders or departments, facilitating information processing. Additionally, it facilitates information interpretation through personal interactions between individuals and can improve process performance, particularly in situations with high uncertainty and ambiguity (Zelt et al., 2019).

Process performance and the moderating impact of the nature of processes

OIPT posits that organizational performance results from aligning Input Processing (IP) requirements with IP capacity, achieved through control and coordination mechanisms (Zelt et al., 2019). High process performance occurs when process management requirements match the process management mechanisms. Misalignment can happen in two ways: providing excessive, detailed information where it's unnecessary (low uncertainty and equivocality), or insufficient, vague information where detailed processing is needed, leading to inefficiency and reduced quality and customer satisfaction (Zelt et al., 2019).

OIPT focuses on the latter, viewing fit as crucial for process performance. Researchers can analyze the impact of fit on performance using moderation, mediation, or profile deviation (Zelt et al., 2019). Process management generally improves performance, but this effect varies based on process characteristics (Zelt et al., 2019).

Process performance includes efficiency (low time and cost) and effectiveness (high quality and customer satisfaction), the main goals of process management (Kohlbacher, 2010). Efficient process management minimizes production costs and time, while effective management ensures high-quality outputs that meet customer requirements. A lack of fit between process management requirements and capacity negatively impacts both efficiency and effectiveness (Zelt et al., 2019). The summary of the theoretical model for contingent process management based on OPIT as proposed by Zelt et al. (2019) is shown in Figure 2.6

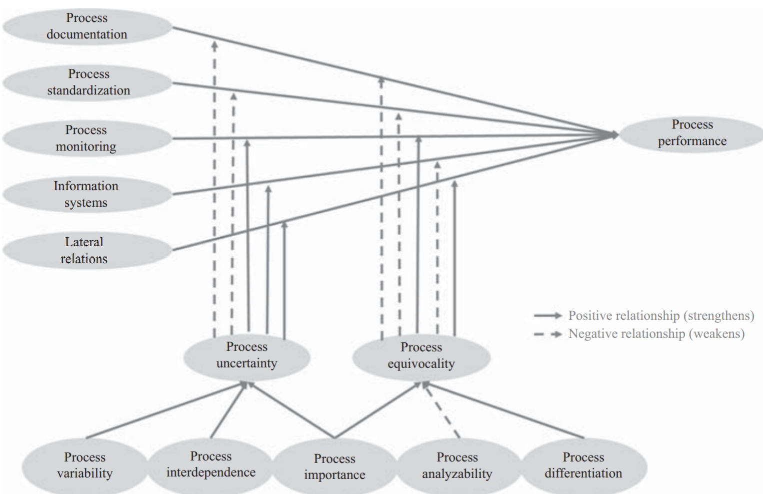


Figure 2.6: Detailed Theoretical model for contingent process management (Zelt et al., 2019)

2.1.9 Change Management

H. O. Awa et al. (2017); Pan & Jang (2008), emphasized that to facilitate the adoption of an IS-like ERP system, proper change management is necessary. As per Park (2018), change management is a critical success factor in IS implementation. Bellantuono et al. (2021) defines change management as a structured method for easing an organization's shift from its current state—where it is now—to its desired future state. It is the process of updating an organization's capabilities, direction, and structure to meet the constantly evolving needs of both internal and external customers. The procedure and resources used to assist individuals during a transition are also referred to as change management (Bellantuono et al., 2021). It ensures minimizing the resistance from the stakeholders involved in the organization towards acceptance of change. A critical success factor in IS adoption is minimizing resistance from organizational members and promoting high adaptation to the IS in an altered environment Park (2018). Park (2018), discussed change management in terms of the IS of ERP which is also the scenario in this thesis research and is discussed in subsection 4.2.7.

Park (2018) argues that few studies on ERP looked at change management, even though involved stakeholders may be resistant to system adoption, and that organizations need to implement change management to achieve successful performance. Furthermore, the research by Park (2018) looks into the well-known DIKW hierarchy (data–information–knowledge–wisdom) which states that when data are collected and analyzed for a certain purpose, they become valuable information. Stakeholders examine and improve the data when they adopt ERP and get access to more precise and large-scale data. ERP improves users' and businesses' information capabilities in this way (Park, 2018).

An organization's efforts to reduce stakeholder resistance to change are reflected in its change management (Park, 2018). Stakeholder's attitudes toward adjusting to these changes are critical because an ERP system necessitates more changes than other IS. As the changes go beyond the IS environments and pertinent tasks to include related organizations, people, and processes, businesses that neglect change management will not be able to use the ERP system to its full potential, which is intended for all corporate processes (Park, 2018). Consequently, ERP management frequently fails as a result of neglecting to address these areas during change management (Park, 2018). The most well-known change management models can be seen in Table C.1 in Appendix C.

2.2 Conclusion

The literature review began with the IS research framework proposed by Hevner et al. (2004), which laid the foundation for the research methodology and approach. This framework guided the exploration of the literature on reverse logistics, particularly the challenges related to information sharing and communication. Following this, the roles of process standardization and formalization, along with the impact of IS on enhancing RL performance, were examined. The review then focused on the TOE framework, exploring how its different contexts affect technology adoption. Additionally, the literature provided insights into business process standardization, highlighting how the nature of business processes impacts performance and how standardization and IS usage can enhance it. Finally, the review emphasized the importance of change management for the adoption of an IS-based process flow.

The literature, however, lacks insights into the impact of non-standardized processes on business performance in high-tech companies especially in RL, focusing more on inter-organizational information sharing while giving limited attention to intra-organizational communication. It provides little information on achieving process standardization through formalization, information systems, performance indicators, and lateral relations. Additionally, it lacks comprehensive details on the technological, organizational, and external environmental factors influencing IS adoption and process standardization. Although the literature acknowledges the role of change management in business process management and standardization, it fails to specify which factors are important for different phases of technology adoption and process standardization.

Chapter-3: Research Methodology

This chapter presents the research methodology employed for this thesis, utilizing a qualitative approach. The research design for this study follows an exploratory qualitative approach, focusing on the key factors and inter-dependencies that influence the adoption of an IS-based standard process flow.

It encompasses both theoretical and practical research methods, including a literature review, a case study, and validation processes. The subsequent sections and subsections of this chapter will detail these methods and explain the rationale behind their selection. Furthermore, this chapter discusses how the target population (participants) was chosen for both the case study and the validation phases of the research.

To address the objective of the adoption of an IS-based standard process flow for managing high-priority issues in RL within high-tech manufacturing companies, a qualitative research methodology is adopted. This approach delves with comprehensively understanding the research problem, stakeholder's perspectives, organizational factors, external factors, technological factors of IT infrastructure, IS capabilities, the role of process standardization, change management, and the impact of proposed IS systems on the performance of RL based on the research problem.

3.1 Research Design

A research design acts as a structured framework or strategy for gathering, measuring, and evaluating data, developed specifically to address your research queries(Sekaran & Bougie, 2016). For the research to be done, research design helps to make decisions related to the research strategy, including whether to utilize experiments, surveys, or case studies, as well as the degree of manipulation and control exerted by the researcher over the study, the setting in which the research is conducted, the level at which data will be analyzed (unit of analysis), and considerations related to time (time horizon) are all crucial aspects of the research design (Sekaran & Bougie, 2016).

In the context of this research on optimizing RL operations through the integration of IS for managing urgent defects, the research design encompasses a strategic selection of qualitative methods, specifically a case study of ASML and a validation phase involving expert interviews. The study minimizes researcher interference to preserve the natural setting of ASML's operations, ensuring authenticity in data collection and analysis. The research primarily unfolds within the operational environment of ASML, leveraging a real-world context to gather in-depth insights. The unit of analysis centers around the processes, stakeholders, and technological systems involved in the RL operations specifically focusing on high-impact issues of urgent defect management. Thus, the unit of analysis is the RL team within the Reuse department itself which performs the RL activities with the RL operations. The temporal aspect of the research spans a short-term horizon for the duration needed to observe, analyze, and understand the current challenges and propose a standardized IS-based framework for improvement. This structured approach allows for a comprehensive understanding of the technological, organizational, and environmental factors influencing the adoption and effectiveness of IS used by ASML in enhancing RL operations. The detailed explanation is as follows:

3.2 Research Framework

The structure of the Research Framework is as follows and consists of three phases namely the literature review, case study, and validation, as seen in Figure 3.1:

The research framework for this thesis study in Figure 3.1, is based on the well-known research framework of Hevner et al. (2004) for the understanding, executing, and evaluation of Information Systems (IS) research. Design Science "addresses research through the building and evaluation of artifacts designed to meet the identified business need" (Hevner et al., 2004). An IT artifact can be a model, method, framework, or instantiation that enables researchers to develop and successfully implement (Hevner et al., 2004). **The IT artifact in the case of this research is the framework that is designed to**

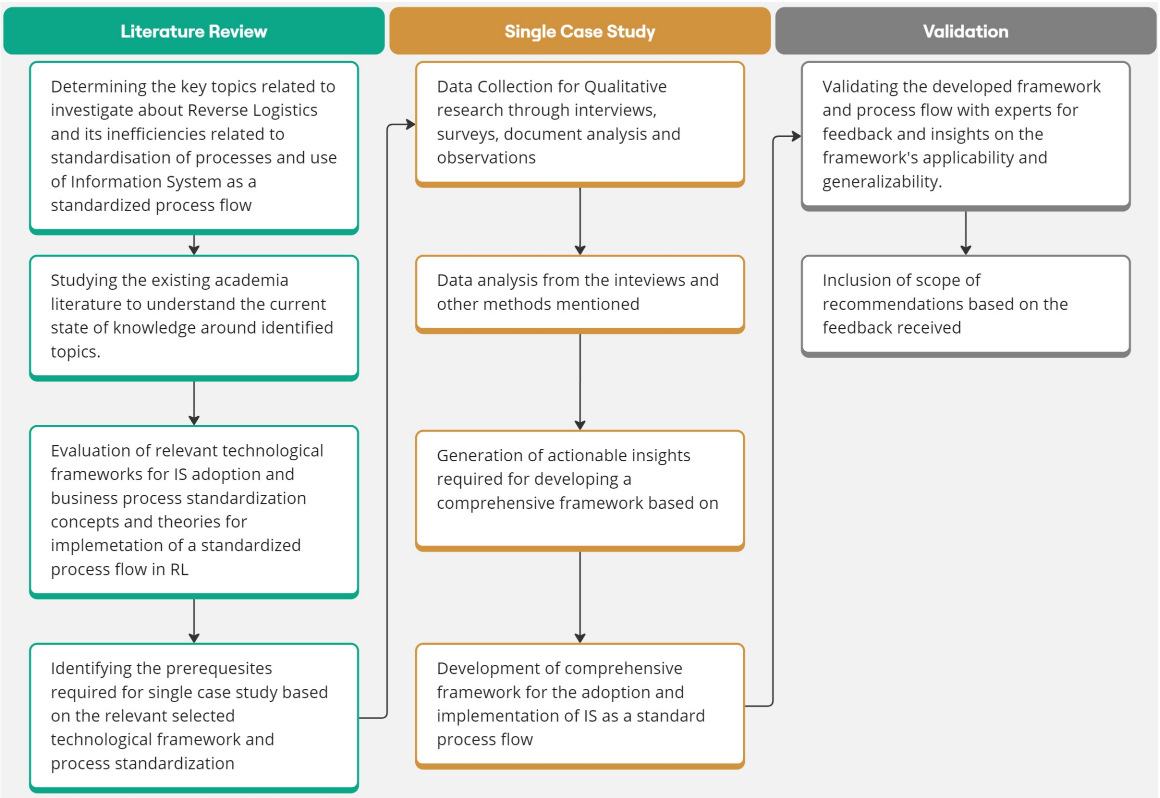


Figure 3.1: Research Framework

identify and analyze the factors and inter-dependencies critical for achieving IS-based standardized process development and adoption. According to Hevner et al. (2004), the design of IS research lies in the complex relationship between individuals, organizations, technology, and existing knowledge-based foundations and methodologies to achieve rigor. The detailed analysis of the Design of IS research is discussed in subsection 2.1.1.

For using design science for research as defined by Hevner et al. (2004), the initial step in designing strategies to standardize business processes using IS for managing the high-impact issues is to understand the underlying business need for such process standardization within organizations. For this research study as case study method is used for evaluation, the organization for the case study is ASML. Analyzing the environment is fundamental to identifying ways to meet the business need defined. The environment of IS research consists of the stakeholders in the organization of ASML, the organization of ASML itself, and the technologies ASML has or plans to use for this research (Hevner et al., 2004). The business needs are assessed and evaluated within the context of organizational strategies, structure, culture, and existing business processes as well as the technology infrastructure and development capabilities (Hevner et al., 2004). **The business needs are this research problem is can be seen in section 1.2 and in Table 1.2.** The impact of the unavailability of standard process and USe of fragmented communication methods for managing high-impact issues, such as urgent defects at ASML, highlight the need for standardization. This comprehensive understanding ensures that research activities address relevant business needs, thereby ensuring the research's relevance (Hevner et al., 2004).

Given such an articulated business need, IS research is conducted in two complementary phases. Behavioral science addresses the research by developing and justifying theories that explain or predict phenomena related to the identified business need (Hevner et al., 2004). Design science, on the other hand, addresses the research by building and evaluating artifacts designed to meet the identified business need (Hevner et al., 2004)p. **For this research, as the design science approach is employed, the focus is on developing an IT artifact in the form of a framework for the standardization of business processes by the adoption of IS.**

The knowledge base provides the essential materials from which IS research is accomplished, comprising both foundations and methodologies (Hevner et al., 2004). Foundations include prior IS research and results from reference disciplines, offering theories, frameworks, instruments, constructs, models, methods, and instantiations used in the development and building phase of a research study

(Hevner et al., 2004). Methodologies offer guidelines for the justification and evaluation phases (Hevner et al., 2004). The knowledge base thus refers to the comprehensive literature review conducted for the research. The summary of the literature review approach can be seen in subsection 3.2.1 and the detailed literature review study can be seen in section 2.1. This literature review helps to investigate the research problem by providing a foundational understanding, context, and background information necessary for addressing the research problem (Hevner et al., 2004). As per Hevner et al. (2004), design science relies on computational and mathematical methods to assess artifact quality and effectiveness, but empirical techniques may also be used. Thus, the knowledge base for this research also includes the literature review conducted using the target SLR, study of documents and observations made during the case study at ASML along with the qualitative analysis done through the semi-structured interviews conducted for the research, which can be seen in chapter 4.

3.2.1 Relevant Literature Review relevant to Research Framework

A literature review is the process of gathering and analyzing available materials, both published and unpublished, to support specific research objectives and illustrate particular points of view. This process involves critically assessing these resources in the context of the planned research (Hart, 1998). By reviewing existing knowledge, the literature review lays the groundwork for future research while also improving understanding of the research problem. This process identifies knowledge gaps, ensuring that the research is relevant, significant, and potentially contributing new knowledge to the field (Sekaran & Bougie, 2016).

For this research on leveraging IS to standardize and improve the management of critical issues in RL operations, a literature review will:

- Establish a strong theoretical foundation in key areas such as RSCM, IS in supply chain operations, and the unique challenges that high-tech manufacturers face when dealing with high-impact issues such as unserviceable and incorrectly received parts. The focus will be on how IS can improve RL performance by standardizing processes.
- Analyze the negative effects of non-standardized processes on RL performance in high-tech companies, focusing on the advantages of increased supply chain transparency, visibility, and coordinated collaboration among internal stakeholders.
- Employ Design Science Research for its rigorous, solution-oriented approach, which ensures the development of innovative IT artifacts that are both theoretically sound and practically applicable.
- Use the TOE framework to better understand the factors that influence IS adoption and implementation, as well as to establish a standard information-sharing and communication process for dealing with critical issues.
- Use OIPT to ensure that organizations can match their information processing needs to their capacity, which is critical for effective process standardization.
- Examine Business Process Standardization theories to better understand how standardization is implemented and how it affects organizational performance.
- Consider Change Management theories to better understand their role in IS adoption and how new standardized process flows will be received by organizational stakeholders.

This literature review seeks to provide a comprehensive understanding of the factors influencing IS adoption and business process standardization in RL, thereby laying the theoretical groundwork for the research objectives and proposing effective solutions.

The above-mentioned topics are closely related to the research problem and the objective to be achieved. A detailed explanation of the topics is available in section 2.1 and in Table 2.2.

Thus, the literature review will act as a structured foundation for the case study. A detailed explanation of the literature review approach followed and a literature review done on the related topics for the research can be found in section 2.1.

3.2.2 Case Study Approach relevant to Research Framework

In the context of this research on leveraging IS as a standardized platform to streamline the management of critical issues in RL operations, a case study approach focusing on Company ASML is selected. Company ASML is experiencing challenges with urgent defect management in its RL operations. This choice is supported by several scholars who emphasize the unique strengths of the case study method for investigating contemporary phenomena within their real-world settings.

According to Yin (2003), a case study is an empirical research method that examines a contemporary phenomenon in its real-world context, particularly when the boundaries between the phenomenon and its context are unclear. This blurred distinction is typical of urgent defect management in high-tech manufacturing, where internal processes and external factors are inextricably linked. The case study methodology enables a thorough examination of this complex subject within its real-world context, providing a platform for considering various perspectives and dimensions.

According to Aberdeen (2013), a case study approach provides rich, in-depth data, leading to a more nuanced understanding of the subject. This is especially important for Company ASML, which faces the challenge of effectively leveraging an IS as the standard process for managing the flow of time-sensitive, critical, and high-impact issues such as urgent defects within its RL operations. A case study allows researchers to delve deeply into these issues, revealing the complex relationships and interdependence that influence IS effectiveness in this context.

According to Sekaran & Bougie (2016), a case study aims to gather comprehensive information on a specific object, event, or activity, such as a business unit or organization. For Company ASML, this entails analyzing a real-life situation from multiple perspectives using various data collection techniques. This comprehensive approach is critical for comprehending the multifaceted nature of urgent defect management, which includes not only technological aspects but also organizational processes, human factors, and external environmental variables.

The importance of the case study approach is highlighted by the need to investigate the specific challenges that Company ASML faces in managing urgent defects within its RL operations. This contemporary issue is set in the complex, real-life context of a high-tech manufacturing company, where the "boundaries" between the phenomenon (urgent defect management) and its context (the Technology-Organization-Environment (TOE) framework within Company ASML) are inextricably linked and cannot be distinguished. Using a case study methodology, researchers can gain in-depth insights into these interconnected factors, providing a comprehensive understanding of how IS can be used to standardize information-sharing and communication processes.

Furthermore, the findings of this case study will serve as the foundation for creating a comprehensive framework that addresses the unique challenges and requirements for adopting IS-based standard process flows for managing RL operations in high-tech companies. While specific details may differ between companies, the insights gained from this case study can be useful for other high-tech firms facing similar issues, increasing the generalizability of the research findings.

To summarize, the case study methodology is not only appropriate but also required, for identifying actionable insights and developing a comprehensive framework for a standardized process for information sharing and communication in the context of urgent defect management at Company ASML. This approach's in-depth, contextualized understanding is consistent with the phenomenon's complex and unique nature, making it an effective research design for examining and addressing the specific challenges that high-tech companies face when managing high-impact issues within their RL operations.

3.2.3 Data Collection

The data collection for this research occurs in two stages: Qualitative analysis for the case study and Documents and Observations for studying the existing process flows and required quantitative data.

Qualitative Analysis for case study

The case study involves performing qualitative analysis. The first step of qualitative analysis is done by conducting semi-structured interviews with participants involved in the RL Operations. The semi-structured interviews will be conducted based on a purposive sampling of the internal stakeholders involved in RL operations. The details of the participants can be seen along with their roles and departments can be seen in Table 3.1. This sample can involve a wide variety of internal stakeholders from the factory, Quality, the Reuse Department, Key action owners of the urgent defect flows, and other relevant key decision-making stakeholders in the case study. A detailed explanation of the selection criteria of the participants for the semi-structured interviews can be seen in subsection 3.2.3.

In the development of the semi-structured interview questions for the research as the case study at ASML, we utilized a comprehensive array of sources to ensure thorough coverage and relevance. The inputs included:

1. Document Study at ASML: Insights gathered from an in-depth review of existing documentation at ASML helped identify the current practices and areas needing improvement in the RL processes.

Participants ID	Department	Role
P1	Reuse	Reverse Logistics Business Process Owner
P2	Reuse	Reverse Logistics Business Process Owner
P3	Supply Chain Management	Supply Chain Planner
P4	Reuse	Reverse Logistics Planner
P5	Supply Chain Management	Supply Chain Planner
P6	Supply Chain Management	Supply Chain Planner
P7	Supply Chain Management	Supply Chain Planner
P8	Supply Chain Management	Supply Chain Planner
P9	Product Lifecycle Management	Product Lifecycle Manager
P10	Product Lifecycle Management	Product Lifecycle Manager
P11	Product Lifecycle Management	Product Lifecycle Manager
P12	Product Lifecycle Management	Product Lifecycle Manager
P13	Product Lifecycle Management	Product Lifecycle Manager
P14	Clean Room Logistics	Internal material Movement Incharge
P15	Clean Room Logistics	Internal material Movement Incharge
P16	Process Improvement	Quality Assurance Expert
P17	Process Improvement	Quality Assurance Expert
P18	Process Improvement	Quality Assurance Expert
P19	Material Quality	Quality Assurance Expert
P20	Supply Chain Management	Supply Chain Planner
P21	Supply Chain Management	Supply Chain Planner
P22	Global Manufacturing	SAP ERP Subject Matter Expert

Table 3.1: Participant attributes for Data Collection

2. Literature on the TOE Framework: Key factors relevant to the technology adoption of IS in organizations were extracted from the literature on the TOE framework, providing a theoretical basis for understanding technology integration challenges and opportunities.
3. Organizational Information Processing Theory (OIPT): The theory aims to evaluate the alignment between current business processes and the information needs of RL operations, identifying gaps that impact business performance. By assessing how well these processes meet essential information requirements, the interview aims to pinpoint inefficiencies and propose standardized IS-based process improvements. These enhancements are expected to boost efficiency and effectiveness, thereby optimizing overall business operations in RL.
4. Strategies for Business Process Standardization: The role and selection of IS and their optimization were critically examined. This examination informed the development of questions that probe into how IS can be effectively harnessed to standardize processes, enhance efficiency, and support organizational goals.

These diverse sources were synthesized to formulate interview questions that are not only grounded in empirical data and theoretical insights but also tailored to uncover specific challenges and opportunities in standardizing RL processes. The aim is to capture comprehensive and actionable data that will inform the design and implementation of a standardized process flow that aligns with both technological capabilities and organizational needs.

The idea is to identify the challenges faced by the stakeholders due to the usage of current non-standardized processes and how they impact the supply chain performance and reliability. Along with this, the qualitative analysis will focus on assessing the capability of an existing IS if any within the organization to act as a standardized process flow for communication and information sharing. The semi-structured interviews will revolve around the TOE framework focussed on addressing the research problem to achieve the research objective as mentioned in section 1.1, section 1.3 and in section 1.5. By structuring the interviews based on the TOE framework, change management models, and business process standardization theories, the research can gather valuable insights into any existing IS that can be optimized to be used by the organization and the factors influencing its adoption and implementation to act as a standardized process flow for streamlining RL activities information sharing, and communication in high-tech companies, in this case, ASML, specifically in the context of managing urgent defects. A detailed explanation of the TOE framework is available in subsection 2.1.6. By aligning the semi-structured interviews with the TOE framework, the case study can contribute to the research in the following ways:

- Technological context: The interviews will explore the technological factors that impact the adoption and implementation of IS for managing urgent defects in reverse logistics. This includes assessing the current state of technology infrastructure regarding information sharing and communication, the compatibility of existing IS (if available) to act as a standard process, and the perceived benefits and challenges of using IS for streamlining information sharing and communication processes.
- Organizational context: The interviews will investigate the organizational factors that influence the adoption and implementation of IS for managing urgent defects in RL. This includes examining the processes, workflows, organizational structure, culture, leadership support, and resource allocation for IS initiatives.
- Environmental context: The interviews will explore the external environmental factors that impact the adoption and implementation of IS for managing urgent defects in RL. This includes assessing the competitive pressure, regulatory requirements, and customer satisfaction that drive the need for streamlined and standardized reverse logistics processes.

By conducting semi-structured interviews that revolve around the TOE framework, the research can gather rich, qualitative data that provides a comprehensive understanding of the factors and interdependencies influencing the adoption and implementation of IS as a standardized process flow for managing urgent defects in reverse logistics. Discussions among different participants are facilitated to explore their experiences, preferences, enablers, and resistances concerning the current processes and potential IS as a standard process for urgent defect management.

Observations and Documents Analysis for case study

Observations about the current process flow and the review of relevant organizational documents allow real-time insights into the operational dynamics and stakeholder interactions involved and related to the research. Observations constitute a pivotal aspect of data collection methodology, offering real-time insights into the operational dynamics and stakeholder interactions within ASML's RL.

The observations are often conducted in a natural setting (Sekaran & Bougie, 2016). The observations of this research were conducted within the natural setting of ASML's operational environment, providing a detailed look into the workflows, communication patterns and methods, and use of the IS system in RL Operations. The observations conducted were of an uncontrolled type as these observations are an observational technique that does not attempt to control, manipulate, or influence the situation (Sekaran & Bougie, 2016). These observations served to corroborate data from interviews, affording a multi-dimensional perspective on the role and challenges posed by the non-standardized communication and information-sharing practices. The observations also served as a source to understand the responsive and critical decision-making factors of the stakeholders across cross-functional departments associated with the RL operations. These observations played a crucial role in understanding the improvements that are needed to stabilize a standard process flow.

Through an immersive approach, the observer, positioned as a non-intrusive participant, documented interactions, system usage, and procedural adherence, capturing both the nuances of individual tasks and the broader context of the organizational ecosystem. The findings from these observations are instrumental in painting a comprehensive picture of the intricate processes that define ASML's urgent defect management and providing a grounded basis for subsequent analysis and recommendations.

As per Bowen (2009) document analysis is frequently combined with other qualitative research techniques to facilitate triangulation, which involves using multiple methodologies to study the same phenomenon. Qualitative researchers are encouraged to utilize at least two sources of evidence, aiming for convergence and confirmation by integrating various sources and methods (Bowen, 2009). In addition to documents, these sources can encompass interviews, either participant or non-participant observation, and physical artifacts (Bowen, 2009).

The observations and document analysis can be done for the following areas:

- Process maps and flowcharts depicting RL Standard operating procedures and work instructions related to RL activities for handling urgent defects.
- To identify and get a hands-on experience of how existing IS (if available) works, its capabilities as depicted in the literature review as mentioned in subsection 2.1.5, and bottlenecks.
- Performance metrics related to RL performance.

- Data related to the potential monetary impact as the business needed as highlighted in the research framework proposed by Hevner et al. (2004) and in qualitative analysis discussed in subsection 4.2.5.

A detailed explanation and finding of observations and document analysis is available in section 4.1.

To conclude, the development of a framework for designing and deploying a standardized process flow for RL involves several critical steps. Initially, main requirements from technological, organizational and external environmental contexts were systematically gathered to ensure all necessary criteria were addressed. A thorough analysis of existing processes was then conducted to identify constraints and challenges within current practices. This analysis also examined the factors influencing the standardization of business processes, particularly through the integration of IS technologies. Utilizing various theoretical frameworks, theories and models from literature, the study explored effective approaches to business process standardization to achieve targeted performance. This comprehensive approach aims to devise a robust framework that enhances efficiency and consistency across RL operations, particularly for managing time-sensitive, critical, and high-impact issues.

3.2.4 Data Analysis

The semi-structured interviews can reveal key factors, inter-dependencies, concerns, and priorities of stakeholders regarding the IS and its optimization for adoption and implementation as a standard process flow. This provides a rich, detailed understanding of the current state and potential improvements for using IS in urgent defect communication. This methodological approach supports the improvement of the information flow of urgent defects in high-tech companies through a single standard platform.

Thematic analysis is conducted based on the semi-structured interviews to identify key themes related to the challenges, opportunities, and stakeholder perceptions regarding IS optimization to act as a standardized process for urgent defect management in RL. Thematic analysis identifies key themes that help describe a phenomenon (Fereday & Muir-Cochrane, 2006).The process involves identifying themes by carefully reading and re-reading the data. Pattern recognition in data involves identifying emerging themes and categorizing them for analysis (Fereday & Muir-Cochrane, 2006).

The TOE framework can be used as a lens to categorize and analyze the collected data, identifying patterns and themes related to technological, organizational, and environmental factors. As the research involves investigating the potential of using an IS, which can act as a standardized information sharing and communication process flow specific organizational context, managing urgent defects in a high-tech company's RL operations, TOE framework can be deployed. The TOE framework along with the Organizational Information Processing Theory (OIPT) provides a valuable lens to analyze the factors influencing the successful adoption and implementation for IS based process flow of the case study.

As explained in subsection 2.1.6, by incorporating the TOE framework the study can provide a more comprehensive understanding of the factors influencing the adoption and implementation of an IS as a standardized platform for managing urgent defects in high-tech companies like ASML's RL operations. This understanding will contribute to the development of a more robust and context-specific framework that addresses the technological, organizational, and environmental challenges faced by high-tech companies in leveraging ERP systems for efficient and effective RL operations and performance. The findings from the literature review can be synthesized with qualitative data from the case study to formulate comprehensive insights into strategies for enhancing the use of IS systems in managing urgent defects. After this is done, sub-research questions can be answered which will eventually answer the main research question. A framework that incorporates the technological, organizational, and environmental factors identified through the TOE analysis can thus be developed.

According to Sekaran & Bougie (2016), the analysis of qualitative data involves three primary steps: Data reduction, Data display, Drawing conclusions.

Data reduction is considered the most crucial step, where coding and categorization of data are key activities. Coding is an analytical process where qualitative data is condensed, reorganized, and synthesized to facilitate theory development. It involves assigning labels, or codes, to text segments which are then grouped and classified to extract meaningful insights. Categorization involves sorting these coded units into organized groups (Sekaran & Bougie, 2016). The software ATLAS.ti is used for analyzing qualitative research data, supporting thematic analysis through the creation and categorization of codes. This study employs a combination of both inductive and deductive coding methods to develop these codes and categories. All the themes related to the factors and inter-dependencies that impact the standardization of IS-based process flow for managing time-sensitive, critical, and high-impact issues like urgent defects are reduced using inductive as well as deductive coding methods. The deductive coding themes are derived based on the literature review, research, and sub-research questions. The inductive coding themes are derived based on the raw data collected from the semi-structured interviews.

A two-level coding strategy is implemented, integrating insights from a thorough literature review in the field of the research problem, key theoretical frameworks such as the Technology-Organization-Environment (TOE) framework, and Organizational Information Processing (IP) Theory. This robust theoretical grounding, combined with empirical data from semi-structured interviews, forms the foundation of our analysis. This approach is specifically designed to explore and address the research objectives concerning the standardization of IS-based process flows within organizational settings. The initial coding was conducted through open coding, based on insights drawn from the literature review and the specific objectives of the research. This initial phase of coding broke down the data into discrete parts, which were examined for patterns and thematic elements relevant to our research questions.These initial codes were subsequently organized into categories, forming the basis for second-level coding. During this second-level coding, the data were further refined and grouped into more distinct categories that reflect deeper thematic insights. The various core themes were then developed from these categories. For certain contexts, the categories were further developed into sub-themes and core themes were developed. These themes alongside the learning's from the literature on the TOE framework, process standardization and change management theories were established as core themes. These identified themes are aligned with the research objectives and the sub-research questions, ensuring that research analysis is directly relevant to the overarching objectives of the study. These themes and categories were manually analyzed to draw conclusions that address the sub-research questions, providing a comprehensive understanding of the factors and inter-dependencies influencing technology adoption in organizational settings. The illustration of data analysis process can be seen in Figure 3.2.

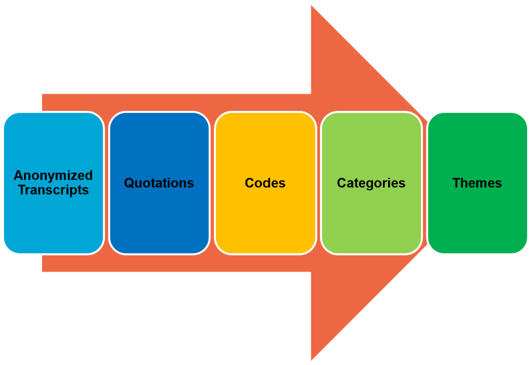


Figure 3.2: Data Analysis Process (Fereday & Muir-Cochrane, 2006)

An example of codes going assigned and themes formed is as follows:

"We don't have any KPIs related to urgent defects flow"- P[2]

For the above quote, the thematic analysis done is:

- Code: Key performance indicators
- Category: Business Process Performance
- Sub-theme: Role of Process Performance Measurement
- Theme: Role of Formalization in Process Standardization

3.2.5 Validation

The final research method employed in this thesis is the validation phase, where the preliminary findings from the perspective of the developed framework can be presented to stakeholders for validation and feedback. Expert interviews are conducted for the validation and feedback. The details of the participants for the expert interviews can be seen along with their roles and departments can be seen in Table 3.2. This step ensures the results are grounded in practical realities and stakeholder experiences. Also, the results can be validated to ensure the generalizability of the perspectives obtained from the interviews. This phase is crucial because a case study has inherent limitations in terms of generalizability (Lowhorn, 2007). To address this limitation, validation is necessary to verify the applicability of the findings beyond the specific case study. Furthermore, based on the validation results, recommendations about the most suitable optimization strategy or strategies for the Information system can be made.

Participants ID	Department	Role
E1	Reuse	Project & Change Management
E2	Reuse	Project & Change Management

Table 3.2: Participant attributes for Validation

3.2.6 Ethics Approval and Considerations

Respecting the autonomy and voluntary participation of individuals is a fundamental ethical principle in research. To ensure compliance with ethical guidelines, the research conducted in this study received approval from the Human Research and Ethics Committee (HREC) of TU Delft. This approval demonstrates that the study has undergone a rigorous review process, addressing essential ethical considerations and safeguarding the well-being of the participants. All participants in the study were volunteers who willingly chose to contribute their time and insights, further emphasizing their informed consent and active engagement in the research.

In this study, the data steward at TU Delft verified the data management plan (DMP), ensuring that appropriate protocols were in place for the handling and storage of data. This verification process guarantees adherence to data protection and privacy regulations, safeguarding the sensitive information provided by the participants.

Thus, by following established protocols, and obtaining HREC approval, this study demonstrates a strong commitment to ethical research practices. These measures not only protect the rights and well-being of the participants but also contribute to the overall integrity and reliability of the research findings. Through adherence to these ethical standards, the study aims to generate valuable insights while upholding the trust and confidentiality of all individuals involved.

Chapter-4: Analysis of the Case Study-Results and Findings

This chapter delves into the results of the qualitative analysis based on the semi-structured interviews and their findings along with document analysis for achieving the research objective of developing the framework that identifies the factors and inter-dependencies influencing the development and adoption of an IS-based process flow. The framework developed is available in Table 5.1. This chapter focuses on the influence of stakeholder actions and behaviors on business processes, as outlined by (Sekaran & Bougie, 2016). It presents findings derived from observations and document analyses that shed light on the current methods and challenges associated with managing issue of urgent defects. Following this, a detailed qualitative analysis constructed from semi-structured interviews with identified participants as mentioned in subsection 3.2.3 is provided. **The insights gained from the case study are then thoroughly interpreted and analyzed. Discussions on these findings are enriched with pertinent data and evidence to underscore their validity and relevance by relating them to the existing literature section 2.1.**

As outlined in chapter 3, the research methodology adopted in this study follows the Design Science framework for IS research detailed in section 3.2. This approach encompasses a comprehensive review and observation of existing documents to understand the current non-standardized processes. This is complemented by conducting semi-stuctured interviews with stakeholders involved in the RL operations flow, specifically focusing on the management of urgent defect requests for repair, recondition, remanufacture and analysis.

The results of the single case study for the case of ASML are divided into 2 stages:

1. Results based on document analysis and observations of the existing ways of working:
    - The document analysis and observations were made to identify and document the existing processes (pictorial representation) used to manage the high-impact issues of urgent defects.
    - The observations were made for studying the interface of the IS-based system available in ASML which was highlighted by the participants during the interviews.
2. Results derived from the qualitative analysis to identify the factors that need to be taken into consideration for influencing the change management during the development and adoption of an IS-based standard process takes place replacing the existing fragmented communication and information sharing processes.

The results of the interviews conducted in the form of qualitative analysis at the high-tech company of ASML are used for the development of the framework aimed at achieving a standard IS-based process flow. The framework can be seen in Table 5.1.

To standardize the business process for managing high-impact issues like urgent defects, the stages of the BPS approach as discussed in subsection 2.1.7 are applied. In the case study, document analysis, observations, and interviews conducted yielded insights into stages 1 to 5 of the existing process flow. Additionally, based on the learning's from these stages, it is examined how to approach stages 6 and 7. However, while doing this, the factors and inter-dependencies involved in developing a standardized process flow and its adoption are analyzed based on the framework developed, which is detailed in section 5.1.

4.1 Document Analysis

The document analysis for this research is done to understand the existing process flow followed to perform the repair,recondition, remanufacture and analysis of defective parts or products in the high-tech company of ASML. Based on the high-level process flow, the processes used for information sharing and communication between the stakeholders and department at ASML to manage the high-impact issue of urgent defects process are identified. The aim is to identify the bottlenecks and pain points used by the various processes and how they impact the performance of the overall RL of ASML. The reasons behind the bottlenecks and pain points are identified by the participants during the interview.

Furthermore, this document and observation-based analysis is used as a method triangulation technique as it involves multiple methods of data collection and analysis (Sekaran & Bougie, 2016). Thus, for this research the document analysis and qualitative analysis through semi-structured interviews as mentioned in subsection 3.2.3 and in item 3.2.3 will used as a method of triangulation.

4.1.1 Defective product repair process flow

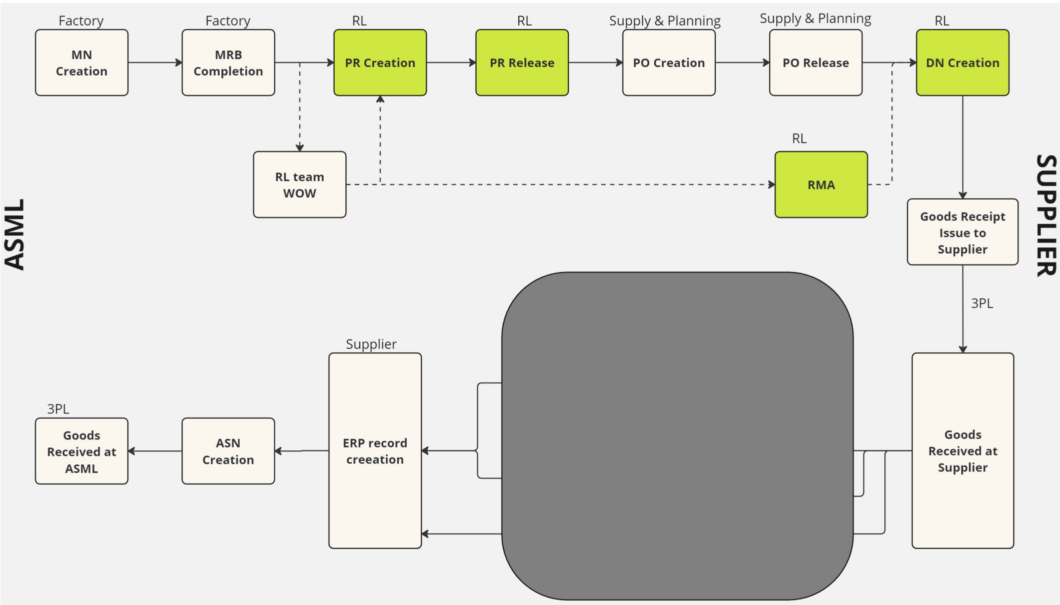


Figure 4.1: Repair/ Recondition/ Remanufacturing Process Flow at ASML

The high-level process flow of the RL at ASML is called the Integral Repair Cycle (IRC). It is an ASML-specific terminology and is defined as the process through which a repair, recondition, or remanufacture of a defective product or part is completed. IRC repair cycle is followed for all the repairs irrespective of the level of urgency. The IRC can be visualized in Figure 4.1. It begins at the moment of defect detection and continues until the part has been repaired,reconditioned, remanufactured, or completed for analysis by the respective supplier and shipped back to be in stock at ASML. The IRC at ASML is initiated with the generation of a Material Notification (MN) in the ERP system of SAP, signaling the need for part repair,recondition, remanufacture or performing root cause analysis and detailing the defect and its requirements. The MN contains the relevant information about defective parts or products which includes its unique identity number which is 12 digit number, and reasons for failure or defects observed which are required for the supplier who manufactured that respective defective part or product to perform the requested repair tasks. The MN process creation is common for defects that are not time-sensitive, critical, and high-impact issues like urgent defects and those for the ones that are high-impact.

The MN is generated in the ERP system called SAP High-Performance Analytic Appliance (HANA). Thus, the IS system available and used at ASML is called SAP HANA. This was also confirmed in the qualitative analysis by participants as seen in subsection 4.2.7. The detailed explanation of SAP is discussed in Appendix B.

The production team in the factory while manufacturing the machines (individual modules or integrating multiple modules to form a system) uses a variety of raw materials in the form of parts or products. Whenever they encounter that a material is not functioning as it should be (defective/ faulty), they raise an MN. To evaluate the defect, its repair, recondition, remanufacture methodology, and the potential for scrap, a Material Review Board (MRB)is convened. This board, comprising ASML Quality staff, deliberates on the appropriate strategy (repair, recondition, remanufacture or analysis) for part reutilization in the manufacturing. Once the repair strategy is agreed upon and informed to the RL team, **the RL team performs a series of administrative activities like Purchase Requisition (PR) generation, which is then transformed into a Purchase Order (PO) requiring approval. Depending upon the supplier's requirements, some of the requests sent to the supplier necessitate a Return Material Authorization (RMA). A Delivery Note (DN) is created and subsequently, the defective part is dispatched to the supplier.** The most time-consuming segment of the IRC follows, is the actual repair process performed by the supplier. [redacted] For parts with undetermined defects, or prolonged downtime while manufacturing due to the defects identified, an MRB may request a Root Cause Analysis (RCA), extending repair duration further compared to parts with identified issues. The record of the repair or analysis done is updated in the ERP system. After repair or analysis, an Advanced Shipping Notice (ASN) is issued, and the part is returned to ASML. This IRC process flow is for the defective parts including urgent and non-urgent defective parts. Certain steps in the process flow Figure 4.1 are redacted for confidential reasons.

4.1.2 Existing Urgent Defective parts Process Flow

The Urgent Defective parts flow for repair requests is a process followed for the defects that need an urgent resolution in the form is repairs, reconditioning, remanufacturing, or an RCA due to the unavailability of fresh, new stock to replace them.

The Urgent defective flow requests are similar to regular non-urgent repair or analysis requests in RL but due to their nature and impact, they need expedited shipment towards the suppliers to get their repaired or analyzed or both as per requester (stakeholder responsible for the sourcing and procurement of that part). Therefore, they are separated from the regular requests and there is the use of a non-standardized process flow to manage them This is as per the statement of Participant P[1] during the semi-structured interview for qualitative analysis in subsection 4.2.1.

The Urgent defective repair or analysis follows the IRC repair cycle mentioned in subsection 4.1.1 with a certain level of changes and escalations due to the nature of the urgent defects. **Urgent defects are distinct because, aside from sending details in the form of the fragmented methdds using emails, Excel file exchanges about the defective part needing urgent repairs or RCA with a subject marked as "Urgent Defects RCA or Repair," there is no unique identifier to distinguish them from regular defects which have no urgency associated with them.**

For this research the scope of the urgent repair and analysis flow is limited until we ship the defective parts requiring urgent repairs to their respective suppliers from the ASML.

The regular non-urgent and urgent process was developed as per the inputs received from the Reverse Logistics team at ASML as they are the process owner for the regular as well as the urgent defects flow as per the statement of Participant P[1] who is the Business Process Owner for regular non-urgent defects but oversees the urgent defect flow as well which can be seen in subsection 4.2.11.

Figure 4.2 shows the process flow for non-urgent or regular defective parts. This is derived based on the IRC flow as discussed in subsection 4.1.1 and the inputs of the RL team.

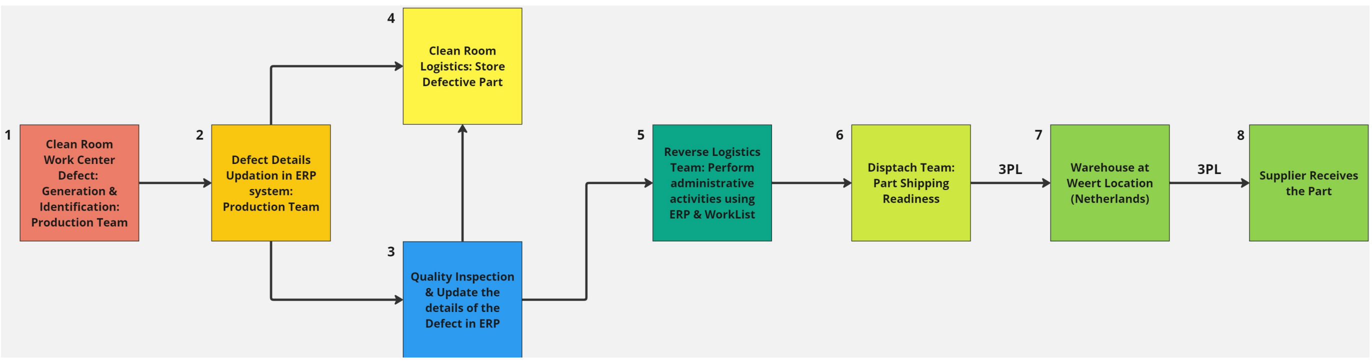


Figure 4.2: Regular or non-urgent defective part information and communication flow

1 **Identification of Defective Parts**: While the Production Team is using the raw materials in the form of parts or products to manufacture machines (systems) in the clear room work center, they identify that there is a defect in those parts. This is marked as step 1 in Figure 4.2.

2 **Update of Defect in ERP system**: The Production team records the details of those defects in the ERP system by generating a Material Notification (MN). This is marked as step 2 in Figure 4.2

3 **Notification and Dashboard Update**: The ERP system updates the Clean Room Logistics and Quality Inspection (Material Review Board) teams about defective parts via a dashboard (interface) that shows incoming MNs. The dashboard is connected to the ERP system. This is marked as step 3 and step 4 in Figure 4.2

4 **Storage and MRB completion**: The Clean Room Logistics team stores the defective parts for the MRB team to review. The MRB team inspects the defects and updates the following information in the ERP system :

- The necessary action to be taken for the defect: repair, recondition, remanufacture, or root cause analysis.
- The supplier-related information like, the supplier name, supplier identifier code
- After inspection, the Clean Room Logistics team moves the parts to the Dispatch area for packaging and preparation for shipping.

5 **RL Team Administration**: The RL team uses an interface connected to the ERP system to view all defect information in terms of MN's raised and perform administrative tasks (PR generation, PO generation, approval, RMA requests, and DN creation) as mentioned in subsection 4.1.1. The interface is only used for viewing and storage of the information, while all the tasks are performed in the ERP system. Based on the input information received from the MRB, the nature of the administrative activities performed by RL changes, thus, accurate input information is highly relevant here. This provides the necessary traceability, visibility and transparency of incoming defect requests raised. This is marked as step 5 in Figure 4.2. **The interface includes both the regular and urgent defects requests, however, it is not possible to distinguish them.**

6 **Packaging and Shipment**:

- The Dispatch team receives the defective parts from the clean room logistics team and packages them and prepares them for shipment, based on details from the RL team through ERP. The regular, non-urgent defective products are shipped first to the warehouse at Weert location and later upon as per the availability of the supplier and demand, they are shipped towards the supplier. This is marked as Steps 6 in Figure 4.3. The parts are stored at the Weert warehouse, as there is no immediate demand of these defective parts (urgent demands).
- Upon availability of supplier or demand, parts are then transferred to the Warehouse and from warehouse to the supplier via a third-party logistics provider (3PL).This is marked as Steps 7 in Figure 4.3.

7 **Supplier's Quality Portal**: After the reception of the part, the supplier starts taking the appropriate action. This is based on the reception of all the relevant information about the defective parts through their Quality Portal, which shows the type of repair or analysis required. This information is based on the activities performed and updated by the MRB and RL team in the ERP system. This is marked as step 8 in Figure 4.2

The flow for urgent defective parts can be seen in Figure 4.3.

1 **Identification of Defective Parts**: While the Production Team is using the raw materials in the form of parts or products to manufacture machines (systems) in the clear room work center, they identify that there is a defect in those parts. This is marked as Step 1 in Figure 4.3.

2 **Update of Defect in ERP**: Details of the defect for those parts are updated in the ERP system by generation of a Material Notification (MN). This is marked as Step 2 in Figure 4.3.

3 **Notification and Dashboard Update**:

- The Clean Room Logistics and Quality Inspection team called the Material Review Board (MRB) is automatically notified via a dashboard connected to the ERP system, which displays the MNs for both regular and urgent defects. There is no identifier to separate the urgent defective parts from the non-urgent defective parts. This is marked as steps 3 and 4 in Figure 4.3.

4 **Supply Chain Planner Involvement**:

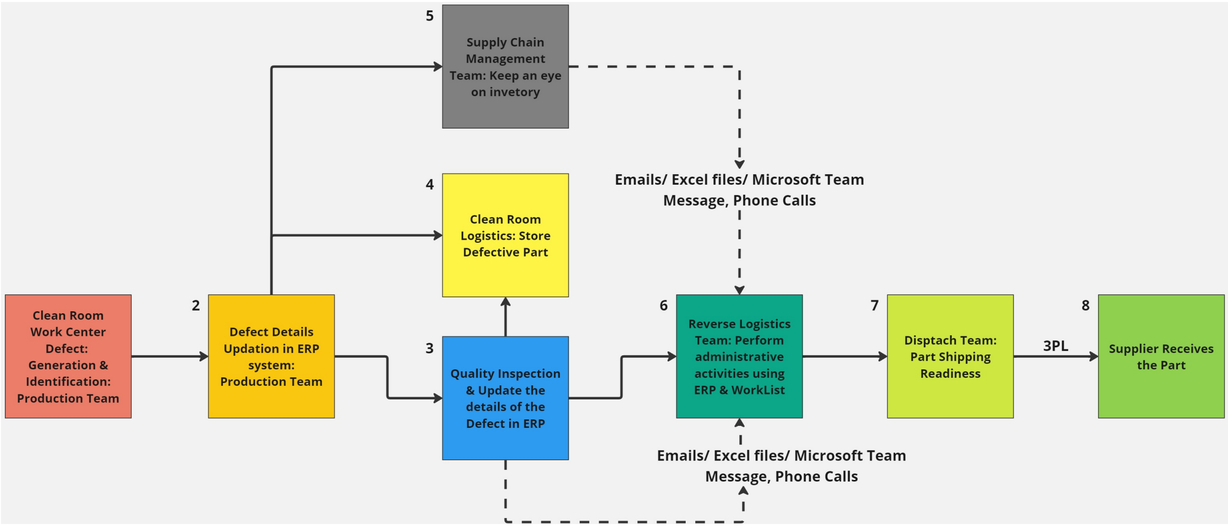


Figure 4.3: Urgent defective part information and communication flow

- If a fresh replacement part against the defective part is not available in inventory, the Production team informs the Supply Chain Planner who is responsible for the sourcing and procurement and making that part available for manufacturing operations.
- The Supply Chain Planner explores options like expedited shipping of a fresh part from the supplier.
- If no fresh part is available, they email the RL team with an Excel file or an Microsoft team message or even a phone call, indicating the part has an urgent defect requiring immediate repair. This is marked as step 5 in Figure 4.3.

5 **Repair Order, Storage and MRB completion**:

- The MRB team inspects the defect and updates the ERP with the following information:
  - The required action (repair, recondition, remanufacture, or root cause analysis) for the defective part
  - The supplier-related information like the supplier name, the supplier code, and other relevant information.
- If the defect is critical and serious, the MRB team can ask for root cause analysis and the reasons for those are dead on arrival, the entire stock available of the part is defective, the defect is critical and has caused the production to halt for more than 24 hours. This is as per the statements of the Quality team who are part of the MRB and can be seen in subsection 4.2.1. In this case, the Quality MRB team also sends an email or an Excel file with the defective part details, Microsoft Team messages, and Phone calls to the RL team stating urgent defective parts urgency to ship them promptly to the supplier.
- The Supply Chain Planner before sending the email to the RL team about urgent defective parts has to perform the following tasks:
  - Place an urgent repair order in the ERP system against that particular defective part
  - Ensure that the defective part is moved out of the clean room for MRB inspection and that the MRB Quality inspection is completed.
- At times, the supply chain planner can also send an Excel file with the defective part details, Microsoft Team messages, and Phone calls to the RL team stating urgent defective parts urgency to ship them promptly to the supplier.
- Post the completion of MRB, the Clean Room Logistics team moves the parts to the Dispatch area for packaging and preparation for shipping. This process is the same for both regular and urgent defects.

6 **RL Team Administration**:

- Post the updation of relevant information from the MRB, the Supply Chain Planner should notify the RL team about urgency as marked in step 5.

- The interface connected to ERP used by RL team for regular defects processing also includes urgent defects requests, however, it is not possible to distinguish them. As there is no dedicated identification to distinguish urgent defect parts from no urgent, the RL team upon reception of the email, uses it as identifier for urgent defects. They then use the ERP directly to perform their administrative activities and not the interface as these requests is not distinguishable in the interface which is used for non-urgent defects.
- They perform administrative tasks like PR generation, PO generation, approval, RMA requests, and creating a Delivery Note (DN). These activities are performed in the ERP system. This is marked as Step 6 in Figure 4.3.

7 **Packaging and Shipment**: The Dispatch team receives details from the RL team and prepares the defective parts for shipment directed towards supplier and not to the warehouse in Weert via a third-party logistics provider (3PL). This is marked as step 6 in Figure 4.2. The aim is to save the time that is wasted in shipping the parts to the Warehouse and then towards the supplier.

8 **Supplier's Quality Portal**:

- The part is received at the supplier and based on the relevant information about the defective parts updated in the supplier's Quality Portal by the MRB team during the inspection, the supplier takes action.
- The supplier can see the type of repair request and other actions needed, based on the MRB and RL team's updates in the ERP. This is marked as Step 8 in Figure 4.3.

The emails sent from the Quality MRB team and Supply Chain Planner act as identifier for the RL team to identify and separate the urgent defective parts from regular non-urgent defective parts.

Therefore, from the above flow, stage 1 and stage 2 of Business Process Standardization as defined subsection 2.1.7 are identified. In the case of Urgent defect repair and analysis requests, there is a single, overarching main process essential to the RL operations which is the IRC process. However, it's important to understand that this main process is not characterized by variant individual processes but by several distinct sub-processes. The only difference between the regular flow and urgent flow is the communication from the Supply Chain Planner and the Quality MRB team who are the requesters of the urgent defect repair or other action and for analysis.

These sub-processes include:

1. Usage of Emails: Communicating the urgency through emails with stakeholders in the flow and to RL.
2. Excel Forms: Logging defect details and sharing them with other stakeholders in the flow and to RL.
3. Microsoft Teams Messages: Informing the RL team members about an urgent defect request.
4. Phone calls for informing about urgency.

Each of these sub-processes utilizes different tools and forms a critical part of the complete urgent requests in the form of repair or other actions and analysis. They are not separate variants of the main process but are integral components that collectively ensure the main process of IRC is carried out effectively with a sense of priority and urgency. By using these various tools, the main process aims to manage defects efficiently. However, the lack of integration among these sub-processes can introduce inefficiencies and inconsistencies. Therefore, the research underscores the need for a standardized approach that integrates these sub-processes into a cohesive IS-based workflow, enhancing the overall effectiveness and efficiency of the urgent defect repair and analysis process. These fragmented processes used for urgent defects information sharing and communication of urgent defects to the RL team in the form of excel files sharing and usage of emails can seen in Figure 4.3. This covers the stage 1 and 2 of the BPS as mentioned in subsection 2.1.7. This has also been confirmed in the qualitative analysis which can be seen in subsection 4.2.2.

The IRC is a standard process flow and the detailed version of IRC until the defective part is shipped to the supplier for regular defective parts repair and analysis is shown in Figure 4.2. The non-urgent regular flow is therefore a standard process flow and does not need any additional inputs from the requesters, the supply chain planners, and the MRB teams to request urgent defect repair and analysis requests.

It is crucial to recognize that for the RL team to effectively conduct administrative activities and promptly ship urgent defective parts, they rely on receiving accurate and timely information from the various stakeholders involved in the flow as seen in Figure 4.3. Based on observations and interviews,

stakeholders requesting urgent defective parts often have their own methods of operation. Due to the absence of a standardized process flow, they are aware of the necessary prerequisites to be completed before communicating with the RL team via fragmented communication tools.

For the RL team to proceed effectively with their activities, it is essential for the requester of the urgent defect to place a repair order promptly, ensure the part is removed from the clean room, and complete the Material Review Board (MRB) process with proper information updates in the ERP. This ensures seamless coordination and timely response after the RL team is informed and failure to do acts as a bottleneck for the RL team. The RL team then has to trace the requester and ensure that all the required prerequisites are completed correctly. The challenges encountered due to this are analyzed in subsection 4.2.2, subsection 4.2.3, and the impact of these challenges is shown and analyzed in subsection 4.2.5.

4.2 Qualitative Analysis and Findings

The objective of conducting the qualitative analysis was to comprehensively understand and examine the organizational journey involved in adopting an IS-based process flow. This includes the entire process from the initial identification of the business need to the final implementation. The qualitative analysis is divided into 3 phases inspired by the TOE framework, Business Process Standardization, contingent theory based on OIPT, and the change Management models explained in section 2.1. The three phases are the Assessment and Alignment Phase, Implementation and Transition Phase & Optimization and Integration Phase.

The qualitative analysis aims to achieve the following:

1. Understand the business need for technology adoption and process standardization and address the technological, organizational, and environmental assessment and alignment to achieve this adoption (Assessment and Alignment Phase):
   - This is done to study and understand the existing state for the management of the high-impact issues.
   - Identify the perceived challenges and inefficiencies in the current non-standardized processes, which defines the business need as per Hevner et al. (2004) and as per the TOE framework discussed in subsection 2.1.6.
   - Investigate how different levels of variability in business processes affect the feasibility and effectiveness of standardizationZelt et al. (2019); Goel et al. (2023).
   - Gather insights on how stakeholders view the potential benefits of standardization, especially for reducing uncertainty and equivocality as defined by Zelt et al. (2019) and adoption of IS as per the TOE framework discussed in subsection 2.1.6.
   - Assess the level of stakeholder buy-in and willingness to adopt a new standardized process flow as per Saghafian et al. (2021) and as per the TOE framework.
   - Gather insights about the appropriate IS system that is best fit and the stakeholders have access to as per Oltra-Badenes et al. (2019); Saghafian et al. (2021) and as per the TOE framework defined by Tornatzky & Fleischer (1990); Baker (2012); H. O. Awa et al. (2017); Pan & Jang (2008); Badenhorst (2016).
   - Collect stakeholder opinions on how the new IS-based process flow can improve efficiency, transparency, and decision-making in managing time-sensitive, critical, and high-impact issues (Badenhorst, 2016; Lambert et al., 2011; Genchev et al., 2011; J. Hall et al., 2013; Olorunniwo & Li, 2010).
   - Examine how the degree of interdependence among process participants influences the success of standardization efforts (Zelt et al., 2019; Wong et al., 2011).
   - Study the impact of continuous process monitoring on maintaining standardized processes, particularly in environments with varying levels of uncertainty and equivocality Zelt et al. (2019).
   - Analyze how aligning process management mechanisms with specific process characteristics can enhance efficiency and effectiveness, ensuring that the standardized process meets performance goals (Zelt et al., 2019; Alarcón et al., 2021; R. Huscroft et al., 2013; Genchev et al., 2011).
   - Identify potential performance metrics and indicators that stakeholders consider important for measuring the success of the standardized process flow (R. Huscroft et al., 2013; J. Hall et al., 2013).

- Investigate how IS can support the standardization of business processes by providing necessary tools for documentation, monitoring, and coordination, especially in complex and variable environments (Badenhorst, 2016; Zelt et al., 2019; Genchev et al., 2011)
- Gather insights on the expected long-term benefits of standardization.

2. Investigate the change management process an organization undergoes during the development and implementation of process standardization through IS adoption (Implementation and Transition Phase):

   - Understand stakeholder concerns and expectations regarding the adoptio of the new IS-based process flow (Saghafian et al., 2021; Mesgari & Okoli, 2019).
   - Examine the challenges that stakeholders consider while adapting the IS-based process flow as per the TOE framework discussed in subsection 2.1.6.
   - Understand the importance of top management support while adopting IS-based business process standardization (Baker, 2012; R. Huscroft et al., 2013; Goel et al., 2023) and as per the TOE framework discussed in subsection 2.1.6.
   - Gather feedback on the effectiveness of change management communication, training, pilot testing, and support strategies during the change management process.

3. Evaluate the potential impact of the standardized process flow (Optimization and Integration Phase):

   - Identify potential barriers and resistance to change among different stakeholder groups as per the TOE framework discussed in subsection 2.1.6.
   - Identify the strategies that will enable the stakeholders to accept the new IS-based process flow.
   - Focus on the role of performance monitoring for continuous improvement.

To perform the qualitative analysis, semi-structured interviews were conducted which provided a rich source of data, enabling an examination of diverse viewpoints within the established research framework. A detailed description of the participants and the roles they play in the process can be seen in Table 3.1 and in Appendix A.

To ensure data accuracy and reliability, the interview transcripts were carefully cleaned to remove any unnecessary or irrelevant material, while maintaining the authenticity of the responses. **The findings from these interviews were interpreted and analyzed based TOE framework, and the process standardization and change management theories reviewed in section 2.1 to identify major themes and patterns. Furthermore, for triangulation purposes, the observations and findings made from the document analysis of processes were cross-validated with qualitative analysis based on interviews with stakeholders involved in these processes.** This approach enhanced the credibility and depth of the research findings by integrating multiple perspectives and data sources.

The major goal of conducting qualitative analysis in this research involves understanding stakeholder beliefs about the need for adopting an IS-based standard process flow and their perceptions of this change are intricately linked to the broader research objective. This thorough analysis provided a detailed and insightful understanding of the studied factors, highlighting specific insights and observations that illuminate the complex interactions and dynamics involved in the process flow. This allowed a detailed understanding of addressing contemporary challenges faced by high-tech companies like ASML during technology-based process flow development and adoption.

As the current process for managing high-impact issues like urgent defects at ASML is not standardized and struggles with efficiency and meeting its goals, it is necessary to develop and adopt a standardized process flow using information systems as discussed in chapter 1 in section 1.1. However, to develop and adopt such a standardized process flow, it is essential to identify the factors and inter-dependencies that will influence its development and smooth adoption in the organization. This research thus aims to develop a comprehensive framework to identify these crucial factors and inter-dependencies that can facilitate the development and adoption of a standardized process flow using information systems. By examining and validating these factors within the framework, a documented, standardized process that efficiently manages urgent defects can be established. The development and implementation of this process will heavily rely on effective change management strategies to ensure smooth adoption and operation. This approach not only addresses the immediate need to enhance defect management but also significantly contributes to the broader field of process standardization within high-tech industries.

This section therefore provides a detailed account of the analysis, including analysis from transcribed interviews and interpretation of findings with the existing literature. It provides an in-depth exploration of the factors and inter-dependencies at hand by delving into the participant's specific viewpoints and perspectives. These insights play a key role in establishing the framework required to identify the factors and inter-dependencies for the development and adoption of IS-based process flow as well as to further develop this process flow in the form of themes and sub-themes. These themes and sub-themes identified based on the semi-structure interviews are as follows:

4.2.1 High Impact Issues in RL

The high-impact issues are those that need to be shipped in an expedited manner to the suppliers for operational continuity and avoidance of impact on the organizational performance as discussed in section 1.1. The participants defined the high-impact issues in RL and explained the various reasons and purposes for which they needed to be addressed.

Urgent Defects Identfication

P[14] defines an urgent defect as the parts that need to be shipped back to the supplier for immediate repair or analysis:

> *"If a defective part stops production for too long due to quality reasons or if that defective part is the last one we have in our inventory because its supplier cannot deliver a new one within the required timeframe, this part becomes urgent defect and has to be shipped to the supplier for immediate analysis or repair as needed"* -P[14]

P[14] defines an urgent defect as a defective part that either halts production for an extended period due to quality issues or is the last available part with no immediate replacement from the supplier. These parts are critical to the manufacturing process and need immediate attention to prevent significant downtime and ensure the continuation of operations.

All the participants agreed to this definition of urgent defects. P[10] noted that expensive and technically critical parts are often treated as urgent defects.

P[16], P[17], P[18] and P[19] who are from Quality Teams added that urgent analysis is required for the following reasons:

- **Entire batch of parts was rejected, a situation referred to as a stock purge.**
- **When the part that is received in a non-functional or defective state ("dead on arrival" or DOA) and cannot be used.**
- **When a defect causes extremely long delays (XLDs) in resuming manufacturing operations, it refers to delays that are unusually prolonged or extended beyond typical expectations or norms.**

These reasons necessitate an immediate return to the supplier for analysis. **This is crucial for maintaining the performance and reliability of the systems from long term perspectives.**

R. Huscroft et al. (2013) emphasizes the **need to expedite parts in the RL process to minimize disruptions to customer demand and avoid significant cost implications. This is particularly relevant in the context of urgent defects, as immediate attention to these defects ensures that production can continue without prolonged interruptions. The insights from P[10] and P[17] align with R. Huscroft et al. (2013) findings, highlighting the necessity for rapid response to high-impact issues to maintain operational efficiency and customer satisfaction.**

Boykin (2001) discusses the critical role of part performance and reliability in the high-tech manufacturing industry, stating that these factors are crucial to an organization's financial success and operational efficiency. This necessitates a process for the immediate return of defective parts to the supplier for rapid resolution and continuity in production. P[14]'s definition, along with the examples provided by P[10] and P[17], supports Boykin (2001) assertion. Immediate repair and analysis of urgent defects are essential to ensure the high performance and reliability of systems, which are integral to the overall success of high-tech manufacturing operations.

P[1] states that urgent defective process is similar to regular defective process but with a need for faster shipment to the respective supplier for required repair or analysis purposes.

"The urgent defect process is similar to the regular non-urgent repair process but requires a much faster turnaround. To expedite these repairs, they were removed from standard operations and are notified by emails and Excel files, distinguishing them from regular non-urgent defects."- P[1]

The statement from P[1] states that the decision to separate urgent defects from standard operations and use email and Excel files as an identifier highlights the organization's recognition of the critical nature of these defects. This approach ensures that urgent defects are given priority and handled swiftly, reducing downtime and maintaining productivity.

Prioritization of Repair V/S Root Cause Analysis

P[10] highlights that there are at times situations where repairing the part and getting the source back to be reutilized are preferred over performing the quality analysis.

"There are situations where performing a root cause analysis is necessary for some critical defects. When there is an urgent demand for these defective parts, Supply Chain Planners often request that the supplier prioritize the repair and return them as soon as possible to avoid any manufacturing disruptions. However, I always advocate for prioritizing quality over speed and logistics. If the root cause is addressed, the issue will not recur, resolving long-term problems. Currently, the urgency often leads to RCA primarily for logistical reasons. There should be a provision in the ERP system to decide this." - P[10]

P[10], highlights situations where there is an urgent demand for defective parts to be repaired and returned quickly to expedite the process. It also emphasizes the tension between the urgency of repairs and the importance of maintaining quality. P[10], further states that the IS of ERP used should incorporate standardized criteria for when to prioritize urgent repairs and when to mandate RCA. This ensures a balanced approach that doesn't compromise quality for speed. The statement showcases the organization's commitment to the importance of the analysis of issues for the long-term benefits of the products.

This criterion will also bring transparency for everyone in the process on the importance of quality versus urgency.

P[1] states that the business impact of prioritizing quality over expedited repairs should be the key criterion for decision-making in this process.

4.2.2 Challenges due to the Existing Processes

Based on the qualitative analysis, the observations made and the review of process-related documents several challenges due to the existing non-standardized process flows to manage the urgent defect repair requests were identified. **To understand the drivers for stakeholders to adopt a new IS-based standardized process flow and address their concerns, the qualitative interviews focused on identifying the challenges faced with the current process flow. These insights are essential to consider the factors for improving the process to the new IS-based standardized flow.**These challenges have a major impact on the repair cycle time which in turn impacts the business operations of ASML to deliver the systems manufactured by ASML to the respective customers on time and with the right quality.

The qualitative analysis started with interviewing the team members of the RL team which includes the Business Process Owners (BPO) who are responsible for performing the administrative RL activities mentioned in subsection 4.1.1. It was then followed by interviewing the other stakeholders as mentioned in subsection 4.1.2. The participants (P[1] & P[2]) are the BPOs and P[4] who is a part of RL for performing the the RL-related activities and are the main stakeholders accountable for the shipment of urgent repairs to the supplier based on the request of the various stakeholders. The qualitative analysis then follows up by gathering the perspectives of other stakeholders involved in the process to understand their views, the challenges they face, and the implications of these challenges. The details about the stakeholders and the roles played by them in the process flow can be seen in Appendix A and in subsection 3.2.3.

Complex Coordination and Collaboration across Departments

P[3] and P[4] reveal the significant interdepartmental dependencies and communication challenges involved in managing urgent defect requests. They state that there is a **need for precise and timely information flow from various departments, which if not met causes delays and inefficiencies, particularly when data ambiguities arise and require clarification:**

> ***"I am dependent on various departments to process my urgent repair request to ship the defective parts towards the supplier, and the different departments involved, in turn, rely on others before an action can be taken."***- P[3]

> ***"To process an urgent defect request and perform the necessary RL administrative activities, I frequently have to depend on multiple departments to obtain the correct details and requirements. Ambiguities in the form of data are common, and I often find myself having to chase down clarifications, which is crucial for immediately shipping defective parts to suppliers"***- P[4]

The participants P[4], and P[3] expressed the importance of the need for collaboration and coordination across different departments to gather accurate information for urgent defect requests. While collaboration and coordination are important, they also highlighted the role of the degree of uncertainty involved in information processing as defined by Zelt et al. (2019) and discussed in subsection 2.1.8 and its impact on the performance of the RL process. The participants also highlighted the importance of prompt action in the process of shipping defective parts, emphasizing the **need for more streamlined procedures and clear guidelines and documentation on information flow requirements** to enhance response times and minimize delays.

These findings align with the existing literature on the critical role of communication and coordination in RL processes. **According to (García-Sánchez et al., 2018) RL requires efficient coordination and execution of the return process among supply chain stakeholders through continuous information flow. This need for efficient coordination is demonstrated in the findings, where participants expressed their reliance on multiple departments to process urgent requests effectively.** R. Huscroft et al. (2013) emphasizes the importance of accurate and timely communication for achieving operational efficiency and maintaining customer satisfaction. **The challenges highlighted by P[4] regarding data ambiguities and the necessity for constant clarification reflect the adverse effects of poor communication on operational efficiency.** R. Huscroft et al. (2013) further notes that the complexities of RL processes make communication and information sharing critical for performance. This is corroborated by the participants' experiences, which underscore the impact of inefficient communication and collaboration in the defect management process.

P[1], P[2], and P[4] point out that the **unavailability of factors of transparency in terms of visibility of incoming urgent requests, and accountability play a hindrance in meeting the end goal of urgent defect processing to ship the defective parts deemed as urgent to the supplier in a faster way:**

> ***"When we are notified about urgency, the defective part may be in the clean room, but we lack visibility into its exact location. Requesters often ask us to urgently send the part for repair. However, locating the part is challenging as it may not be listed under our responsibility in the SAP ERP system, we lack the requester's contact details, and we struggle with communicating the transfer of the defective part from the clean room to a shippable location."***- P[1]

The above statement from P[1] highlights significant challenges when processing urgent defect repair requests. They noted that when the RL team receives email communications about urgent defect repairs, they attempt to complete the necessary administrative activities. However, they often encounter issues because the defective part is not located within the ERP system of SAP under RL's direct oversight, which is required to perform these activities. **The defective part has to be moved to a location inside the ERP system of SAP by the requester of the urgent defects and then they have to place a request, which is not always followed by the requesters.** Also, the details of the requester are not known to the RL team, making it difficult for them to communicate with the requester about the correct process flow and the necessary steps to be followed. **This is refers to the subsection 4.1.2 and Figure 4.3, which showcases the role and actions need to taken by Supply Chain Planner while communicating urgent defects flow.** This is further analyzed in detail in the subtheme of **Process Awareness Enhancement**.

This lack of visibility into the exact location of defective parts and the unavailability of the requester details significantly impede the efficiency of the RL administrative process. This results in delays and complications in retrieving parts for shipment, highlighting a critical gap in the current workflow for information availability, sharing, and coordination and the need for a new process flow.

These challenges identified by the participants align with Prasad et al. (2010), who emphasizes that for a supply chain to be managed effectively, it is crucial to handle visibility, coordination,

information sharing, and communication both within the organization and across the supply chain. The issues identified by the participants are aligned with Lambert et al. (2011) which emphasizes the use of an Information System (IS) to improve transparency and visibility in RL as it ensures effective communication between different involved parties. The existing email processes of communication and information sharing for urgent requests thus hinder efficient collaboration among stakeholders, as it may lead to **siloed conversations and a lack of a centralized information platform.** This underscores the need for **improved IS integration, visibility of the requester, and enhanced process clarity** to facilitate faster and more reliable handling of urgent defects.

To resolve the above challenges faced by the RL team, email conversations are exchanged between the various stakeholders involved from various departments like RL, Clean Room Logistics, Process Improvement, Material Quality, and Dispatch as mentioned in Appendix A depending upon the requester and the reason for the urgent request (Repair or RCA). This to and fro email communications only **add up to the time taken to resolve these requests, suggesting better protocols and clear guidelines establishment.** This is made clear by the following statement of P[1]:

> ***"Reverse Logistics coordinates all necessary administrative work amid considerable uncertainty. Clarity about who to contact for each request would streamline the process significantly which the current process lacks. However, every request involves multiple email queries between stakeholders and delays in getting answers. If communication protocols were clearer, for instance, knowing exactly who to contact to move a part out of the clean room, it would ensure more efficient operations"***- P[1]

P[1] therefore expresses a need for establishing **clear guidelines of communication protocols**. Apart from the visibility and transparency challenges mentioned, the management of urgent defects is complicated by **a lack of structured communication protocols** for coordination, and necessary administrative work. The current system is fraught with uncertainty, every request received by email leads to numerous follow-up questions, significantly delaying the response process.

These findings highlight the critical **need for formalization** within the organization. Formalization is initially described as the degree to which rules, procedures, instructions, and communications are documented (Alarcón et al., 2021). This is analyzed in detail in subsection 4.2.3.

Operational Risks in Existing Processes

P[2] and P[4] identified the existing process of communicating urgent defect requests pose significant risks, primarily due to their vulnerability to miscommunication and important information getting overlooked. P[2] and P[4] are from the RL team and are responsible for all the administrative work that is necessary to ship the parts out of ASML and thus play a very vital role in RL process flow. These risks are elaborated by following statements from P[2] and P[4]:

> ***"If we receive email communication from stakeholders about urgent defects, the risk is that we may not see the email on time or maybe the expected team member does not see the email or the requester does not loop the correct team members into the email"***- P[2]

> ***"Since the email system is accessible to everyone, there's a risk that if someone reads the email about urgent defect request, it might get overlooked. Often, I find myself having to sift through entire email chains to extract the necessary information or to grasp the urgency of the request. Additionally, when I'm engaged with other tasks, there's a real possibility that I might miss an email about urgent defects."*** -P[4]

P[2] and P[4] stressed that **critical information may be lost, misinterpreted, overlooked, and missed by them when it is dispersed across multiple communication channels or buried within extensive email chains.**. **At times they might even lose the oversight of an incoming request or one that has already been made in resides in the inbox.** Such fragmentation can result in **incorrect decision-making resulting in delayed responses to urgent defects,** adversely affecting stakeholder decision-making and the necessity to respond on time which is crucial for effectively managing these defects.

When information about an urgent defect request is scattered across multiple email threads, it leads to a **lack of visibility, transparency and traceability.** The RL team may not have a complete view of all communications related to an issue, resulting in a **fragmented understanding and misinformed decision-making**. An overload of email requests can **obscure critical information, hindering team**

members ability to access and act on essential data. This congestion of information **complicates decision-making and responsiveness of RL**, particularly in managing urgent defects.

These findings align with the research of Jayasinghe et al. (2019), which highlights the root causes for barriers of succesful RL operations include the lack of information flow and fragmentation and inconsistency of operations. Therefore, the entire RL supply chain operation requires a sound information flow and information management (IM) approach to regulate input, output, and process-related information effectively Jayasinghe et al. (2019). **By establishing structured communication protocols and improving information management, the RL team can mitigate these risks, ensuring timely and accurate responses to urgent defect requests.** This demands a need for proper IS for information management as the lack of an IS introduces significant risks, uncertainties, and barriers, which need to be collectively addressed to improve the effectiveness of RLSC operations Jayasinghe et al. (2019).

The findings about the importance of on-time response align closely with the research by R. Huscroft et al. (2013), which emphasizes that the timing of operations significantly impacts RL performance. R. Huscroft et al. (2013) notes that timing concerns, including on-time delivery requirements, service requirements, cycle time, and the effective use of transportation opportunities, are crucial for the success of RL operations.

In the context of the current study, the interviews highlight significant risks associated with the existing communication and information-sharing processes, specifically the failure to respond promptly to urgent email communications. This lack of timely response can lead to delays and inefficiencies, directly affecting the RL performance.

R. Huscroft et al. (2013) further emphasizes that while the aspect of timing in RL operations initially received less attention, it is increasingly recognized as organizations integrate RL management more thoroughly into their system-wide operations. **The emphasis on timing underscores the necessity for precise coordination among stakeholders involved in RL processes.**

Therefore, the findings from the interviews reinforce the importance of on-time response in communication as a critical factor in improving RL performance. Ensuring timely checking and addressing of emails is essential to meet on-time delivery requirements and optimize cycle times. By improving the timeliness of responses and coordination among stakeholders, organizations can enhance the overall efficiency and effectiveness of their RL operations, as highlighted by R. Huscroft et al. (2013).

P[1], P[3], P[4], P[6], P[7], P[8], P[9], P[10], P[11] highlighted the lack of collaboration between stakeholders and indicated that this eventually leads to miscommunication and inaccurate or delayed information reception, which ultimately impacts the business performance of RL. This is evident from the below statement of P[4] who is part of RL and works with the BPOs.

> ***"The common challenges we face include defective parts not being correctly located in SAP, no repair demand raised by requesters, lack of MRB quality validation, missing critical data such as vendor codes, and parts still being installed in machines. It is the responsibility of the requester and the responsible stakeholders to clear these issues. These issues hinder our ability to decide whether to repair, perform RCA, recondition, or remanufacture the defective parts."*** - P[4]

P[4] identifies several challenges encountered while processing urgent defect requests. Often, requesters do not complete the prerequisite tasks mentioned by P[4], before placing a request, indicating a lack of awareness of the fundamental process flow and necessary knowledge. This eventually leads to a bottleneck for the RL team and only increases the time necessary to ship the parts. This was discussed earlier in the subsection 4.1.2 and in Figure 4.3.

Additionally, there is a clear lack of clarity regarding the roles and responsibilities of the stakeholders involved in the process. This highlights the critical need for clarity in roles and responsibilities, as well as enhanced process awareness and knowledge, to ensure effective RL operations. These findings underscore the importance of formalization in addressing the challenges faced in RL. By defining clear responsibilities, standardizing processes and procedures, and equipping individuals with the necessary information, formalization can significantly improve the efficiency and effectiveness of RL operations. This aligns with R. Huscroft et al. (2013) assertion that formalization is a vital factor affecting RL. Implementing these formalized procedures will enhance role clarity, process awareness, and overall operational performance in managing urgent defects. This is analyzed in detail in subsection 4.2.3.

Need of Operational Alignment Across Organization

P[1], and P[4] emphasize the need to have an operational alignment between the operational hours of the RL department and the factory.

> *"The requesters from different departments are not aware of our process. They often send us urgent defect requests incorrectly and even on weekends—Saturday and Sunday. Our department operates Monday through Friday, unlike the factory that runs all week"*-P[4]

P[4] points out that there is a significant lack of communication and process awareness between different departments and the RL team. Specifically, requesters from various departments are not adequately informed about the RL team's operational procedures and schedules, leading to incorrect submission of urgent defect requests. Additionally, there is a clear misalignment in working schedules; while the factory operates all week, the RL team works only from Monday to Friday. This discrepancy is not effectively communicated, causing requests to be sent during the RL team's non-operational hours, further exacerbating the issue.

P[1] about the operational misalignment indicates that there is a need to have an service level agreements (SLA) that clearly outlines the expected response times and responsibilities of the RL department. SLAs are explained further in subsection 4.2.3. This ensures that there are predefined procedures and expectations for handling requests during off-hours:

> *"If the requester logs a priority request for urgency at one minute before 5 P.M. when our official working hours end, then we can look up to an SLA and inform them accordingly about the expected delivery timeline, but currently there are no such SLAs."*- P[1]

> *"We need to discuss with our 3PL and our logistics team about the SLAs and expected delivery times and then inform the requester of the defective part accordingly."*- P[1]

The need for operational alignment further sheds light on the importance of having SLAs. This is aligned with the necessity of formalization in the form of agreed proceedures and rules defined by R. Huscroft et al. (2013); Genchev et al. (2011) and analyzed in subsection 4.2.3.

Overcoming the Continuous Monitoring and Manual Interventions

The participants highlighted the significant risks associated with the current communication and information-sharing processes, specifically the failure to respond promptly to urgent email communications. This underscores the critical need for timely checking and addressing of emails to ensure urgent matters are handled efficiently. The RL team members, P[2] and P[4], who are responsible for processing the urgent defect requests brought to attention risks associated with the existing process of communication and information flow:

> *"If we receive email communication from stakeholders about urgent defects, the risk is that we may not see the email on time or maybe the expected team member does not see the email or the requester does not loop the correct team members into the email"*- P[2]

P[2] highlights that the current communication methods introduce a significant risk, as emails or shared Excel files may not be seen or acted upon promptly. This can lead to delays in addressing urgent defect requests. Various factors contribute to this issue, such as recipients not constantly monitoring their email or the email getting lost amid a large volume of incoming email and messages.

The risks mentioned by P[2] were experienced firsthand by one of the stakeholders who had submitted an urgent repair request to the RL team, as illustrated below:

> *"I sent an email about an emergency repair of a part to the RL team email, expecting a reply within one or two hours. However, due to loose controls, the email was not recognized as an emergency."*- P[21]

The statement from P[21] indicates the drawbacks of the existing practices and also presents an example of risks highlighted by P[2].

P[6], P[7], P[9], P[10], P[11], and P[12] whose roles and responsibilities fall in the supply chain planning and product life cycle management and whose responsibilities are to ensure that there is a gap in the demand and supply planning, rely on urgent defects repair process as the last resort to avoid any supply chain disruption. These stakeholders who are frequent requester's for urgent defects point out that they have to keep a continuous track of the defective part until it reaches the supplier and the way to do it is by having continuous email follow-ups and telephonic conversations with the RL team.

P[9] indicates that the reliance on the existing process of sharing Excel files, and manual tracking methods, such as constant communication via calls and emails poses significant challenges and limitations:

> *"The main limitation of the current non-standardized process is the extensive manual effort required to track and trace the status of urgent defects. Additionally, the Excel form needs to be manually downloaded and filled out, which adds a significant workload. This leads to constantly monitoring, manually tracking and updating, the existing process is highly inefficient."*- P[9]

The statement from P[9] highlights the limitations of the existing processes in terms of traceability and manual workload. This indicates the needs of an IS for triggering the urgent defects and automated interface to track their progress.

P[11] underscores the importance of meticulous tracking at each step of the process to ensure timely resolution of issues:

> *"Every step needs to be tracked one by one for any issue in the flow. If you don't track it can take weeks or even months before it reaches the supplier"*- P[11]

The statement P[11], illustrates the lack of comprehensive tracking can result in significant delays, potentially taking weeks or even months before the defective part reaches the supplier. This highlights a critical gap in the process flow where tracking mechanisms are either inadequate or inefficient. The statement points to the need for a more robust tracking system that can provide visibility of the progress of defect resolution in real-time and ensure accountability at every stage.

P[10] points out that although there is an established process involving an Excel form that should theoretically facilitate communication with the RL team, the practical implementation is fraught with issues:

> *"In theory, we have the Excel form, and emailing it to the RL should work, but there are too many occasions where something goes wrong. The way that's handled could be improved because it involves a lot of back-and-forth communication via email, which is not ideal."*- P[10]

The statement from P[10] highlights that the errors and mishandling of the form lead to cumbersome back-and-forth email communication, which is inefficient and prone to miscommunication. This iterative email exchange not only delays the process but also increases the likelihood of errors and oversight.

The findings from the interviews highlight the critical role of transparency, traceability and visibility in tracking the progress of defective parts. This is strongly supported by Olorunniwo & Li (2010) emphasis on the IT-driven nature of RL, which is essential for improving visibility and managing goods in motion effectively.

According to Prasad et al. (2010), enterprise information systems like ERP systems offers a robust platform for standardization, integration, information management practices, and real-time transaction processing. These capabilities provide an excellent basis for integration with supply chain stakeholders, ensuring that all stakeholders have access to accurate, real-time information. The integration of ERP into RL processes can significantly enhance data integrity, visibility, and control across the organization (Prasad et al., 2010).

Establishment of Clear Accountability

P[2] emphasized giving an example of a recent case for the importance of visibility regarding the requester's details, as it ensures accountability for those requesting urgent defect repairs or Root Cause Analysis (RCA).

> *"There was a recent case when we received an urgent defect request and we processed the defect repair and shipped the part urgently with emergency delivery towards the supplier in France and when the truck went to France at the supplier, the supplier was closed. Everyone asked the RL team member why they shipped the part out urgently, and since the requester's name was not known, it was difficult to trace everything"*- P[2]

In the recent case explained by P[2], despite the RL team's efforts to ship the part urgently to the supplier, the end goal was not achieved. This incident underscores the critical issue of **lacking visibility of the requester.** It becomes challenging to track the origin of requests, follow up on necessary details, and hold the appropriate individuals accountable, leading to miscommunication and inefficiencies. Implementing a system that **ensures clear visibility of the requester's details is essential for improving accountability and streamlining the handling of urgent defect requests.**

Input Processing Data Accuracy and availability

While understanding the variability of input steps or ways of communicating urgent defect requests leading to uncertainty and impacting the performance of RL for managing urgent defects, the issues related to input data quality surfaced. The participants identified the critical role of accurate data as an input required to perform the administrative RL activities which plays a vital role in ensuring that the RL process is both efficient and effective.

The interviews revealed that **although the trigger for urgent defect requests is sent by various non-standardized processes, the administrative activities to ship the defective parts are performed in the IS ERP system of SAP.** The detailed explanation of this available in subsection 2.1.5, in subsection 4.1.1.

P[12] and P[9] highlight the significance of accurate data required for processing the urgent defect request the RL team receives:

> ***"Reverse Logistics relies on emails and Excel files they receive for urgent requests triggers but must use SAP ERP for critical data in the Material Notification (MN) to perform their administrative activities to ship the defective part. Often, the MN is incorrectly filled or at times left empty, impacting its role as the driver for RL activities, RL team is stuck and cannot respond in the timely manner as they are expected to be. The RL team then needs to contact stakeholders for information in the email, increasing the lead time for shipping defective parts."*** - P[12]

> ***"The YES codes in MN are crucial for ensuring the correct flow towards the supplier, but they're often filled incorrectly. Recently, we noticed that all the YES codes were filled in incorrectly, and the failure descriptions are often inaccurate. This is an entirely non-value-added way of doing things that impacts the main purpose of the process and is a bottleneck for the process flow"*** - P[9]

The above statement by P[12], P[9], emphasizes the importance of accurate data availability in operational processes, specifically regarding YES codes and failure descriptions by stakeholders requesting urgent defect repairs. The Yes codes play a crucial role in identifying if the defective parts need an urgent RCA to be conducted or if an urgent repair, recondition, remanufacturing is needed. Accurate information is critical for enabling suppliers and the RL team to understand the type of urgency and specific requirements, influencing the efficiency and responsiveness of the supply chain. This issue reflects the non-availability of process control procedures to prevent, detect, or correct errors in the existing information flow as denied by Bai et al. (2013). **This necessitates the presence of control procedures that will not only reduce the errors but also act to reduce the variations in the inputs and thus reduce uncertainty leading to a positive impact on RL and the urgent defect request process. The control procedures need to be placed at different task locations of a process, the control system can reduce errors and ultimately mitigate risk (Bai et al., 2013).** The control procedures therefore have to be instilled at various locations of information flow in the system of IS ERP of SAP used. **This also sheds light that although existing process flows of communicating are risky and not efficient, the IS ERP of SAP used has no control procedures to control the errors which then impact the RL performance.** Bai et al. (2013) mentions examples of control like manual or automated checks, performance reviews, restricted access, and segregation of duties. These should be thus adopted in IS of ERP SAP. **Standardization of the processes and procedure in the form of formalization comes into the picture by as R. Huscroft et al. (2013), it encompasses equipping the users with the appropriate knowledge for the process.**

Bai et al. (2013) argues that inaccurate and incomplete transactional data leads to more effort spent on nonproductive inquiry and reporting functions. The qualitative analysis done and as defined by the above statements are aligned to the perspective put by Bai et al. (2013). The risk introduced by the inaccurate data impacts the lead time necessary to ship parts which only hampers the performance of the organization. Furthermore, this highlights the broader challenges in **process compliance and the need for rigorous training and process control strategies to ensure data integrity**. Such challenges can hinder the effectiveness of communication with the RL team and suppliers, leading to delays and potential mishandling of urgent needs.

The above concerns only add up to the risks and potential impacts that the current way of working and processing of urgent requests. This emphasizes the **necessity for formalization through documentation in the form of guidelines, and work Instructions** to ensure that all necessary information is accurate and complete, fostering more effective management of urgent defects.

The concerns raised are well aligned with Wurm & Mendling (2020) who states that using fragmented systems, manual workarounds using tools like Excel often leads to erros and process variations.

Necessity of Periodic Reviews

P[1], P[7], P[11], P[13], P[14], P[18] P[16], emphasized that as business operations expand, it is crucial to **review the capabilities of existing processes to ensure they can manage the increased volume of data transactions resulting from this growth.**

> *"In large and rapidly growing organizations like ASML, we initially implemented processes that were manageable when we were smaller and less complex. However, as we've expanded, these processes, including the urgent defects process flow, have become unsustainable and now contribute to more problems than they solve as the number of products that need repairs are increasing."*- P[9]

The statement from P[9] highlights, as the business grows, it becomes essential to **conduct periodic reviews of processes and assess their scalability to ensure they can handle the increased demands effectively.**

This emphasizes the need of performance indicators or metrics to monitor business process performance. This is aligned with J. Hall et al. (2013); Ravi & Shankar (2005) who state that performance metrics by provide the performance of a business process showcase the scope and need of improvements so that the business process meets the expected requirements of the organization.

However, P[14], highlighted that the existing process where the Excel form process flow was introduced in 2016, and was form was updated in December 2023 with some changes to it.

> *"The urgent defect form we had was from 2016 and was updated with some changes in December 2023."*- P[14]

The statement from P[14] showcases that periodic review using performance monitoring was done. However, based on the various challenges highlighted, the periodic review conducted sas not effective and thus there is a need for a proactive strategy adoption regarding performance monitoring.

P[18] pointed out that results of the adopted process will only be visible after the process is used and to visualize its impact, periodic reviews are necessary.

Therefore, there's a need to redesign processes not just for efficiency but also to ensure they are robust enough to handle the demands of a larger, more complex environment. This involves integrating more flexible, scalable solutions that can adapt over time as the organization continues to grow. The aspect of **scalability** of existing processes to manage urgent defects comes into the picture. The scalability perspective is discussed in detail in subsection 4.2.8. Thus, to ensure that processes this demands periodic reviews of processes set. These findings are aligned with Huang & Yang (2014); Badenhorst (2016), which states that as product returns increase organizations aim to standardize the RL process.

P[6] mentions that while processes are built with the aim of getting right the first time, periodic reviews can be helpful:

> *"Ideally, we build the processes right the first time, and not much reflection is needed. But of course, everything changes, especially in our high-tech environment, so it makes sense to review the process flow maybe twice a year or annually."*- P[6]

The statement from P[6], emphasizes the initial goal of designing a process flow correctly from the start to minimize the need for frequent adjustments. However, they state it is important to acknowledge the reality of the external environments, especially in dynamic environment of high-tech, which are constantly evolving. Therefore, it is prudent to review and assess the process flow periodically, such as twice a year or annually. This ensures that the process remains relevant and effective in adapting to any changes or new requirements.

P[9] complemented the importance of periodic reviews expressed by P[6]:

> ***"First, check if the implementation of the new process went well and if it's being followed as planned. Ensure it improves the process and enhances traceability, standardization, and tracking. Then, consider extending it to other parts of the organization as well with similar concerns."***- P[9]

The statement from P[9] emphasizes the importance of initially verifying that a new process implementation is successful and adheres to the planned design. It also highlights the need to assess whether the process improves operations and provides greater traceability, standardization, and tracking. If these criteria are met, the process can then be horizontally deployed to other areas within the organization facing similar issues.

This aligns with Wurm & Mendling (2020), who states that periodic process audits should be conducted to check if the defined practices and process flow are being followed or not.

Role of Process Awareness Enhancement

The "Complex Coordination and Collaboration across Departments" sub-theme as seen in subsection 4.2.2, emphasizes the critical role of collaboration and coordination in RL, especially for time-sensitive and high-impact activities. Several participants namely P[1], P[2], and P[4] highlighted a key issue: a lack of knowledge and awareness among stakeholders regarding the procedural steps for initiating urgent defect repairs. Despite having the Urgent Defect Request Excel form to communicate the high-impact issues, its impact on RL performance is minimal. There is a clear deficiency in communication protocol and guidelines, correct procedures along with data quality standards.

The urgent defect form lists the departments involved in the flow, as well as the contact information for each department's team members. However, relying solely on this form is impractical for several reasons.

The participants in the interviews have highlighted the drawbacks of the existing usage of the Urgent Defect Request Excel form to share and communicate urgent repairs and RCAs:

Firstly, given scalability and the growing number of urgent defect requests, constantly following up via phone calls post sharing the form will hamper the workflow, potentially leading to communication breakdowns. Second, a static form does not provide real-time updates or tracking of the defect's status, which is critical for timely resolution. Third, using a form for urgent communications may result in delays and errors information filled will be manually and to correct it will lead to further email communication or follow-ups with stakeholders

P[4], the RL team planner, plays a vital role in ensuring that urgent defect requests are processed promptly upon reception. Their responsibility is to expedite the shipment of defective parts out of the organization to the supplier as quickly as possible. **P[4] points out that the stakeholders who request urgent defects are often unaware of the correct process in terms of the prior tasks to be fulfilled as mentioned in the sub-theme Overcoming Operational Risks in Communication Processes before requesting urgent defect processing:**

> ***"The requester's are often unaware of the correct process steps to be followed. The urgent defect repair requester's are from various departments within the company, have their ways of communicating, and frequently submit requests incorrectly without following the procedures."***- P[4]

Process awareness, as highlighted by P[4], is crucial for the smooth operations of RL. P[2], the BPO of RL also confirmed this concern raised by P[4]. **P[4] also points out an important observation that the requester's come from different departments and each of them has their ways of communicating.**

The findings from the statement of P[4] are confirmed by P[5] and P[11]. P[5] highlighted that there appears to be a lack of awareness regarding the existing processes for managing urgent defects within the Supply Chain department where P[5] belongs to:

> ***"I am not sure if everyone within my department is aware of the current process for managing urgent defects and its possibility to use the Excel form that we email to RL. I also had to search for it and I found the old version in my inbox"***- P[5]

> ***"I was not aware that there is Excel form that I have to fill when for the first time I had to request an urgent defect repair"***-P[11]

The statements from P[5] and P[11] emphasize the lack of awareness about the correct procedures to be followed for urgent defect management and underscore the need for formalization in the form of process flow, roles and responsibilities, and training for the involved stakeholders to correctly follow the process flow.

P[2] highlighted a incident where they received a request that did not have the pre-requisite tasks of placement of demand for repair, without which the RL team cannot proceed. It is the responsibility of the requester to ensure this is completed:

> *"I had a case today when the Pack team requested a DN (Delivery Note) for an urgent defect repair request to ship the defective part urgently to the supplier by sending a Teams Message and I had to ask them who is the stakeholder who has requested for the urgent defect repair because there is no demand in SAP. Then I communicated with the requester to place a demand as without demand we cannot send the part to the supplier. The requester was then, together with the PLM team, checking if they could place a demand. "*- P[2]

The lack of awareness of the placement of demand as highlighted by P[2] leads to delays in processing urgent defects because they are the prerequisites for the administrative steps that facilitate the shipping of defective parts to the supplier. The reason for the delay is that there is a lot of to-and-fro email communication happening between the RL team and the requester about the initiation of a demand for urgent defect repair.

P[12], P[13], and P[18] highlighted the importance of ensuring that new hires in any department are thoroughly trained on the process flow right from the start of their joining. This knowledge is crucial for effectively requesting and managing urgent defect repairs, ensuring they are aware of and can adhere to the established procedures.

Although the participants indicated that process knowledge is deficient along with a lack of awareness among the stakeholders, the existing non-standardized communications and information-sharing processes are a challenge and have an impact on smooth operations for managing urgent requests.

The challenges identified in the interviews align with the need for formalization in RL processes. Formalization involves defining clear responsibilities, standardizing processes and procedures, and equipping individuals with the necessary information for process implementation (Alarcón et al., 2021; R. Huscroft et al., 2013; Genchev et al., 2011). The lack of formalized processes and clear communication protocols has led to inefficiencies and delays in managing urgent defect requests.

This lack of process awareness demands the need for formalization and change management communication to train stakeholders about the correct process flow. Formalization in the form of documentation ensures correct inputs and process flow, as stakeholders understand their roles (Alarcón et al., 2021; R. Huscroft et al., 2013; Genchev et al., 2011).

Genchev et al. (2011) suggests that the potential of formalization to help managers **"make order out of chaos"** in return is substantial and can be a valuable tool in streamlining RL operations. This is exactly the situation the RL team and other involved stakeholders are facing. Consequently, providing a platform to help measure the effectiveness of RL process formalization becomes a necessity Genchev et al. (2011). The platform can be an Information System (IS) like ERP systems as discussed in subsection 2.1.5. IS provides visibility, and improves communication, data accuracy, and process standardization. IS can be highly valuable in RL as they provide real-time tracking, integrate communication channels, enforce data entry standards, and automate return processes, thereby reducing inefficiencies and delays Prasad et al. (2010); Adaileh & Abu-Alganam (2010); Lambert et al. (2011).

Therefore, the lack of awareness and the challenges posed by existing processes underscore the need for Formalization and an IS-based standardized process flow. This involves ensuring that all process flows and associated procedures are accessible to stakeholders, implementing effective change management communication, providing the necessary training, and ensuring process adherence.

However, the current processes introduce high uncertainty, as analyzed in subsection 4.2.6. Implementing an information system (IS), alongside standardization and documentation, is essential, as defined by Zelt et al. (2019).

Resource Allocation Efficiency

P[1] points out that there is a dedicated RL team member assigned to monitor emails and other communication methods for urgent requests is an inefficient use of their skills and time. The team member could be better utilized for other tasks that require their expertise.

> *"We currently have a dedicated team member assigned solely to monitor emails related to urgent defects, ensuring that none are overlooked. However, this approach represents a significant allocation of resources that could be better utilized elsewhere. Automating this process within our standard way of working operations with WorkList, perhaps by flagging urgent defects distinctly, would not only free up valuable manpower but also enhance the efficiency and responsiveness of our defect management system. Implementing such a feature would greatly aid in prioritizing urgent defects without the need for constant manual oversight"*- P[1]

The above statement from P[1], clearly underscores the need for a technological solution rather than the current manual way of doing things. This further demands a standard IS-based process flow which will not only streamline and integrate the urgent defect requests into a normal way of working but also help to efficiently allocate and utilize the manpower resources.

Overall the challenges faced can be improved by the development of a process flow that is efficient (improves performance and the response of RL), transparent (clear and everyone involved can see it and thus easy to trace), visible (Clear picture of reasons for urgency), and scalable (capable of communicating higher number requests about urgent defects as the business grows).

The theme of "Challenges due to the Existing Processes" and its various sub-themes/ categories as explained above answers the sub-research one: *What are the current challenges in managing high-impact issues in reverse logistics for high-tech companies?*

4.2.3 Role of Formalization in Process Standardization

An important aspect of the lack of formalization in the form of process awareness, communication protocols, clarity of roles and responsibilities, input data requirements, and service level agreements amongst the involved stakeholders and their departments was informed by the participants during the interviews.

According to Genchev et al. (2011), formalization refers to the extent to which rules, procedures, instructions, and communications are written for stakeholders understand what is expected. It is, therefore, a key aspect to guide and control intra-firm or inter-firm SC operations Alarcón et al. (2021). Its tools include written policies, role descriptions, organizational responsibility charts, procedures, strategic and operational plans, objective-setting systems, standardized processes, and establish formal communication channels within and between firms Alarcón et al. (2021); Genchev et al. (2011). Alarcón et al. (2021); Richey et al. (2005) state that lack of formalization is a challenge for the successful management of RL. The interviews underscored the detrimental effects of lacking standardization in RL operations, emphasizing the critical need for formalization to enhance process efficiency and effectiveness.

Necessity of Clear Communication Protocols

Participants highlighted the necessity of having clear communication protocols for getting timely responses and updates as the defective parts and associated information traverse through multiple cross-functional departments within the Supply Chain:

> *"I believe clear communication across all departments is crucial which is currently lacking. So, basically whom to reach out to if any particular information or status update is needed."*- P[17]

P[17] understands the importance of having clear communication as that helps in making correct and timely decisions, but this gets hampered due to the unavailability of communication protocols.

Thus, it becomes **essential to establish clear and standardized communication protocols.** These protocols should clearly define the stakeholders and their backups who are the point of contact at each step of the process to get the relevant information and stay up-to-date, ensuring efficient and streamlined communications across departments.

The impact of non-existent communication protocols is further explained by P[17]:

> *"I once had a case wherein the defective part took over a month to reach the supplier due to poor communication and information flow. Once the communication protocols are established, it will eliminate the need to sift through extensive email threads, enabling faster work processes."*- P[17]

The need for communication protocols is to monitor the progress of the process for the urgent request. For this the requesters aim to identify which stakeholder is responsible at each stage of the process, ensuring clear and effective communication throughout the entire urgent defect repair process. This clarity helps prevent miscommunication, reduces delays, and ensures that each step is executed efficiently and accurately. As highlighted in the sub-theme **Process Awareness Enhancement**, the current use of Excel forms and email for updates is neither scalable nor efficient. Therefore, an Information System that can track the process flow is essential.

Although there is an urgent defect request form for existing processes, the above statement from P[17] clearly shows that the existing process flow was not communicated to the stakeholders, highlighting the importance of proper change management communication for the existing processes, which was not communicated to them. This further emphasizes that whenever an IS based standard process flow is developed and is required to be successfully adopted, effective change management is highly important.

This has been well discussed and explained in the subsection 4.2.14. Furthermore, the existing processes fail to provide communication protocols highlighting the **importance of formalization of the process flow.**

Furthermore, this highlights that with standardized processes using IS, such scenarios **could be resolved much quicker, significantly reducing my workload and allowing me to complete tasks more efficiently.**

A significant the existing process is the lack of a robust, standardized communication system. This deficiency was illustrated in a recent incident is highlighted by P[2]:

> ***"I didn't receive any Teams Message about the urgent defect request, the Pack team just saw the administrative papers on the packaging of the physical part they received and they requested me for the Delivery Note to ship the part out of ASML towards the supplier, that they didn't even say it's an urgent defect, they just said emergency. There was no mention of the requester, and I had to revert to them to inform the requester to place a demand for the request"***- P[2]

P[2] states that they received an urgent defect repair request from the Pack team to perform the administrative activities needed by RL to ship the part to the supplier. However, the Pack team is not the original requester, as they are responsible for packaging the defective part and getting them ready for shipping. It is the requester who should contact the RL team, but in this case, it was the Pack team that made the request.

This is another example where the correct procedure and flow was not followed as it was not known to the requester and the Pack team. These issues highlight the significant gaps in process awareness and the need for the establishment of protocols. The lack of proper training and communication regarding the correct procedures results in inefficiencies and delays in handling urgent defect repairs. Addressing these gaps through comprehensive training, clear documentation, and effective communication protocols is essential to ensure that all stakeholders understand and follow the correct procedures, thereby improving the overall efficiency and effectiveness of the RL process.

Need for clarity of Roles and Responsibilities

Multiple researchers including Alarcón et al. (2021); Baker (2012); Hevner et al. (2004); Zelt et al. (2019); Olorunniwo & Li (2010); R. Huscroft et al. (2013); Genchev et al. (2011), have underscored the critical importance of clearly defining roles and responsibilities for stakeholders as a key aspect of formalization in the efficient management of RL. While the literature emphasizes this point, it often lacks detailed discussion on the direct impacts of such formalization on RL performance. However, insights gathered from interviews highlight the consequences that emerge when stakeholder roles and responsibilities within the RL process flow are ambiguous. These interviews provide valuable, concrete examples illustrating how a lack of clarity can disrupt operations, leading to inefficiencies and reduced performance in RL systems.

Although the participants are aware of their role and responsibilities in the organization, they explained that roles and responsibilities are unclear in managing urgent defect requests process, including who initiates the request, who to contact for missing information, and who handles the logistics in ERP SAP. This lack of clarity leads to excessive communication among multiple stakeholders, resulting in time delays and extended lead times for shipping parts, as discussed in subsection 4.2.2 and subsection 4.2.5. This was highlighted by P[1], P[9], P[10], P[11], P[16], P[17].

The importance of roles and responsibilities of stakeholders involved in the process flow during process standardization is well aligned with Wurm & Mendling (2020).

Role of Process Performance Measurement

The primary goal of performance metrics or indicators is to explain how a certain process generates value for an organization (J. Hall et al., 2013). Zelt et al. (2019), defined that business processes with high uncertainty and high equivocality need to have performance monitoring measures that have a positive impact on RL business process performance. As per Ravi & Shankar (2005), the lack of defined performance metrics significantly hinders RL. Effective performance metrics are essential as they provide a structured basis for managing and enhancing operations. Without these metrics, optimizing RL processes becomes challenging. Implementing a performance measurement system linked to RL can improve coordination, focus on value recovery, and provide data to ensure the program meets expectations, fostering continual improvement. Participant P[2] who is the BPO of RL stated there are currently no performance indicators present for monitoring the urgent defects process flow.

> *"We don't have any KPIs related to urgent defects flow"*- P[2]

The statement from P[1] indicate the absence of specific Key Performance Indicators (KPIs) for managing urgent defects is an indication of a lack of formal mechanisms to measure and assess the efficiency and effectiveness of the urgent defect management process.

P[1] and P[2], further state that the establishment of KPIs in the form of processing time per step in the process flow needs to be established:

> *"I want to see the performance indicators in terms of time taken per step in the process flow to get an overview of the operations to monitor process performance against agreed timelines for shipping parts out of ASML, and identify areas for improvement."* - P[1]

> *"I would like to see the processing time per step as performance measure of the process flow to identify which steps are relevant and focus on improvements. This will help us determine which steps are affected by other teams and see what can be improved."*- P[2]

These statements by P[1], and P[2], who are BPOs of the RL processes emphasize the need to measure the processing time for each step in the process flow. By doing so, it aims to identify which steps are crucial and require improvement. This analysis will also help determine how the inputs from different stakeholders apart from RL influence various steps, enabling a more targeted approach to enhance the overall process efficiency. The ultimate goal is to pinpoint inefficiencies, monitor performance, and make data-driven improvements to the process. They agree that KPIs can act as performance metrics for business processes and help improve business performance by identifying the drawbacks. This is aligned with J. Hall et al. (2013); Hazen et al. (2015), who states that high-tech companies should prioritize the internal processing time to prepare the products ready for shipment as a performance metric and quickly facilitate return transactions.

Along with this, J. Hall et al. (2013) states that the most common metric is cost reduction/ control. Letunovska et al. (2023) presents that the defective parts return timings are one of the factors along with returned product quantities, and the product's favorable recovery that influences the cost analysis of RL. The impact of the delay in shipping/ returning the defective part to the supplier in the case of ASML is highlighted in Table 1.1.

Need of defined Service Level Agreements (SLAs) between Departments

As each of the requesters has their interpretation about urgent shipment delivery without knowing the various steps involved in the process flow, the RL team BPO's P[1], and P[2] highlighted an important factor of requirements of Service Level Agreements. The factor of the necessity of SLAs was highlighted by the interviews regarding the expectations and responsibilities of various stakeholders involved in the process. An SLA is an agreement between the service provider (RL team in this case) and its customers (the requester's of urgent defects in this case) quantifying the minimum acceptable service to the customer (Karhunen et al., 2006). The service description, service and support hours, service availability, performance, dependability, change management protocols, charging procedures, and service reviews are the minimum components of the SLAs (Karhunen et al., 2006). The unavailability of SLAs can lead to miscommunications, and discrepancies in service delivery, directly impacting the efficiency and effectiveness of urgent defect repairs. This is explained in the below statements by the BPO of RL:

> *"The current process is not mature enough. So as mentioned, we don't know whom to contact, we don't know the SLA and what is expected from the lead time for delivering the part to the supplier."*- P[1]

> *"It's important that everyone understands the process and timelines because the requesters, who are from different teams, often assume that if they send a request now, it will reach the vendor in two hours. We need to manage their expectations. It's crucial to clearly define what can be expected and what the SLAs are. Otherwise, they keep pushing us, and we find ourselves constantly having to explain to them the procedures."*- P[1]

The statements from P[1] points out that the current process for handling urgent defect repair requests within ASML faces significant maturity and clarity issues, largely stemming from significant gaps in communication undefined Service Level Agreements (SLAs), and unclear process expectations of the stakeholders requesting them. The SLAs in this case are usually the period that will used to process the defective part or product to get it ready to be shipped out of ASML to its respective suppliers.

The stakeholders initiating requests for urgent defect resolution often fail to specify their expected timelines for shipping, exacerbating the lack of clarity. This issue is further compounded by the absence of established SLAs, leaving requestors in the dark about the procedural steps required to address defects. Without a clear understanding of the process, stakeholders' expectations for rapid resolution are often unrealistic, leading to delays and dissatisfaction within the urgent defect management process. Without explicitly defined SLAs, parts that are flagged as high priority by requestors do not have established timelines communicated, causing potential delays spanning several days—far beyond the assumed same-day resolution. This deficiency in defining and communicating SLAs contributes to operational inefficiencies and widespread dissatisfaction among those involved in the urgent defect management process.

The above was confirmed by one of the urgent defect repair requesters P[5] of the urgent defect repair who is the Supply Chain Planner, responsible for ensuring that the required parts or products required for manufacturing machines at ASML are available on time:

> *"I would expect that urgent defects could be shipped within one, maximum of two working days. However, that's just my expectation as a planner. I'm not familiar with the reverse logistics process, their capacity, or how long things might take. I also don't know how many stakeholders they depend on, so my assumption that something can be shipped within one or two days is based solely on my gut feeling."*- P[5]

This statement from P[5] clearly states that there is a need for an SLA to be established and agreed between the requester and the RL regarding the timeline of shipping the urgent defective part or product out of ASML to the supplier.

Process Flow Documentation and Guidelines

As highlighted by participants the major reason for the delay in shipping the urgent defective parts is due to unawareness of the process flow and guidelines related to it as seen in subsection 4.2.2. This thus necessitates documentation of process flow and providing clear guidelines about it. Thus, formalization in the form of BPMN, documentation of procedures, and instructions should be communicated to all the stakeholders involved during the change management process as highlighted in subsection 2.1.9 and is discussed in detail in Appendix C.This is aligned with Wurm & Mendling (2020) who states that standardized processes rely on documentation to guide the stakeholders about the process flow.

Therefore, as the existing processes aim for transition into an IS-based standardized process, it is crucial to base this development on identified factors and interdependencies that influence its development and adoption. Once the process flow is developed, it should be properly formalized using Business Process Model Notation, along with comprehensive documentation of procedures and instructions and other relevant documentations. This formalization should be clearly communicated to all stakeholders involved during the change management process to ensure smooth implementation and understanding.

Enhancing Process Governance

Participants P[13], P[18], P[19, and P[12] emphasized the importance of ensuring that the process flow for urgent requests is used appropriately and only when necessary while developing and adopting

the standard process using IS. They noted that currently, there is no verification mechanism in place to validate the urgency of repair or analysis requests, and the RL team relies on the trustworthiness of the requesters. Implementing a verification process could enhance the system's integrity and ensure that urgent requests are genuinely critical, thereby optimizing RL efficiency:

> ***"Establishing stringent criteria for urgent defect requests is crucial to prevent misuse of the process. Each request should be accompanied by concrete proof of its urgency, such as detailed impacts on production or potential risks, to justify its emergency status. This ensures that resources are dedicated to genuinely critical issues, thereby enhancing operational efficiency and maintaining process integrity. We must include the details of the requester and the ultimate need date to hold stakeholders accountable and prioritize tasks effectively based on their true necessity.s"***- P[12]
>
> ***"Normally, parts are returned to the supplier through standard logistics, which takes a certain number of days to weeks. However, for critical parts, due to demand and supply gaps, we use the urgent defect process to expedite shipment. Unfortunately, this process is often misused. Stakeholders can flag every request as urgent, insisting that parts be sent to the supplier within 24 hours, regardless of actual urgency"***- P[19]

The above statements from P[12] and P[19] highlight the need for process governance to maintain the efficiency and the values and norms of the organization. Improper use of the urgency protocol can lead to operational inefficiencies, where non-critical parts are prioritized over truly urgent needs, disrupting the supply chain and potentially impacting production schedules. This indicates a need for a clear definition and strict adherence to criteria that dictate what constitutes an 'urgent' defect. The guidelines and SLAs mentioned in subsection 4.2.3, should also include the guidelines for criteria for when urgent defects should be used.

P[19] emphasizes that ultimate need date- the date before which the part needs to be repaired and received back to overcome any downsides and operational impacts.

This further enforces the need for IS-based process standardization, the role of documentation. The process owner and the process champion need to ensure rigorous enforcement of the guidelines. The need for periodic reviews not only focussing on the performance but on maintaining the governance over the process is equally important.

P[8] points out that to overcome the misuse there is a need for Service Level Agreements (SLAs) clearly stating the criteria for when to use this process:

> ***"While defining SLAs for adopting the IS ERP-based process flow, we should consider the escalation levels. Is the impact just on a single machine, or does it affect the entire assembly of machines? For example, an L2 level escalation indicates a hit on the factory's needed date, delaying supply, whereas an L3 means there's an actual impact on shipment to the customer, which should then be our highest priority. It is required to get these SLAs agreed upon by the relevant stakeholders and introduced in the ERP system before the adoption of IS ERP. This will act as automatic control as unless the set criteria are not met, the request can use it which will be like a Poka Yoke"***- P[8]

P[8] emphasizes the importance of setting priorities for the usage of urgent defect repair based on the severity and impact of defects on production stages. The use of escalation levels (L2, L3) helps in understanding and classifying the urgency of defects. This has to be mentioned in the SLA as this will ensure that resources are allocated efficiently and that responses are appropriately scaled to the severity of the impact. These SLAs have to communicate and agree with the stakeholders. These agreements can be proposed and agreed upon before the adoption of the IS ERP. P[8], further states that these criteria should be introduced in the SAP ERP system, as the requester can only utilize this process flow if the criteria are met in the ERP system and therefore act as a Poka Yoke. This will therefore act as a process control procedure as defined by Bai et al. (2013). Currently, as seen in Figure 4.3 and in subsection 4.1.2, the stakeholder named as Supply Chain Planner is the one who based on their judgment place the urgency request. This control procedure if introduced in the IS ERP can remove any manual intervention used for the judgment of urgency of the Supply Chain Planner.

> ***"So the requester of an urgent defect should know upfront that processing this urgent defect will take one day if I log it as a priority or if I log it as an emergency delivery, it's needed to be within 4 hours, so they just flag it, but I don't know the consequences because the process is not clarified yet."***- P[1]

The above statement from P[1] highlights that the requester does not know what to expect about the shipping readiness so they just flag a hard priority and they think it's like in one maybe the same day, but it requires a lot of steps so it can take a few days. They don't know that, so the clarity is not there and the SLAs are not set.

4.2.4 Impact of Organic Organizational Structure

Participants P[9] and P[11] mentioned that despite having a formal hierarchical structure, the organization maintains a culture of open and accessible communication across the organization:

> *"Although the organization has a hierarchy, communication-wise it's a rather flat organization, so people are kind and can talk and walk to everyone basically."*- P[9]
>
> *"The organizational structure is quite flat. I think we can go easily towards someone a little higher up to align on this, so I don't see any issue there"* - P[11]

The statements from P[9] and P[11] state that despite having a formal hierarchical structure, the organization of ASML maintains a culture of open and accessible communication. Employees feel comfortable approaching team members and superiors at all levels, fostering a collaborative and inclusive environment. The findings align with the literature on organic system in organizational structures. An organic system is characterized by a less hierarchical and more flexible communication approach (Saghafian et al., 2021). According to Saghafian et al. (2021), such systems encourage stakeholder engagement, communication, and knowledge sharing. These factors are crucial during technology adoption, enhancing acceptance and speeding up the adoption process. Saghafian et al. (2021) further suggests that an organic structure is particularly effective for transitioning towards a change, and the experiences shared by P[9] and P[11] regarding their organization's communication culture, point out that the culture adopted by organizational will allow effective change management adoption.

4.2.5 Business Need for Process Standardization

The themes and sub-themes in subsection 4.2.2, subsection 4.2.6 and in subsection 4.2.3, investigate the various challenges and barriers stakeholders face due to non-standardized business processes and the potential reasons behind these challenges. It is thus important to analyze and examine the impacts of these challenges. These impacts highlight the business need to standardize business processes for managing issues such as urgent defects, as detailed in section 1.2, Table 1.2, and subsection 2.1.1. This standardization is crucial to address the outlined operational challenges and optimize organizational efficiency and effectiveness for RL performance.

As per J. Hall et al. (2013); Vlachos (2016); Morgan et al. (2016), efficient return processing benefits both the company and its customers. Effective customer management and establishing RL service levels can be extremely beneficial (J. Hall et al., 2013).

However, the interviews highlighted that currently efficient management of processes of returns for urgent defective parts or products at ASML continues to be hindered by non-standardized and fragmented practices, leading to inconsistencies in managing returns and delays in processing. This variability in the RL process not only impacts customer satisfaction but also affects the company's operational efficiency and cost-effectiveness. In the context of our research on standardizing processes for managing urgent defects in reverse logistics, the importance of aligning return processing with customer expectations is paramount and its impact is visible on different fronts which has been stated during the interviews as follows:

Impact on Factory

Important information can become trapped in individual email chains, which are inaccessible to everyone who may require it unless explicitly shared. This can result in information silos, in which only certain team members are aware of critical updates. Emails can easily become buried in crowded inboxes, causing delays in identifying and responding to urgent issues. This lack of immediacy is detrimental in situations where timely actions are required. The impact of this is a delay in shipping the defective parts to the supplier. P[7] mentioned an incident which highlighted the impacts of risks and challenges pointed out earlier:

> *"Recently I had to send a defective part urgently to a Supplier in Eindhoven from our ASML facility in Veldhoven and I sent an email about the same. This should have happened in*

> ***a couple of hours or maximum in a day, but it took more than a week. The parts were shipped to Weert and then to the supplier which should have been shipped directly to the supplier. This type of delay is not acceptable as the emails were picked up late. The risk led to downtime in the factory which resulted in having monetary implications and this escalated the need to review the existing process flow for managing the urgent requests"***- P[7]

The above statement from P[7], illustrates the impacts of the existing practices leading to the stoppage of factory operations resulting into a monetary implications. The incident pointed by P[7] shows a example of how important it is to have a traceable, transparent and centralized interface or platform against the existing practices used.

Upon analysis of this above case, it was found that the emails due to existing practices and its risks, was picked up late. However, as mentioned in subsection 4.1.2, the interface used by RL team showcases both the regular and urgent defects requests, however, it is not possible to distinguish them. Since, the email was picked late, and the defect request which was urgent was already present in the interface, it was treated as normal request as there is no way to identify the urgency except the email notification. Along with the emails being picked up late, the input data required for the RL team in the form of Material Notification (MN) was not filled with the appropriate data necessary to process it urgently in the IS ERP system SAP by the stakeholders (MRB team who does the MRB as defined in the Figure 4.1). The required data was missing, which further lead the RL team to treat these MNs as routine.

Consequently, this incomplete information resulted in defective parts being sent to the Weert warehouse which is as per the normal, non-urgent defect requests process flow against sending them towards the supplier. This can be seen in Figure 4.2 and explained in subsection 4.1.2. Upon correction of the data and identification of urgency, the part was shipped to the supplier. **This only resulted in adding additional lead time to shipping the part to the supplier. The correction requires continuous to-and-fro email exchanges between the different stakeholders within cross-functional departments, leading to the essence of the urgency being lost. This is highlighted by the P[21] in subsection 4.2.8.**

The role of the urgent defect repair process is critical as it serves as the last resort to **prevent downtime and adverse impacts on manufacturing operations.** This process is essential when machine or system operations are threatened by the unavailability of parts due to defects. **This is emphasized by P[5] wherein they explain the critical importance of even minor time savings in a factory environment, where every half-day can affect production schedules and overall operational efficiency:**

> ***"In my view, the urgent defect repair process needs to offer added value compared to the regular repair process. Right now, the regular process takes five working days, and the urgent defect process shortens it to four days, which doesn't make a significant difference. However, in the factory manufacturing operations environment, even one day can be crucial, and every half day counts. So, while the difference may seem minor, the impact on production timelines can be significant"***- P[5]

The above statement from P[5], showcases the value offered by urgent defect to the business by keeping the manufacturing operations running

The **complex coordination, lack of accountability, and lack of proper communication protocols and norms between cross-functional departments** impacts the **end goal for faster shipment as it acts as a hurdle in performing operations related to the administrative activities for the RL team.** This was pointed out by P[2] in the below statement:

> ***"When we receive an email from Pack about urgent defects, we do not know who is the requester and we also do not get any other information. We need to email them back for any required information to process the defective parts. We need to know the requester because if anything happens to the part after we process we need to know the requester"***- P[2]

Impact on Business Operation and Environment

The impact of complex coordination, lack of accountability, and lack of proper communication protocols in the existing way of working is illustrated by a classic example by P[2] as follows:

> ***"There was a recent case when we received an urgent defect request and we processed the defect repair and shipped the part urgently with emergency Delivery towards the supplier in France and when the truck went to France at the Supplier, the Supplier was closed. Everyone asked the RL team member why they shipped the part out urgently, and since the requester's name was not known, it was difficult to trace everything"***- P[2]

The incident highlighted by P[2] explains that When the part was shipped urgently to a supplier in France without verifying the supplier's availability, it led to an unnecessary delay because the supplier was closed upon the part's arrival. This incident not only failed to expedite the repair, which is a primary objective of the urgent defect process flow, but **it also extended the expected repair time.** The delay in repair can lead to extended downtime of the manufacturing operations, resulting in lost productivity and revenue. Also, from a sustainability perspective, it resulted in **unnecessary material movement, contributing to environmental impact and additional costs** that could have been avoided with better communication and coordination. To mitigate these impacts, standardizing and optimizing the urgent defect process flow is crucial. This involves **implementing proper communication protocols, real-time visibility, accountability, presence of norms, and robust risk management strategies to minimize delays, reduce costs, improve customer satisfaction**, and strengthen organizations business operations.

Impact on Future Growth

The participants elaborated on the capabilities of existing processes to handle business growth. They emphasized how these processes impact the overall supply chain by ensuring repaired parts are available to maintain operational pace:

> ***"So ASML is really ramping up production, they're building machines at a faster pace. As a result, we need to ensure material availability more quickly. Generally, this means we need to shorten the repair flow so we can accelerate the output of machines. That's our main concern right now. We must optimize the repair process to achieve optimized output for the machines."***- P[1]

There is a significant ramp-up in the manufacturing of machines at ASML, highlighting the **urgency to increase the speed of material availability and the repair processes to keep pace with the production** of advanced machinery. The primary concern expressed by the BPO (P[1]) of the RL team is that there is **need to optimize the repair flow of urgent defective parts** to ensure that the urgent defective parts are **shipped in a faster manner towards the supplier**s, so there is no time wasted in preparing and thus **getting them back faster to be reused which will aid the manufacturing** of the machines and systems by ASML to **meet the rapidly growing customer demands**. This situation necessitates strategic enhancements in the RL and SC processes to support the heightened production rates effectively. This underscores **the importance of scalability and the necessity of periodic process reviews.**

Impact on Customer Delivery Lead Times

P[7] highlights impact of existing process flows and practices on the customer delivery times to ship the machines manufactured towards the customers:

> ***"I filled out the urgent defect Excel form and sent it to the specified email addresses, but often, there's no response, leading to a cycle of reminders. Sometimes they direct you to involve another department, or the urgency isn't perceived, making it challenging to mobilize the necessary actions in the factory. This inefficiency in communication can delay the repair process significantly. Such delays increase the risk of operational disruptions, like delayed factory starts, which can negatively impact our customers. The risk escalates when we can't swiftly manage and resolve these urgent defects, highlighting the critical need for a more streamlined and responsive process."***- P[7]

This statement from P[7] clearly states a disconnect between the perceived urgency of the defect by the urgent defects repair requester and the response urgency by those responsible for action, suggesting a misalignment in the urgency recognition across departments. The perception of urgency amongst the stakeholders is missing. Thus, the delays and inefficiencies in addressing urgent defects can lead to significant operational consequences, such as delayed factory starts and subsequent customer impact. This highlights the critical nature of efficient defect-handling processes in maintaining operational continuity and customer satisfaction.

Impact on Quality perspective

The participants point out that the current process not only impacts the repair lead time of the defective parts but also in analysis of the nature of the defect for quality purposes at the supplier:

> *"If a part takes too long to arrive, the supplier may not be able to reproduce the issue we encountered, like an error code, because too much time has passed. The part may not be in the same condition anymore, or it might not go directly to the supplier but to an intermediary location, where something could happen during transport. Additionally, the supplier has a defined period for conducting a repair or RCA, complicating the process further."*- P[16]

The statement from P[16] points out that the delays in shipping the defective parts which are critical for the machines lead to changes in the condition of the parts, making it difficult for the suppliers to accurately diagnose or replicate the issues, which directly **impacts the reliability of the part and thus on the systems or machines manufactured.**

P[16] explains the that at times the customer also demands a reports about a particular issues in a urgent manner and failure to do so impacts customer satsifaction:

> *"We face deadlines on reporting, particularly when the issue stems from customer complaints, which escalate the situation. We're then required to provide updates at least weekly, and in some cases, even more frequently. Our focus is on rapidly obtaining the root cause analysis from the supplier and ensuring customer satisfaction by keeping them informed throughout the process."*- P[16]

P[16] states that there is significant pressure from customers who are system or machine users, as they demand detailed reports on part failures when such a situation arises. ASML's Process Improvement and Material Quality teams are required to urgently provide these reports to customers and failure to do so leads to customer escalations, negatively impacting customer relations.

Impact on Future Growth of Organization

The impacts on the organization, including factory outputs, future growth prospects, customer delivery lead times, manufactured system quality, and overall business performance, highlight the important aspect of the **necessity of standardizing** processes based on a centralized platform. Thus, the existing processes are a risk to the organization. This platform should be accessible and connected across the entire organization, ensuring efficiency, and enhanced communication through transparency, which are crucial for sustaining growth in terms of scalability and improving operational outcomes.

> *"In Supplier Operations at ASML, our mission is to prevent material availability issues within our supply chain. A key strategy thus should be to utilize a standardized SAP process for managing urgent repairs, ensuring that materials are available precisely when needed. This approach is crucial for maintaining production schedules and supporting ASML's commitment to delivering the highest quality by swiftly addressing and resolving urgent repairs to minimize supply chain disruptions."*- P[8]

The above statement by P[8] aligns with the strategy of adopting a new IS-based process which requires an organization to have a shared vision and goals that support its adoption. In the above statement by P[8] about ASML's Supplier Operations, the distinct vision to ensure zero material availability issues by handling urgent repairs swiftly and effectively is integral to ASML's overarching mission of maintaining high-quality production standards.

4.2.6 Nature of business processes

The participants highlighted that each stakeholder or department has developed their ad-hoc sub-processes based on their preferences and the tools available to request urgent defects processing. Inputs required for processing the urgent defects come from various channels and methods, including emails, and Microsoft Excel forms, in the form of Screenshot and Microsoft Teams notifications. Additionally, the lack of correct information needed to process requests, coupled with the occasional provision of incorrect data, complicates the handling of these requests. This results in delays as the Reverse Logistics team must spend extra time obtaining the correct information from the appropriate requesters, negatively impacting performance. These challenges emphasize the variability in the business processes of Reverse Logistics, contributing to uncertainty. Additionally, the ability to analyze these processes contributes to the clarity and definitiveness of the business operations in the RL urgent defects process.

Furthermore, since the stakeholders are not aware of the process and as there is a lack of communication protocols, each stakeholder requesting has their interpretation of the process and expectations. As mentioned in subsection 4.1.1, there are no clear guidelines and SLAs defined for the processing of urgent defects, the requesters use their judgment and knowledge to request the urgent defects, which not only leads to uncertainty but also causes equivocality.

Impact of Process Variability

Hazen et al. (2015) notes that information flow in RL frequently exhibits high variability, underscoring the necessity for an IS to manage the RL operations effectively. This variability is clear from the qualitative analysis, which reveals inconsistencies in how urgent defects are reported, as indicated by statements from participants P[4] and P[12]. The variety in the format and completeness of incoming data, due to different tools structuring information in their ways, increases unpredictability and uncertainty in the process. As the uncertainty increases it negatively impacts RL performance as more effort and time are needed to receive the inputs and data in the correct way which causes the lead time to ship the defective parts to increase.

> ***"Requesters of urgent defects frequently employ diverse communication methods, including emails, SAP system screenshots, Microsoft Teams, Excel Forms, and marking high priority in MN in SAP, each based on their understanding. This variability, combined with often incorrect or incomplete data necessary for processing requests urgently, significantly impacts the time required to ship these parts."*** -P[4]

The statement from P[4], responsible for RL administrative activities as mentioned in subsection 4.1.1, illustrates the increased workload caused by varied inputs and data issues. This also shows how the information passage through different stakeholders until it reaches the RL team varies. Bai et al. (2013), states that the information flow in a business process is the flow of information units passing through a sequence of tasks in a process and errors may be introduced due to omissions and mistakes. Therefore, there is a need to have control procedures as mentioned in the "Input Processing Data Accuracy and Availability" sub-theme.

This is corroborated by the experiences of P[12], one of the requesters of urgent defect requests as follows:

> ***"Inputs vary significantly from one person to another, complicating the task for those in reverse logistics who must process this information. Centralizing and optimizing the process to ensure consistent information delivery rather than having to chase down disparate emails could significantly streamline our processes and reduce the lead time."***- P[12]

The above statements from P[4] and P[12] highlight the negative impact of uncertainty due to the variability in the process along with the requirements of data accuracy. This confirms the proposition made by Zelt et al. (2019) as seen in Figure 2.6 that an increase in uncertainty of processes negatively impacts the performance of the processes which in this case is the urgent defect request process.

The quality and reliability of information about defects can vary significantly, depending on the source and the requester's understanding of what details are necessary, which increases the degree of equivocality of the processes. This inconsistency makes it challenging to quickly and accurately assess and prioritize defects which in turn hampers the performance of urgent defects process flow. This is in line with the contingent model of process management as defined in Figure 2.6 by Zelt et al. (2019). **Thus, as per Zelt et al. (2019), to reduce the negative impact on urgent defects management process flow caused due to the increase in uncertainty, formalization in the form of documentation and standardization alone will not be efficient but there will be the requirement of an IS along with performance metrics. Therefore, IS can act as the only standard input process flow for communicating urgent defect requests, aligning seamlessly with the insights from the interviews regarding the need to minimize information redundancy.**

As Participant P[16] highlights, much of the data in emails and Excel forms often drawn from the Material Notification (MN) in SAP redundantly mirrors information already present in the SAP system.

> ***"In our email requests we provide 12NC of the material, the MN number, Point of Contact which. This information is already available in the SAP ERP system where eventually RL processes the request"***- P[16]

The statement from P[16] points out the redundancy of information flow in the process.

By centralizing urgent defect requests in the IS of SAP, it is possible to eliminate unnecessary manual information transfer in the form of emails, and Excel files and improve process efficiency, making SAP the primary and most effective platform for managing these requests.

Impact of Process Equivocality

As highlighted in subsection 4.2.3, subsection 4.2.2, different stakeholders who are the requesters of the urgent defect repair or RCA, are not aware of the correct approach, correct input data, have unclear expectations along with unclarity of their roles and responsibilities. Due to these reasons, the stakeholders use their judgment and knowledge to communicate their requests, making the process to be knowledge intensive.

As per Zelt et al. (2019), the knowledge-intensive nature of the business processes demands significant personal judgment in executing tasks, which is indicative of low analyzability. The use of judgments and knowledge to communicate their requests by stakeholders leads to lower analyzability and ultimately contributes to the high equivocality of the process.

Haußmann et al. (2012) defines analyzability as how well stakeholders can complete a task by following clear and systematic procedures. This is aligned with the views expressed by the participants in the interviews who stated the need of systematic procedures to made available. Thus, this means that systematic procedures can be used in the case of analyzable tasks.

The participants emphasize the need for systematic procedures and documentation about the roles and responsibilities, process awareness and clarity on input data to allow them to executive their activities efficiently. This indicates that the activities needed to be performed by the stakeholders can be achieved by systematic documentation and clearer process guidelines would therefore significantly aid in reducing the need for personal judgment and disparate interpretations, aligning with the principles of high analyzability. This change could enhance the efficiency of the process by providing a standardized approach that all stakeholders can follow, thereby reducing confusion and the potential for errors in the execution of tasks related to urgent defect management.

However, this goes against the contingent theory by Zelt et al. (2019) which states that the higher the degree of process equivocality, the lower the positive impact of process standardization and documentation on process performance. Also, Zelt et al. (2019) states that the higher the degree of process equivocality, the lower the positive impact of IS on process performance. This is due to the use of IS in such cases can lead to higher compromise and design costs. The design compromise means finding solutions that meet the overall organizational goals while also considering the specific needs of individual departments or divisions which is the demand of the RL department in this case(Goodhue et al., 1992). **However, as mentioned in P[16], the necessary information required to process urgent defects is available in the IS system of SAP ERP, suggesting that the design compromise can be overcome and use of IS can be effective and efficient.** This is further supported by the theories proposed by Romero et al. (2015); Seethamraju & Seethamraju (2009) which states that use of IS based on ERP is highly beneficial for process which are routine and highly transactional and as per the statement of P[1] in subsection 4.2.1, the urgent defects are routine process flow with an need of expedited deliveries. This is explained in detail in subsection 4.2.7.

Furthermore, to support the interpretation of information in processes with high equivocality, Zelt et al. (2019); Haußmann et al. (2012) emphasize the application of lateral relations could be established that facilitate coordination efforts. These lateral relations connect process participants or departments which helps to process information (Zelt et al., 2019).

P[1] highlighted that the requesters of the repair or analysis of the urgent defect come from different backgrounds apart from logistics:

> *"Everybody must know the process flow and timeline to ship the part because the requesters are not logistics department but from product lifecycle management, Supply Chain Planning, Development and Engineering, Quality teams and they think if we send the request now, then in two hours the defective part is that the Supplier"*-P[2]

The above statement from P[2] points out that the requesters come from different departments and have a different understanding of the process flow. This aligns with Zelt et al. (2019), the differentiation nature of the business process wherein the involved stakeholders come from different departments leading to higher differentiation which in turn increases the equivocality. This in turn necessitates process standardization to increase the process performance (Zelt et al., 2019).

All the participants agree that the urgent defect process flow is highly important and value-adding to the organization. The importance of the urgent defect process flow is analyzed in subsection 4.2.5. Therefore, as per Zelt et al. (2019), the higher the process importance, the higher the process uncertainty and equivocality demanding the need for standardization using IS and lateral relations.

4.2.7 Role of Information System in process standardization

The challenges related to a lack of process awareness, unclear roles and responsibilities, insufficient communication protocols, and incorrect data availability can be resolved through formalization, as discussed in subsection 4.2.3. However, addressing the issues presented by participants regarding urgent defect management including process inefficiency, lack of transparency (no clear visibility of urgent information at a centralized interface), scalability issues, uncertainty, and the need for process standardization—requires the adoption of an IS.

As per the analysis done in subsection 4.2.2, subsection 4.2.6 and subsection 4.2.8, stakeholders clearly addressed the need for a standardized process flow using Information Systems.

These systems enable better coordination, automation, and real-time data access, which are crucial for effectively managing urgent defects. By leveraging IS systems, organizations can ensure that all relevant information is centralized and accessible, reducing the likelihood of errors and delays (Prasad et al., 2010). Additionally, these systems support the enforcement of standardized processes, enhance transparency across different departments, and facilitate better decision-making by providing stakeholders with timely and accurate information. This approach not only addresses operational inefficiencies but also aligns with strategic goals for sustainable process improvement and enhanced stakeholder satisfaction.

As discussed and analyzed in subsection 4.2.3 and subsection 4.2.6, standardization through formalization is not enough to solve the problems and challenges faced by the stakeholders. Therefore, IS systems have to be adopted to provide an integrated and comprehensive solution. However, to adopt an IS, it is important to select the most suitable IS for the desired outcomes expected by the Participants.

Appropriate IS Technology Selection

Gunasekaran & Ngai (2004) indicates that strategic IT planning in SCM involves organizational structure, top management awareness, business processes, strategic alliances, and information technology. These factors impact the overall performance of IT-enabled SCM. IS capabilities are derived from the integration of information technology (IT), knowledgeable staff, and processes and have the potential to provide a firm with a competitive advantage (Hazen et al., 2015). Therefore, it is important to analyze the IT integration and IT infrastructure of the organization along with the knowledge and skills of the stakeholders for selecting an IS. As discussed in subsection 4.2.3, subsection 4.2.6 and as per Zelt et al. (2019), for effective RL performance for managing urgent defect issues, there is a need for IS. However, correct IS-based technology selection is also crucial because as per the findings of Pan & Jang (2008), one of the major reasons for the failure of ERP-based IS adoption in organizations was a lack of organizational readiness for adoption. Technology selection allows to explore the organizational readiness Saghafian et al. (2021) by understanding the availability of resources necessary.

According to Badenhorst (2016), for RL processes to be successful, organizations usually require specialized infrastructure with unique information systems for tracking, dedicated equipment for processing returns, trained manpower, other value-added services, and flexibility to deal with operational issues. To confirm the requirement of IS infrastructure availability for RL, all 22 participants highlighted the presence of a robust SAP ERP system for managing all transactions of RL and overall SCM through SAP ERP. All the data used in the organization is derived from SAP as all the transactions related to information and material flow go through SAP to all the stakeholders for making important decisions.

Furthermore, 18 out of 22 participants responded that **the most effective tool for enhancing timely communication and information sharing about repairs, or RCA including urgent requests at ASML, should be the IS-based ERP system of SAP which is currently used in the organization.** The interviews highlighted all the stakeholders in the organization involved in urgent defect flow are aware of the SAP system and its functionalities.

Information Systems IT Infrastructure Maturity of the Organization

The participants identified that it is the presence of robust ERP infrastructure in the organization based on ERP SAP, which allows for all business transactions and operations to happen adequately and effectively making it an ideal selection for development and adoption of an IS based process flow. While several non-standardized processes initiate urgent defect requests, the SAP ERP system handles the administrative tasks involved in shipping those urgent defective parts.

P[8] points out the robust IT infrastructure and network maturity of SAP ERP:

> ***"ASML has well-developed ERP Infrastructure of SAP. All the defective parts are registered through MN in SAP, the Quality portal to take the necessary action for the defective parts is connected to SAP and is accessible even to the supplier, the repair purchase order is in SAP, and SAP is also connected to Ariba network, used for sourcing and procurement of parts and supplier management."***- P[8]

The statement from P[8], highlights that the SAP ERP infrastructure available in the organization not only supports the registration and management of defects through the MN in SAP but also integrates a Quality Portal accessible to suppliers through the Material Quality and Process Improvement team to share relevant defect analysis data. Furthermore, the SAP ERP is connected to the Ariba Network tool for managing supplier interactions. This comprehensive use of SAP facilitates a seamless flow of information and operational efficiency, which are essential for adopting new processes or technologies.

The presence of such an integrated IS system at ASML means that the necessary foundation for introducing a new technology or process, such as managing urgent defect processes is already in place. As per Yeh et al. (2015), a well-established IT infrastructure allows organizations to connect with their internal departments, external suppliers, and customers efficiently by using information platforms, networks, and core applications. This is very much the case in ASML. Furthermore, Yeh et al. (2015) highlights that greater IT infrastructure reflects relative increases in IT capability, indicating that investing in robust IT infrastructure is essential for business success.

This robust infrastructure likely enhances the attitude and behavior of the stakeholders to adopt SAP to manage the urgent defects by reducing the barriers to adoption and solving many potential problems upfront. The stakeholders are more likely to accept and adapt to the new processes when they perceive that the ASML's existing tech infrastructure of SAP can support these changes effectively. Furthermore, the established SAP system provides a foundation upon which new technologies and processes can be built, allowing for technological infrastructure to accumulate and evolve.

This is aligned with Laudon & Laudon (2014) which highlights the importance of studying the IT infrastructure as it provides a platform or foundation on which companies can build their IS. Therefore, organizations must carefully design and manage their IT infrastructure so that it has the set of technology services it needs for the work it wants to accomplish with IS (Laudon & Laudon, 2014).

The existing capabilities of SAP at ASML suggest that it is well-equipped to incorporate such a process, potentially enhancing responsiveness and efficiency in urgent defect management. This provides an opportunity to explore how the existing SAP system can be optimized or extended to support this specific need, leveraging ASML's technological foundation facilitates smoother transitions and better outcomes in urgent defect handling.

Analysis of Relative Advantages, Compatability, Triability and Observability for IS adoption

Taking guidance from Hsu & Lin (2016), the adoption and role of IS-based process flow for managing urgent defects within high-tech companies like ASML are examined through various technological factors. Relative advantage assesses the degree to which an IS-based process flow improves upon the existing processes it aims to replace, highlighting the benefits and efficiency it introduces (Hsu & Lin, 2016; H. O. Awa et al., 2017). Compatibility measures the extent to which the new IS-based process aligns with the existing values, needs, current tasks, and past experiences of potential adopters, ensuring it integrates smoothly without significant disruption (Hsu & Lin, 2016; H. O. Awa et al., 2017; Saghafian et al., 2021). Trialability allows potential adopters to experiment with the IS-based process flow before full adoption, providing an opportunity to explore its effectiveness and suitability (Hsu & Lin, 2016). Finally, observability focuses on the visibility of the results of the IS-based process flow, emphasizing how observable benefits can encourage wider acceptance and adoption among stakeholders by demonstrating tangible improvements (Hsu & Lin, 2016). These factors collectively influence the decision-making process regarding the adoption of technological processes in firms (Hsu & Lin, 2016)

The relative advantages of adopting the IS of SAP ERP for managing urgent defects processes were mentioned by the participants.

- Information Centralization: P[1], and P[7] mentioned that SAP ERP acts as a central system or "source of truth" for managing data and processes, indicating the critical role it plays in ASML RL operations. P[5], P[7], P[8] and P[10] noted that SAP ERP stores all the data necessary to process the defects

  > *"We rely on SAP as our centralized data system, which serves as the 'source of truth' for all our operational data and processes."*- P[1]

> ***"I believe all our processes, including urgent defect management, should be centralized in SAP, rather than using disparate tools like Excel and emails. However, SAP ERP lacks flexibility, which prevents its optimal use for our needs."***- P[10]

The quote from P[10] illustrates a preference for using a single, integrated IS of SAP to manage all processes, including urgent defect repairs. P[10] identifies the centralization of processes within SAP as an ideal solution to enhance efficiency and reduce the complexity associated with using multiple tools. However, the statement also acknowledges the current limitations of SAP, particularly its lack of flexibility, which hampers its full utilization.

- Optimization Capabilities of functions of SAP-based IS: Participants P[1], P[2], p[11], P[14], P[16], and P[18] indicated that existing SAP functions can be optimized for triggering urgent RCA-related defects process flow.

> ***"Utilizing the Execution section's priority setting in MN within SAP would greatly simplify how we notify urgent defect RCA requests. It also allows us to see the requester's name and make the entire process smarter and more transparent."***- P[2]

> ***"We can manage urgent defects by setting a criticality indicator directly in the Material Number (MN) in SAP, making it visible to all departments involved about its urgency "***- P[9]

The above statements of P[2], and P[9] highlight the optimization capabilities of SAP ERP functionalities wherein by integrating criticality indicators and requester details into the MN within SAP, the visibility of urgent defects RCA requests is enhanced across all relevant departments. This will act as an identifier for urgent defects identifier for root causes analysis. If the requester uses marks this identifier in the SAP system, they can be highlighted as urgent RCA requests. This integration ensures that all necessary details, including the requester's name, are immediately visible, which **promotes accountability, visibility, and traceability.**

The provision of details of the requester ensures accountability a major drawback in existing processes as mentioned in **Complex Coordination and Collaboration across Departments** sub-theme in subsection 4.2.2.

- Customization capabilities of functions of SAP-based IS

As discussed in **Optimization of functions of SAP-based IS**, the SAP functionality of criticality indicators can be used for urgent RCA requests but not for repair requests. P[1], and P[14] thus, propose that SAP ERP functionalities need to be customized so that the urgent defects repair can be highlighted uniquely and thus can be integrated into our normal workflow.

P[14] highlighted that there is a need for SAP ERP customization in the form of an identifier to separate the urgent repair requests from the regular repair requests and urgent RCA for SAP-based IS to be used for urgent defect repair requests:

> ***"To use SAP for urgent repair communication, a new Task code can used for urgent repairs provided that this customization separates and highlights the urgent requests from other requests."***- P[14]

P[22], who is a Subject Matter Expert in this field confirmed the optimization and customization capabilities of the ERP SAP system.

Participant P[4] points out that optimization and customization of the SAP IS function of MN to be used as urgent defects RCA and repair requests respectively which will allow the information about urgency to be collected and integrated in the regular way of working:

> ***" By automating urgent requests using priority settings SAP ERP and new Task code by the requesters, the urgent requests will be visible in the regular working environment interface of WorkList, allowing us to take immediate action. There is no need to send any emails or Excel files to convey the urgency. This allows centralization and integration with regular working, significantly reducing cycle times and the risk of missing an urgent email will be minimized. This can overcome any miscommunication as urgent repair requests will become visible to everyone"***- P[4]

P[4] makes it clear that the optimization and customization of ERP SAP can allow the integration and centralization of urgent requests including repairs and RCA in the regular working environment of WorkList wherein the RL team works on performing the administrative activities for other activities of repair and RCA. This integration and centralization allows risk minimization caused due to emails for tracking and tracing of urgent requests. This allows the RL team to respond faster reducing the lead times and improving the RL performance by directly reducing the impacts of the non-standardized process used as discussed in subsection 4.2.5. The P[1] and P[2] who are the BPO in RL approved this.

This optimization and customization will provide the necessary visibility for all stakeholders involved in urgent defect repair or analysis, thereby overcoming any miscommunication. This aligns with J. Hall et al. (2013), which states that enhancing product visibility can help mediate communication issues.

However, the optimization and customization changes proposed post the development will have to be adopted and accepted by the stakeholders in the organization. This presents a need for change management along with providing formalization in the form of process flow, clarity of roles and responsibilities, and equipping the stakeholders with relevant knowledge and training. This has been analyzed in subsection 2.1.9.

- Integration Capabilities of IS

  The participants noted that the IS system of ERP SAP can be integrated with the existing way of working and act as a standardized process.

  > ***"Everything from creating MNs where for the first time the defective parts details are logged to final delivery note creation happens in SAP ERP, therefore for triggering the urgent repairs SAP should be used, keeping it all centralized. This would be the best scenario as it integrates all information and processes in one platform."***- P[10]

  The statement from P[10] indicates that integrating all steps of urgent defect management within SAP would provide a unified and efficient platform for handling urgent issues, albeit contingent on addressing SAP's flexibility and capability enhancements. This is aligned with the definition of ERP defined by H. O. Awa et al. (2017) as a comprehensive IS-based innovation that integrates external stakeholders (inter) and internal functions, operations, and processes (intra) into a single, integrated system that facilitates and supports activities and promotes cost-cutting, alignment, and information sharing. This was also confirmed by the statement of P[8] in the sub-theme **ERP system Infrastructure** as mentioned in subsection 4.2.7.

  The statement from P[1] in subsection 4.2.8, highlights that for regular non-urgent defects where there is no need for emails and Excel communication, the requests come directly into the interface which allows them to track and perform efficiently and can be optimized for the urgent requests well. This is possible with the optimization and customization capabilities of IS ERP of SAP as pointed out by P[4].

- Compatibility and interoperability with Integrated Systems for Enhanced Traceability

  Participants P[7], and P[11] brought to attention that although SAP IS will streamline the process flow, it won't directly provide the traceability function to check which department or stakeholder is currently handling the urgent request and where the part physically located in the process flow, necessitating the need for an integrated system to provide this.

  P[3] pointed out that tracing the progress of a defect request can achieved in the ERP of SAP but it is a cumbersome process and not all the stakeholders are aware of this, thus a different interface is needed for traceability of the progress.

  To compliment this, the participants addressed that currently, they use the IT tool called **SpotFire** which acts as a dashboard for other RL activities apart from urgent defects and can be adapted to urgent defects as it is integrated with ERP SAP and gets its data from ERP SAP itself and projects it in a dashboard format. This is evident from below statement of P[7]:

  > ***"Spotfire is the better tool to track the progress and physical storage of parts which we use for all other activities, which will be beneficial if adopted for urgent defects for serial as well as non-serial parts. As it gets its data from SAP we can build a dashboard complementing the SAP ERP based urgent defects flow"***- P[7]

P[7] highlights the compatibility and interoperability of ERP SAP with other Integrated Systems like Spotfire for enhanced traceability and effective functioning.

P[12] and P[13] further complemented this saying it will ease the tracking and reduce the follows up necessary which is done by email communications and is highly cumbersome and does not yeil the expected response in terms of tracking and getting the timely updates. As P[7] mentioned, SAP ERP has interoperability with other interfaces allowing the user to visualize the information more simply and easily improving their efficiency. Butt (2020), defines information and the interaction of different system components to communicate and understand the information for effective decision-making. This is highly relevant and critical for the RL team and also the stakeholders involved. Thus, SAP ERP poses the interoperability capabilities which with the interaction with the **Spotfire** tool can resolve the traceability and tracking challenges of existing urgent defects flow. This will allow the stakeholders to track and trace the progress of the urgent defects flow and contact the relevant stakeholders in case of any concerns or breaches found in the agreed SLAs and the process documentation.

- Automation Capabilities of IS

  The optimization, customization, integration, and interoperability capabilities of the ERP SAP system align well with its potential for automation. P[10] and P[16] emphasized the importance of leveraging ERP SAP to automate process flows:

  > *"SAP ERP is capable of automation. I just press a button in it and let the process do its work of conveying urgency and meeting its end goal of shipping defects out fast"*- P[10]

  > *" We should automate the triggering of urgent defect flow and let the stakeholders involved know about the urgency, as everyone has access to ERP SAP and this will overcome the need to send emails"*- P[16]

  The statements from P[10] and P[16] reveal significant insights into the potential benefits of automating process flows using ERP SAP within the context of managing urgent defects at ASML. This is consistent with the ERP SAP system's optimization, customization, integration, and interoperability capabilities, which help to meet the strategic goal of expediting the shipment of defective parts. This alignment emphasizes the importance of IS in businesses, which extends beyond the automation of daily transactions Yeh et al. (2015). According to Yeh et al. (2015), these systems must be integrated with business strategies to become strategically important. By leveraging ERP SAP for urgent defect management, it is possible to align the ERP SAP system with the organizational strategic goal of improving operational efficiency, demonstrating how ERP SAP is more than just an automation tool—it is a strategic asset that supports the organization's overall goals.

  The statements by P[10] and P[16] further emphasize that while automation aids in meeting strategic goals, it also enhances the performance of the Reverse Logistics (RL) team and the overall organization by expediting the shipment of urgent defective parts, ensuring that manufacturing operations remain uninterrupted. This confirms that organizational digitalization allows the automation of operating activities and business processes, reducing service costs, increasing product quality, and accelerating service delivery. More importantly, enterprises aim for digitalization to achieve efficient supply chain management and improved customer service (Yeh et al., 2015).

- Availability of IT Technical Support

  P[11] mentioned the role of technical support in the form of IT experts which support for any support needed to resolve any concerns or issues with the IS ERP of the SAP system.

  > *"We have well-maintained SAP IT support for any technical support ensuring smooth operations during development as well as deployment of any changes"*- P[11]

  The statement from P[11] emphasizes the availability of strong IT support for making changes to SAP ERP, as well as the support required to ensure the system's smooth operation and customer satisfaction. This includes providing timely assistance, addressing technical issues, and implementing any necessary updates or customizations to meet the organization's evolving needs. This is aligned with the Gunasekaran & Ngai (2004) which states that key areas in the organizational development of IT in an organization are the management and technical skills needed by the

IT department team to enhance IT capabilities. Furthermore, Yeh et al. (2015) highlight that to successfully integrate IS into business processes, organizations must also consider human factors in terms of IT technical support. Developing IT department staff's management and technical skills is crucial for improving information technology capabilities (Yeh et al., 2015). IT department team must be aware of current IT developments when implementing digitalization strategies in organizations Yeh et al. (2015). They must solve organizational problems and teach stakeholders how to use technology to solve work-related issues through integrated solutions Yeh et al. (2015). The statement from P[8] further showcases the IT maturity of the organization in terms of the level of development and readiness of IT capabilities towards the adoption of IS.

Building on Hsu & Lin (2016); H. O. Awa et al. (2017), the analysis was done for technology selection and adoption based on factors of relative advantages, compatibility, trialability, and observability. All four factors proved to be crucial as stakeholders related their selection and adoption of SAP ERP relating to these factors.

The observed relative advantages are information centralization and a continuous standard process flow. The optimization and the customization techniques to trigger urgent defects using SAP ERP directly instead of the email way of communication, removing the risks identified in sub-themes of **Operational Risks in Communication Processes** mentioned in subsection 4.2.2 and also reduce the uncertainty and equivocality as mentioned in subsection 4.2.6. This will allow the RL team to visualize the incoming urgent defect requests and track them. This optimization and customization allows for the integration of the SAP ERP IS into the regular working environment. Furthermore, the centralization allows tracking of the urgent defective requests in the interface similar to how regular non-urgent defects are tracked. This overcomes the risks highlighted by P[2] and P[4] in subsection 4.2.2. Furthermore, the advantages extend to providing visibility and accountability which are lacking.

Therefore the adoption of an IS-based process will act as a single source of information flow (through IS of ERP SAP) against the various tools used to communicate and share the information. This allows the incoming urgent defect request to get accumulated into an interface environment similar to regular non-urgent defects which provides visibility of urgent defect requests, transparency in the information flow, traceability of the requests, and accountability in the form of requester identity needed. The cumulative advantage is the increase in response time to address the requests by the RL team, leading to a reduction in the lead time necessary to ship the defective parts.

The ability to optimize, customize, and integrate with other interfaces to meet stakeholder expectations is a reassuring factor of the SAP IS which allows trialability. As the IS-based flow provides the expected outcomes and overcomes the existing drawbacks and limitations, observability is achieved. All the factors are further complemented by the availability of robust SAP ERP infrastructure and the necessary technical support required.

The presence of robust ERP SAP architecture, complemented by its integration and interoperability, demonstrates the high compatibility of using IS-based ERP SAP for managing urgent defects. Technological compatibility is one of the barriers to new technology adoption H. O. Awa et al. (2017); Hsu & Lin (2016), and the seamless integration of using SAP for urgent defects flow with a regular working environment mitigates this barrier. By leveraging the capabilities of ERP SAP, organizations can streamline their urgent defect management processes, reduce manual effort, and enhance overall efficiency and responsiveness. This alignment not only facilitates smoother adoption.

Furthermore, the existing robust ERP SAP infrastructure, along with its functionality optimization capabilities, can be considered a form of organizational slack. Organizational slack refers to the surplus resources within an organization that are not fully utilized but have the potential to be leveraged when needed Baker (2012); Álvarez-Gil et al. (2007). Although the ERP SAP system is already in place, its features were not fully optimized and customized for handling urgent defects. This underutilization represents a reserve of untapped potential that, when effectively harnessed, can enhance the efficiency and responsiveness of the defect management process. Therefore, organizational slack is a factor beneficial for innovation and desirable to have during technology adoption.

Therefore, it is crucial to access the existing ICT infrastructure of the organization as analyzed in subsection 4.2.7 along with various technology selection criteria to judge if the organization has suitable technological resources available to adopt new processes based on IS.

However, to truly adopt IS ERP for urgent defects process flow, the need for process control procedures discussed in subsection 4.2.2 should be considered.

4.2.8 Technology Sensemaking by Stakeholders for Adoption

Technology sensemaking refers to the process through which individuals or groups in an organization make sense of new technologies and decide whether to adopt them based on their understanding and interpretation (Mesgari & Okoli, 2019), which in this case is the IS based on ERP system of SAP. As sensemaking involves both individual and collective understanding, it will help in aligning the actions of all stakeholders of the organization toward the successful adoption of IS based process. It considers the emotions and cognitive structures of users, which can influence their willingness to adopt new technologies and processes (Mesgari & Okoli, 2019). Furthermore, sensemaking helps the involved stakeholders to understand and interpret new standardized process flows, making it easier for them to integrate these processes into their daily tasks and workflows. Thus, understanding these perspectives and the underlying factors that influence technology adoption for new process flow, allows us to develop a more effective strategy for implementing an IS-based standardized process flow for managing urgent defect repair requests (Mesgari & Okoli, 2019). Furthermore, Mesgari & Okoli (2019) states that the way stakeholders understand and make sense of new technology can be initiated by different types of triggers which can be situational factors or technological factors. The situational triggers can be specific contexts that necessitate the need to understand and adopt new technology (Mesgari & Okoli, 2019). The technological trigger can be the aspects inherent to the technology itself that draw attention and necessitate understanding. This includes the core and concrete features of the technology such as its capabilities, functionalities, user interface, and the specific problems it solves Mesgari & Okoli (2019).

To understand the process that stakeholders go through when evaluating a technology adoption-based process a survey was conducted during the semi-structured interviews for 22 participants. 4 Participants did not participate in the survey. The existing process flow for information sharing and communication for managing urgent defects was rated by them on four critical aspects for the RL performance of an organization: Efficiency, Transparency, Scalability, and Necessity of Standardization using IS. The aspects were chosen based on the literature review done as mentioned in subsection 2.1.2, subsection 2.1.4, subsection 2.1.5 and subsection 2.1.5.

Critical Aspects Necessary for Standardized Process Adoption using IS

The challenges faced by the stakeholders shed light on the different critical aspects of the existing process flow. These aspects are necessary to be studied so that they can be evaluated to develop a new standardized process flow and meet the stakeholder expectations while meeting the organizational performance. The stakeholders rated the different aspects of the existing process flow on a scale of 1 to 5

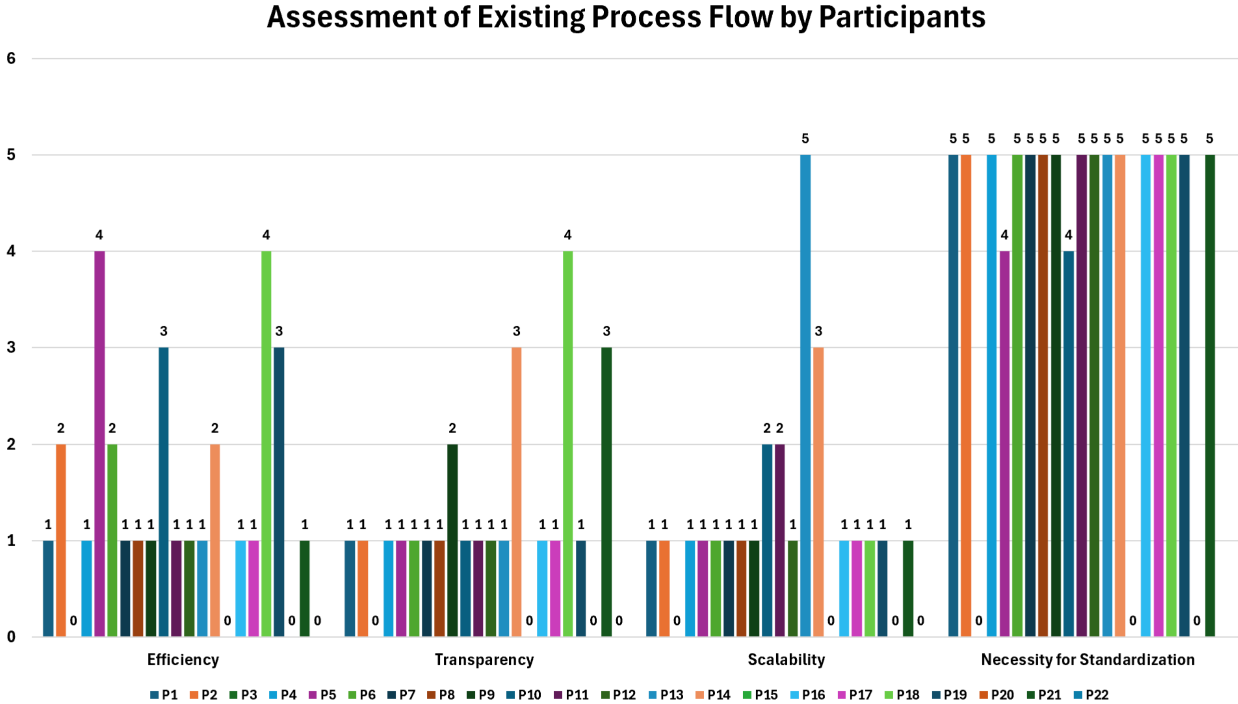


Figure 4.4: Assessment of existing non-standardized process flow by participants

for each of the aspects with the following explanation:

1. Rate on a scale of 1 to 5, where 1 means you completely disagree and 5 means you completely agree that the current process is efficient in terms of timely management of shipping urgent defective parts or products out of the organization.
2. Rate on a scale of 1 to 5, where 1 means you completely disagree and 5 means you completely agree that the current process is transparent in terms of traceability and visibility of the necessary information flow required for the management of urgent defective parts or products to ship out of the organization.
3. Rate on a scale of 1 to 5, where 1 means you completely disagree and 5 means you completely agree that the current process is transparent in terms of handling the number of urgent defective repair requests.
4. Rate on a scale of 1 to 5, where 1 means you completely disagree and 5 means you completely agree that there is a need for an IS-based standardized process flow to manage urgent defect repairs considering efficiency, transparency, and scalability.

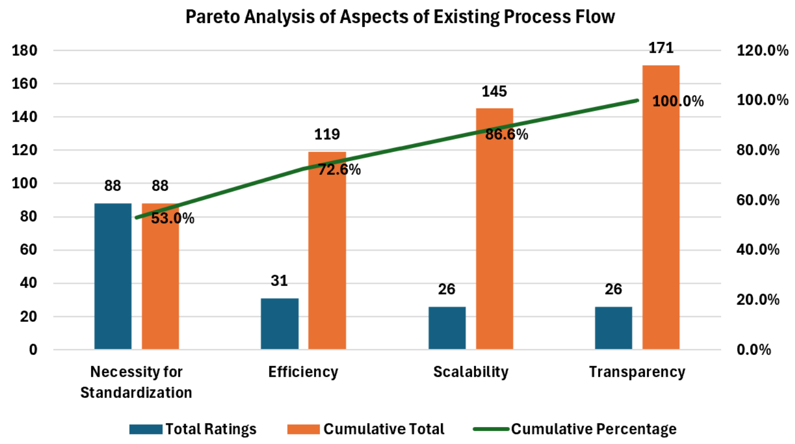


Figure 4.5: Pareto Analysis of aspects of existing non-standardized process flow

The Pareto Analysis of the survey reveals that the "Necessity for Standardization" is the most critical aspect, accounting for 53.0% of the total ratings. Focusing on improving this aspect, along with "Efficiency" and "Scalability," would address 86.6% of the total impact, highlighting the key areas for process improvement initiatives. It also highlights that while standardization, efficiency, and scalability are critical for improving the process flow, the significant concern regarding transparency cannot be overlooked. Addressing these aspects holistically will lead to a more robust, reliable, and effective process for managing urgent defects at ASML. The low ratings (predominantly 1) indicate strong disagreement with current transparency in terms of traceability and visibility in handling urgent defective repair requests. Prioritizing improvements in transparency, alongside standardization and efficiency, will ensure a comprehensive enhancement of the current process, fostering better performance and greater stakeholder satisfaction.

1. Efficiency: The goal of task-technology congruence is to determine whether the existing processes (task) and technology used do what it is supposed to do and improve efficiency (Saghafian et al., 2021). This aligns with the survey's assessment of the current process flow's efficiency in managing urgent defect repair requests. As the stakeholders perceive that the existing technologies and processes used are not efficient, they are more receptive to adopting a new, standardized process flow. As per J. Hall et al. (2013), the organizations to return the defective parts to the suppliers recognize the effect of the returns process flow on their efficiencies and the associated costs. One of the goals of the return process flow is efficient product return which focuses on identifying defective parts and getting them ready to be shipped to the respective suppliers. The associated performance metric is the amount of time the above process takes to complete J. Hall et al. (2013) which is the internal process time as mentioned in subsection 4.1.1.
2. Transparency and Scalability: Saghafian et al. (2021) states that assess the need for and appropriateness of the technology based on the urgency and legitimate need for this technology. The stakeholders highlighted the concern of transparency and visibility of the existing process flow

suggesting the non-availability of any traceability in the existing process flow to track and trace the urgent defective part in the process flow to monitor its progress. Participants raised concerns about scalability, specifically the difficulty in tracking and tracing the increasing number of incoming urgent repair requests as the organization grows, using existing processes. Thus, these concerns highlighted the urgent and legitimate need for a new process flow based on IS technology that integrates with the existing way of working and is easy to use.

3. Necessity for Standardization using IS: The stakeholders evaluated the need for standardization of the urgent defects requests process using an IS based on the challenges faced due to the existing processes. The survey results indicate a high necessity for standardization, showcasing receptivity to the adoption of a standardized process flow that addresses these shortcomings. As per J. Hall et al. (2013), for organizations focused on outbound RL, establishing RL standards and processes is a challenge standardizing and formalizing RL processes, and establishing RL metrics.

. Along with formalization and documentation to achieve standardization, the use of the IS system of SAP was highlighted by participants as this would aid in integrating the new standardized process flow with existing working, aiding in ease of adoption of IS-based process flow. This is aligned to Zelt et al. (2019) theoretical model for process performance enhancement using IS as defined in subsection 2.1.8. This is discussed in detail in subsection 4.2.7

The scope of improvements and the necessity of standardization of the RL process for urgent defects flow are evident from the following analysis conducted based on the interviews with the participants:

- Impact of Efficiency & Transparency:

  P[2] raises concerns about the existing process flow of receiving urgent defect notifications via email directly related to aspects of technology sensemaking, particularly in terms of how they view the adoption of a new technology in terms of its usability and compatibility:

  > ***"We receive emails, Excel files, and time Microsoft Teams as the way of communication from stakeholders about urgent defects, the risk is that we may not see the email or message on time or maybe the expected team member does not see the email or the requester does not loop the correct team members into the email. We need to move from this existing working to a new process flow which eliminates these risks."***- P[2]

  P[2] indicates that the current process involves using emails that lack transparency and negatively impact efficiency while increasing the risk of delayed responses and miscommunication. This situation reflects a **gap in task-technology congruence**, where the technology (in this case, email and excel files as a communication tool) **fails in its task to adequately meet the needs of the urgent defect management process whose aim is to respond faster to the urgent defect requests and ship them faster towards the suppliers. The risks of the existing processes present situational and technological triggers that act as a sensemaking for the P[2] to understand the need to move away from the existing process flow to a new process flow.**

  This gap and risks in the existing flow as highlighted by P[2] was further strengthened by the statements of P[21] and P[12] as follows:

  > ***"Since I did not get a reply to my email from the RL team about an emergency repair request, I had to call a colleague in the RL team directly to ensure the request was handled urgently. The challenge is that when emails are sent to the RL team email ID, they lose their urgency and become routine. There is a need for a change in the way we manage urgent defects currently. "***- P[21]

  > ***"I emailed the Reverse Logistics team about an urgent repair but received no response for two weeks, requiring a personal follow-up to initiate processing. This inefficiency disrupts production planning and timely communication with suppliers, adversely impacting overall project performance and factory output. The personal follow-up for every request is not the correct approach as it causes a waste of time for everyone. We need to change the approach and adapt a more transparent and visible process."***- P[12]

  These statements from P[21] and P[12] point to the inadequacy of the current processes for managing urgent defect requests. The risks mentioned by P[2] are confirmed by P[12] and P[21].

For, P[21] and P[12] the lack of efficiency and transparency of existing technologies in the form of using emails used to inform about the urgency along with its impact act as technological and situational triggers for the sensemaking to adopt a new process flow.

To counter the above challenges faced by P[2] themselves and the problems raised by P[21] and P[12] in the below statement suggests using the IS system of SAP ERP, which will increase transparency and provide accountability which will eventually lead to efficiency:

> *"Utilizing the Execution section's priority setting in MN within SAP ERP would greatly simplify how we notify urgent defect RCA requests. It also allows us to see the requester's name and make the entire process smarter and more transparent."*- P[2]

Therefore P[2] considers that by making sense of the features of IS SAP ERP technology, stakeholders can identify ways to streamline processes, reduce time and effort, and improve overall efficiency in their tasks. Furthermore, sensemaking allows users to see how the new technology improves transparency by providing clear and accessible information, enabling accountability of the request. Therefore sensemaking to adopt and move towards IS SAP ERP as a new process flow is triggered by situation aspects due to the lack of transparency and impacts on efficiency. The sensemaking further is triggered by the capabilities of the IS SAP ERP to solve the problems raised. For P[2], the availability of IS and its features act as a technological trigger-based sensemaking for its adoption.

- Necessity of standardization:

  P[1] emphasizes that information centralization is an important parameter of the organizational context necessary for the adoption of technology. The existing interface environment for regular non-urgent defective parts is effective for managing the other because it allows for tracking and responsibility.

  > *"The timely processing of urgent defects repair requests is possible and scalable when we have them in one place, where they can be visible and we can track them, where we have a sort of interface for them, and yeah, the problem now is that for the regular defective parts which we use SAP ERP and have a Work list, a type of interface for storage of the information about making them visible and so we are responsible for them and thus we can track them. But for urgent defects repair requests, since we get them in emails, we cannot track them."*- P[1]

  The above statements of P[1] stressed that the existing non-standardized way of communication for managing urgent defects repair requests **lacks centralization in terms of integration with the regular working environment, relying on emails and manual entry, which hinders transparency, scalability, and efficiency. For non-urgent defects, there is an interface available that is connected and integrated with the SAP ERP system that acts as a storage of all incoming urgent defect-related requests with all the relevant information necessary for the RL team to process them, which is not the case for urgent cases. This showcases the interoperability and integration capabilities of IS of ERP system SAP for regular defect requests, thus providing an opportunity to adopt it for the defects as well.**

  Therefore, for P[1] the situational as well as technological characteristics of lack of scalability and information centralization for traceability of existing process flow is the sensemaking that demands moving out of existing process flow towards a more centralized, scalable, traceable, and standardized process flow. This also showcases the cognitive structure of the stakeholders which acts as an influence for the adoption of IS for urgent flow as well

  As per P[7], the existing processes lead to potential bottlenecks where the absence of proactive engagement from one stakeholder can halt the entire process, indicating a need for a more robust and responsive communication system. Furthermore, it is highlighted that the current "push" nature of the process does not adequately support the urgent nature of the repair activities, as there are no prompts or triggers to ensure continuous movement. Introducing a "pull" component, where subsequent stakeholders actively request updates or completion of prior activities mentioned in IRC, might mitigate delays and improve the overall pace and reliability of the process. This further showcases the complex coordination and collaboration necessary to achieve the end goal of faster shipment of defective parts to the supplier:

> *"The process isn't transparent or traceable, it operates through an email chain where you can see actions being passed along. However, it essentially functions as a push process where everyone needs to take action, but if someone misses their email or any other reason prevents them from acting the process stalls. There's no mechanism for pulling or prompting the next person in line, so it's very easy for delays to occur. Since many people are involved in each step of the process, if it stagnates at any point, there is no automatic trigger to continue the workflow"*- P[7]

Therefore, for P[7], the need for a robust automated process flow that is efficient enough where all the stakeholders are proactive is driven by the technological sensemaking for the adoption of a new process flow.

P[8] highlights significant **communication inefficiencies** within the urgent defect process, particularly in terms of reaching the correct department responsible for handling the urgent defects. This issue contributes to delays and potential confusion, as the currently stated communication channels provided (email and phone) do not always ensure timely or appropriate responses.

> *"The challenge is in the right department to approach. The standard email address provided in the urgent defect Excel form does not always lead to the department that needs to follow up. So the urgent defect form with its current email address flow isn't always effective. Moreover, there have been instances where I didn't receive a response for two days, which is unacceptable for urgent cases. Although the form includes a contact number, my attempts to reach out via this channel were also unsuccessful. There is a need for a change in process flow through automation and interface that allows this."*- P[8]

Therefore, for P[8], the need for the adoption of change and standardization stems from the technological sensemaking of the unavailability of traceability and the need for automation and an interface for traceability.

P[10] points out the drawbacks of standardization which leads to rigidity:

> *"Downside of standardization is when processes are strictly defined. Sometimes, you need direct alignment and interaction with someone who truly understands your specific issue, someone willing to step away from their desk if necessary. Over-standardization can lead to rigidity, reducing human interaction and flexibility. When something goes wrong, such inflexibility can impede the effectiveness of the process"*- P[10]

The statement from P[10] points out that the downside of strict process standardization is the potential loss of flexibility and human interaction. Over-standardization can lead to rigidity, making it difficult to address specific issues that require direct and personalized attention. This inflexibility can hinder the effectiveness of processes, especially when unexpected problems arise. The need to address certain specific issues mentioned by P[10] aligns with the Seethamraju & Seethamraju (2009), who states that if the processes are unique specific standardization can limit the organizational agility. This is only limited to unique situations when presented in the process flow.

However, Seethamraju & Seethamraju (2009); Romero et al. (2015), states that higher standardization enhances agility provided that processes are highly transactional and routine. As highlighted by P[1] in subsection 4.2.1, the urgent defects flow is similar to regular defects flow except for the need for an immediate response making the urgent defects process highly routine and transactional and thus agile. Therefore, unless a unique situation is presented in the process flow, standardization won't limit the agility of the process flow.

However, the unavailability of a standard process flow and unawareness about the correct process steps to be followed among the stakeholders make them non-agile and non-routine. Therefore, to enhance the performance of RL in managing urgent defect requests, it's crucial to diminish the uncertainty and equivocality inherent in current business processes by making them agile and routine. This improvement demands the implementation of formalization in the form of documentation and standardization, the strategic use of IS equipped with performance metrics and the fostering of effective lateral relationships among stakeholders and departments (Zelt et al., 2019).

To overcome the drawbacks of standardization, P[4] in subsection 4.2.7 highlights that adopting an IS ERP system, with its optimization and customization capabilities, can make processes highly routine and transactional. This aligns with Romero et al. (2015), which states that process standardization is a crucial step in implementing ERP systems. Aligning an ERP system with supporting business processes leads to a more uniform implementation and increases process agility (Romero et al., 2015). Therefore, standardized processes make it easier to adapt and make changes to processes when needed, enhancing the organization's agility and responsiveness to change (Romero et al., 2015).

Furthermore, Prasad et al. (2010); Seethamraju & Seethamraju (2009) state that many organizations struggle to change their processes after implementation, despite the need to adapt to the current environment. Dynamic and adaptable to evolving needs. **The ERP system's rigidity creates a conflict with the flexibility of business operations.** Therefore, to overcome this, Seethamraju & Seethamraju (2009) suggests using the best practice processes embedded in ERP software, which are considered true best practices in this organization. Regular updates in the ERP ensure the incorporation of the latest developments in practices and technologies, providing the necessary agility. Research by Seethamraju & Seethamraju (2009) indicates that integration and standardization characteristics influence a firm's ability to build agility in its processes. However, the effects vary depending on the type of integration and the extent of integration achieved by the organization after implementing the ERP.

- Scope of Scalability

Urgent defects, communicated through emails and without a centralized tracking system, become unmanageable when the volume of urgent repair requests increases. The manual tracking process required for these urgent requests is inefficient and prone to errors and risk as stated earlier by P[2], underscoring the need for a unified standardized system that provides a comprehensive overview of all urgent repair requests. P[1] further elaborates this concern as follows:

> ***"Now we track the urgent requests manually and if they scale off, then we suddenly have like 20 urgent defective repair requests at any given time laying, needing to keep track of everything without a list which is hard to do for us. If you receive them by email and Excel files, you will have to write them down or note them manually, then so they are not scalable. We should have an overview of all urgent repair requests."*** -P[1]

The statement from P[1] raises concerns about limitations of the existing processes scalability for management of higher number of incoming requests. To complement the above concern by P[1], P[21] states that they have to also call the RL team members to convey emergency urgent requests. This continuous reliance on interpersonal communication for urgent matters, such as calling coworkers directly, is unsustainable. This method can place a significant strain on RL team members, who may become overwhelmed by the volume of requests, resulting in decreased productivity and increased frustration. This is evident from the statement of P[21]:

> ***"Upon not getting a reply for my repair request, I had to directly call a colleague in the RL team which is not a sustainable option. Imagine needing to send numerous emergency parts to a supplier daily or even hourly. If everyone starts calling RL team members to request urgent processing, they will be overwhelmed. The main challenge I face with urgent dispatches is not knowing the appropriate contact. This results in inefficiency and confusion."***- P[21]

Based on the above statement of P[21] resonates with P[1] sensemaking for the adoption of a new standardized process flow.

- Attitude and Aptitude of the stakeholders

The participants P[1], P[2], P[21], P[12], P[7], and P[8] use their sensemaking to collectively highlight the recognition of the need for more efficient, transparent scalable, and standardized processes for managing urgent defects. The below statements from P[7] and P[1] reflect both the aptitude and attitude toward the adoption of new technology, specifically the integration of SAP ERP-based solutions.

> ***"With the growth of ASML, we've recognized that our old processes simply don't cut it anymore, not now and certainly not in the future. We're shifting from outdated Excel***

files to more efficient Spotfire reports that are derived from SAP. So the new process using SAP as a tool to act as a standard process flow will be a significant improvement."- P[7]

"It is necessary to have a standardized process flow because we work with different departments, and we have to be sure that everybody's aligned. Standardization makes everything clear and more information available for everyone and it does not apply only for urgent defects but for all processes "- P[1]

The example given by P[7] and the above statement by P[1] show the attitude towards adopting new technology is overwhelmingly positive.

Along with this, the overall analysis done based on the perceptions of sensemaking of the participants at individual level as well as organizational level have a collective demonstrates a clear understanding of the limitations of current processes and the potential benefits and need of adoption of the IS-based standardized process flow. This reflects that the organization has a positive attitude and aptitude towards adoption. This is crucial because attitude and aptitude can either slow down or speed up the adoption process of IS technology based on how they are shaped and utilized (Saghafian et al., 2021).

4.2.9 Participation of Top Management for Adoption and Implementation of IS-based Standard Process Flow

Participative management focuses on management support and commitment, as well as openness to continuous dialogue, which can lead to successful organizational change (Andersen, 2016). As per Olorunniwo & Li (2010), successful RL initiatives require management commitment, including leadership support, financial resources, and investment in technology innovations.

Competitive Business Case Development

P[6], P[10], and P[14] emphasized that **to drive any change in the organization in the form of IS adoption and propose a new standard process flow, top management support, and commitment are necessary. To get this support and commitment, the process owner needs to put forward a competitive business case explaining the problem, proposed solution, advantages gained, investment, and resources needed. The proposed solution has to be aligned with the business priorities, goals, and vision.**

"A positive business case presenting the problem, its impact, a proposed solution involving the cost and IT resources necessary needs to be presented to the top management. There has to be a balance between the cost involved and the gains to be achieved and has to be linked with the organization's priorities."- P[10]

This statement of P[10] aligns with the IBPM framework developed by Butt (2020) and discussed in subsection 2.1.7. Therefore, for successful top management support in adopting any new technology or changes required in the IS system of ERP, as discussed in the sub-theme **Analysis of Relative Advantages, Compatability, Triability and Observability for IS adoption** in subsection 4.2.7, a cost-benefit evaluation must be provided to the top management. The statement further showcases the importance of balance between investment and the returns of the investment, highlighting the role of ensuring a valid and realistic return on investment. This is aligned with Butt (2020), in which digital transformation while adopting technologies fails due to the unavailability of a realistic return on investment. Furthermore, as per Gunasekaran & Ngai (2004), top management participation is important to make strategic decisions regarding IT investment to achieve an effective supply chain management system.

Vision and Goal Alignment

Participants P[8], P[9], and P[11] highlighted that the goal and vision of the organization are to ensure smooth supply chain operations by meeting demand and supply, and thus urgent defect repairs process flow is deployed as the last resort to avoid any impact on the demand and supply planning. However, the participants mentioned that there is a notable gap in the vision and goal of the organization with the vision and goal of urgent defect process flow. This is discussed in the below statement by P[9]:

"I believe that our current way of working doesn't align with the organization's vision and goals in respect to supply chain management, particularly the goal to reduce the outgoing repair flow lead time and enhance sustainability. The existing repair process for urgent

> ***defects isn't optimized for this objective. By standardizing this process using IS SAP, we could handle urgent defects more efficiently, both internally throughout ASML and at the supplier's end, which would expedite their return to ASML and decrease our outstanding commitments with suppliers."***- P[9]

According to the statement by P[9], the current processes for managing urgent defects at ASML are not aligned with the organization's goals of reducing supply and demand gaps. These processes need to be improved to enable quicker repairs of defective parts by suppliers, minimize business disruptions, and uphold the sustainability commitments of the organization. The top management should set meaningful goals and communicate the organization's priorities to the organization so that stakeholders involved can align themselves to achieve these goals (J. Hall et al., 2013). Top management support is crucial in this context as it provides the necessary backing and resources to the stakeholders to adopt and implement these process improvements effectively. This is aligned with the top management perspective stated by H. O. Awa et al. (2017); García-Sánchez et al. (2018)to support the organizational vision and goal by providing the required IT resources, and financial resources. By ensuring top management is engaged and supportive, the organization can foster alignment with strategic goals, ultimately enhancing operational efficiency and sustainability.

Shared Vision and Goals

The participants expressed that all the stakeholders involved in the urgent defect process flow should have an equivalent perception of urgency aligned with the goals and vision of the organization and not only the requesters of the request, creating a sense of shared vision and goal. This is evident from the below statements of P[11] and P[3]:

> ***" I feel the pressure, but others don't seem to feel the urgency. It's a challenge to motivate people to prioritize my requests when not everyone involved feels responsible. It feels like I'm constantly having to micromanage and employ those tactics."***- P[11]

> ***"When I send an email of the urgent repair request, I just hope that everyone picks it up immediately as several steps are involved and there is no way to check it is received with the correct urgency."***- P[3]

Thus, all the stakeholders must share the vision and goals of the organization, which is necessary for the efficient management of process flows. This aligns with J. Hall et al. (2013), where it is stated that senior management is responsible for establishing meaningful goals for the organization, thereby conveying the priorities of the organization to stakeholders. Furthermore, Saghafian et al. (2021) states that before adopting a new technology, it's crucial to ensure the successful establishment of a shared vision and set of goals across different levels of the organization that fosters the adoption of new technologies.

Proactive Strategy Planning

The case scenario presented by P[7] as mentioned in subsection 4.2.5, showcased that businesses need to change the existing way business processes used for managing urgent defect requests came into light when the existing processes stalled and had an impact on the business operations and performance. This highlights the need for proactive strategic change management to be adopted by the Top Management and the necessity of periodic reviews to monitor if the processes developed are performing as they were planned. This then connects to the roles of the Business Process Owners and Business Process Champions and the importance of Peirodic Reviews along with the role of implementing key performance indicators.

According to Price & Chahal (2006), a proactive approach to change, driven by stakeholders committed to organizational success, is preferable. Price & Chahal (2006) further suggests that organizations should consider developmental changes, which enhance process execution beyond current capabilities. This aligns with Saghafian et al. (2021), who advocates for proactive strategies to enhance efficiency and adapt to technological advancements, thereby preventing obsolescence and maintaining a competitive edge.

Goal Congruence with strategy

The above statement from P[9], focuses on aligning the organization's supply chain planning-specific strategies, such as adopting a SAP IS-based process for urgent repairs, with the broader organizational goals, demonstrates how having a coherent vision and clear goals can drive the technological adoption of IS that supports operational efficiency and service quality. This is aligned with García-Sánchez et al. (2018) who states that top Management not only provides the IT resources but also provides a plan that guides the organizations to achieve their strategic goals. This alignment thus ensures that every stakeholder is working towards the same end-state and enhancing the organization's ability to adapt to new technologies effectively García-Sánchez et al. (2018). This is particularly relevant in environments like high-tech environments where timely and effective response to material defects is critical to maintaining supply chain continuity (García-Sánchez et al., 2018).

Inter-departmental Conflict Resolution

P[11] pointed out that at times when adopting a new process flow or during change management for transitioning to a new process, there can be conflicts over agreeing on the process flow and top management needs to step in to resolve it:

> ***"When departmental disagreements arise, it's essential for managers to align and make final agreements. If consensus isn't reached, escalate the issue to management rather than discussing across departments."***- P[11]

The statement from P[11] indicates that whenever disagreements arise between departments regarding work instructions or procedures, managers should come together to align and make final agreements. If individuals still do not agree with the resolution, they should escalate the issue to higher management rather than arguing across departments. This approach ensures that conflicts are resolved efficiently and professionally, maintaining harmony and clarity within the organization.

4.2.10 Necessity of Human Factors Analysis

According to García-Sánchez et al. (2018), as per the Resource Based View (RBV), RL is viewed as a strategic resource that can assist the company in gaining a competitive edge by effectively recovering the value of its products. According to this viewpoint, one of the most important intangible resources for the creation and upkeep of successful RL operations is human resources (García-Sánchez et al., 2018). Human resources are essential for creating RL activities, according to the RBV of organizational rationality. They are even more important in the high-tech industry, where employees must be highly qualified and continuously updated due to the industry's culture of continuous research and innovation García-Sánchez et al. (2018).

Technological Skills

The participants P[9] and P[21] addressed the importance of the technological skills necessary for the stakeholders to use the IS ERP solution instead of the existing way of working. The participants further indicated that although the stakeholders involved have been using ERP SAP for a long period and is a part of their daily activities, it is essential that stakeholders possess the necessary knowledge of functionalities and skills of the IS as it will be easier for them to adapt.

This issue is critical because the primary reason for the existing challenges faced, existing impacts, and failure to meet organizational requirements is the lack of awareness of the process flow along with required input information knowledge among stakeholders, as discussed in subsection 4.2.2. Therefore, addressing this unawareness is essential and will significantly facilitate the adoption of a new process flow, as emphasized by the participants and is evident from below statement by P[21]:

> ***"Everyone involved in the process flow must know SAP ERP functionalities to adapt the any new process flow"***- P[21]

The importance of necessary technological skills of SAP ERP highlighted by P[21] is supported by García-Sánchez et al. (2018); H. O. Awa et al. (2017), who emphasized that the possession of technological skills by an organization's stakeholders is crucial for strengthening technological knowledge and exploring new results. García-Sánchez et al. (2018) further highlights that these skills are particularly important in high-tech firms engaged in reverse logistics (RL) processes, which involve continuous innovation and the incorporation of new technologies in asset recovery. Additionally, García-Sánchez et al. (2018) points out that technological skills are essential for facilitating collaborative communication among supply chain members through the significant and timely exchange of information.

As per García-Sánchez et al. (2018); H. O. Awa et al. (2017) beyond tangible assets, technology competence also encompasses intangible human resources. Since technological skills and know-how enhance tangible assets and are harder for competitors to copy and difficult to imitate, they may provide innovators with a competitive edge García-Sánchez et al. (2018); H. O. Awa et al. (2017).

IS System Familiarity and Accessibility

P[7], P[8], P[11], P[12] and P[16] reflect a high level of familiarity and acceptance of SAP among the stakeholders, which is crucial for the adoption of any new modifications or extensions to the system to act as a standardized flow. This is evident from the following statement of P[12]:

> *"SAP ERP is integral to our daily operations as all material planners frequently interact with it. It's central to our workflows, which is beneficial. MN registration also occurs within SAP, linking it directly to our current practices. Therefore, I believe integrating it further into our processes represents a strong and direct connection to our existing way of working"*- P[12]

The above statement from P[12] states that frequent interaction of material planners with SAP ERP indicates a high level of engagement and familiarity with the system. This familiarity can lead to increased efficiency and productivity, as stakeholders are comfortable navigating the system and utilizing its features to complete their tasks.

The participants further express positive user experience and are willing to adopt the ERP SAP, which is evident from the following statements:

> *"Stakeholders are already working in SAP for various other administrative activities, so they can adopt the new process in the faster way"*-P[7]

> *"SAP is a nice tool to use for standardization as if the criticality indicators is used which will allow the help operators and material handlers to first process the urgent ones"*-P[9]

> *"I think it's always better to have it really in SAP so that it can be accessed by everyone"*- P[5]

> *"I have been using SAP for a long time and am familiar with most of its functionalities, so it will be easier for me to adapt to the new process"*- P[11]

The statements from P[7], P[9], P[5] and P[11] showcase the familiarity and accessibility of ERP SAP by all the relevant involved stakeholders depicting that this system familiarity and accessibility supports the objective of having a IS ERP based standardized process flow.

User Centric Design Flow

The participants emphasized that for an IS to be adopted as a standard process, its optimization, customization capabilities, and integration with other tools are crucial. Additionally, the changes made to adopt the IS should be user-friendly and less complex, which will enhance the stakeholders' ease of adaptability. This is pointed out P[9] and P[21] as follows:

> *"The new process flow should be straightforward and easy to follow, balancing ease of adaptation with improved effectiveness over the existing one."*- P[9]

> *"The proposed process using IS should have a simpler SAP interface, reducing the number of functions and clicks required, making it more user-friendly and efficient for everyone* - P[21]

The statements from P[9] and P[21] highlight the importance of user centric design in adoption of an IS based process flow. This shows that more the design is user friendly and user centric, more it is susceptible for faster adoption by the stakeholders.

Therefore, technological skills, familiarity, and accessibility towards IS, and user-centric designing of the new process flow are the human-related factors that play a crucial role in IS-based process adoption.

The analysis and findings in sub-themes of IS System Familiarity and Accessibility and User Centric Design Flow are aligned with arguments placed by Park (2018). Park (2018) states that when users are well-adapted to the task process and have less difficulty using the ERP system, the ERP can improve organizational management performance, decision-making, and task completion through information exchange between departments. Successful ERP implementation requires adapting to both business and task changes.

The findings of the sub-theme User Centric Design Flow confirm the technical complexity of the TOE framework, as stated by Pan & Jang (2008); H. O. Awa et al. (2017), which indicates that higher ERP complexity requires greater adaptation efforts and can increase the risk of adoption.

Therefore, along with robuts IT infrastructure and maturity, the role of human factors is equally important for adoption of an IS based process flow.

Conducting a Pilot Testing

P[10] highlighted conducting Pilot testing to evaluate the user acceptance of the selected IS proposed standard process flow:

> ***"I also think that conducting a user acceptance test in a pilot environment is necessary. This allows departments to provide feedback and ensure the system meets their needs and if necessary train them."***- P[10]

The statement from P[10] highlights the importance of user acceptance testing through pilot testing as a crucial step in selecting the appropriate IS. The stakeholders from multiple departments involved in the testing process provide valuable feedback. This feedback is essential for identifying issues, making adjustments, and ensuring the system is user-friendly and effective. This further emphasizes that the output of the pilot testing can also showcase the necessary training to be provided to the stakeholders. This aligns with the concept of viability analysis, which helps managers make better decisions by detecting opportunities and threats of new technologies and adjusting processes and services accordingly as proposed by Saghafian et al. (2021). Conducting pilot testing of the new technology to uncover potential future barriers before its full implementation is a key solution mentioned in the viability analysis. This emphasizes the critical role of pilot testing in identifying issues and making necessary adjustments to ensure successful implementation and system effectiveness (Saghafian et al., 2021).

4.2.11 Role of Process Owner

P[6], P[7], P[9], and P[11] highlighted the need for the process owner to manage the urgent defects flow to control the process flow by monitoring the performance and providing guidelines about the roles and responsibilities of involved stakeholders. This is evident from below statement of P[7]:

> ***"There is a need for process owner for urgent defects flow responsible for monitoring the process flow and giving guidelines about roles and responsibilities in the flow"***- P[7]

The necessity of process owner highlighted by P[7] is aligned to Trkman (2010) who defines a Process Owner who reviews business process performance and is responsible for its continuous improvement. They are responsible for defining the business process, setting performance metrics, and continually optimizing the process to improve efficiency and effectiveness. They are responsible for the training of the stakeholders involved in the process (Trkman, 2010).

P[1], the BPO of the RL team stated that due to the way urgent defects flow requests are being managed and their impact on the overall business operations, the RL team has taken ownership of the urgent defect process from the moment an MN is generated and triggered as an urgent defect, it can be asserted that the RL team acts as a champion or emerging influencer within the urgent defects process flow. As as defined

> ***"When urgent defect repair requests are raised, the requesters often panic due to a lack of process flow information and guidelines. They want the part to be shipped as soon as possible. Thus, now the RL team has decided to own up the process right from the moment MN is generated to have better control of the process."***- P[1]

The above statement from P[1] is aligned with the discussion and analysis in the themes and sub-themes mentioned in subsection 4.2.2, subsection 4.2.3, subsection 4.2.5.

4.2.12 Role of Process Champion

P[21] and P[7] addressed the need to define a single point of contact who will act as the process champion within the RL department, whose contact information can be communicated during change management adoption and communication to all the stakeholders. This will allow the stakeholders to have a single point of contact, minimizing confusion and ensuring that all inquiries and feedback are directed appropriately. Such a centralized communication strategy streamlines the flow of information, enhances clarity, and facilitates the efficient resolution of issues during the implementation of new processes.

> *"Whenever a new process flow is adopted, it is the responsibility of the process champion to communicate this to all the stakeholders involved in the process"*- P[7]

P[7] highlights the role of process champion which is aligned with C.-P. Lee & Shim (2007), who defines a process champion as a member of the management team who sees an idea's potential benefits to the company and provides resources and authority to support innovation during its conception and execution. The role of process champion further extends to overcoming any resistance while adopting new technologies and processes (C.-P. Lee & Shim, 2007). Therefore, the existence of a champion is a significant factor in the successful adoption and implementation of IS (C.-P. Lee & Shim, 2007).

4.2.13 Necessary Resources Availability and Management

Participant P[10] mentioned the importance of IT resources along with their availability in terms of the development team, budget, and lead time of development.

> *"IT resources are invariably scarce and expensive. Setting up a new process that requires IT support can be quite costly because of the extensive hours needed. To get top management support it is needed to thus balance the gains of adopting the new process against the IT resources cost. If the new proposed process is critical, the resources will be prioritized "*- P[10]

The statement from P[10] highlights that top management support is critical for securing the limited IT resources required for implementing new process flows. Top management typically allocates these resources based on the perceived criticality of proposed process changes. This aligns with R. Huscroft et al. (2013), who states that proper resource allocation by top management is essential for operational success. However, organizational resources are limited and constrained, making it impossible to fully support all processes. Therefore, top management must make decisions based on institutional pressures to meet goals and maintain the organization's strategic direction.

This perspective expands on the findings of Saghafian et al. (2021), which investigated how organizations reconfigure resources across various ongoing projects without addressing the critical role of top management in prioritizing IT resource allocation based on strategic needs. This extension emphasizes the strategic decision-making process within organizations and offers a more nuanced understanding of resource management dynamics in technologically driven environments.

4.2.14 Role and Importance of Change Management in Technology Adoption and Process Standardization

The participants highlighted the importance of effective change management communication in the adoption of new process flows and technology. They also pointed out that being informed about the existing processes for communication and information sharing in managing urgent defects is crucial for success. The lack of communication therefore contributed to the process unawareness issues discussed in subsection 4.2.2, underscoring the need for improved dissemination of change management information.

Change Management Communication and Strategy

The participants P[5], P[7], P[9], P[11], P[8], P[12], P[18], and P[21] point out that change management about the adoption of IS based process flow should be communicated very strategically.

- Stakeholder Mapping

  P[8] stresses the importance of stakeholder mapping during change management communication:

  > *"From my experience, we've seen that processes rolled out without involving all departments can lead to failure due to the fast-paced and large environment. It's crucial to involve all the right stakeholders and ensure that every department is aligned and agrees on the new process. Understanding the role of each department and gaining their consensus on future procedures is essential for effective implementation"*-P[8]

The statement from P[8] indicates the importance of involving all the necessary departments and stakeholders in the organization as the size of the organization is large and involves multiple divisions, as it only takes one department to be left out for the change management for the adoption of a new process flow to fail. To complement this, it is equally crucial that each department is fully aware of this and agrees to follow the newly updated process flow. An important point highlighted is providing clarity of roles and responsibilities of each department as it is lacking in the current process flow.

This analysis in change management highlights the necessity to address the change to all the relevant stakeholders involved in the process flow. Thus, this makes it crucial to identify all the related and involved stakeholders in the process flow. The stakeholder mapping based on the process documentation studied and the various stakeholders identified by the participants during the interviews along with their identified responsibilities is shown in Appendix A. As the roles and responsibilities of stakeholders involved are not clear, stakeholder mapping is necessary. This is in line with García-Sánchez et al. (2018) which stresses the importance of studying the influence of stakeholders on the performance of RL practices and processes. Stakeholder mapping provides the responsibilities of the people involved, their connection to each other, and who can influence the adoption Butt (2020).

- Change Management Enforcement

  Participant P[3] pointed out that it is necessary to involve the top management to enforce change management in an organization and get support from other cross-functional departments:

  > ***"There is a need for management support for performing change management because, without it, support from other departments will also be less."***- P[3]

  The statement from P[3] about the role of top management during change management supports the analysis by Bellantuono et al. (2021), which states that top management commitment and support for driving the change is critical for effective change management adoption. This analysis also aligns with the findings of H. O. Awa et al. (2017), which emphasizes that top management support is critical during the implementation of new systems. According to H. O. Awa et al. (2017), substantial changes in organizational structure, stakeholders' roles, job relations, control mechanisms, and work processes necessitate robust management backing to ensure successful adoption and integration.

- Top Down Management Approach

  P[9] complements the statement of P[3] about the role of Top Management in change management enforcement. Furthermore, P[9] highlights a top-down strategy of change management, wherein change management starts with its introduction to the managerial level and then it cascades down, ensuring that those who lead teams are well-prepared to guide their members:

  > ***"The change management first should be communicated to the managers of the stakeholders who are directly involved and then to them as the managers are therefore aware of the change so that those stakeholders can adapt the process"***- P[9]

  The statement from P[9] points out that it is crucial that the Managers who are direct supervisors of the stakeholders who request the urgent defects are presented with this change management and they are aligned and committed to carrying this change by communicating about this to the department managers and then the department can be sure that this change is implemented.

- Proactive Change Management and Engagement:

  P[1], P[3], P[5], P[8] and P[18] addressed that change management is a proactive engagement process.

  > ***"We should communicate a clear timeline for the new process implementation, ensuring stakeholders are aware and adequately trained beforehand "*** - P[10]

  > ***"The new process flow needs to be written down in the work instructions and similar documents like SLAs. Additionally, those work instructions and training need to be rolled out towards older departments that are involved"***- P[3]

> ***"Prepare a presentation for business process model pointing the key difference in the new process flow against the old showcasing the activities that are needed to perform in ERP SAP"***- P[5]

> ***"It's crucial to ensure that new processes are presented effectively across all departments. Simply sending an email may not be sufficient. Facilitating meetings, proper training, setting expectations like SLAs, communication protocols, response times, and updating documentation are essential for successful change management. This ensures everyone is aware and can adapt to changes, preventing any oversight that might cause people to forget crucial updates"***- P[8]

> ***"Make sure the documentation for new process flow in the form of a BPMN is available and accessible for everyone "***- P[18]

The above statements of P[1], P[3], P[5], P[8], and P[18], emphasize that for change management to have a real impact it has to go beyond passive methods like sending emails conveying the change management to having in-person meetings, showcasing presentations, and providing necessary formalization in the form of documentation about the change and work instruction ensuring that the documentation is accessible to everyone, and direct dialogues facilitated by process owners and stakeholders. The documentation should include work instructions about what are tasks to be performed by the stakeholders and how they are different from the existing way of working, roles, and responsibilities of each stakeholder, SLAs, communication protocols, and guidelines for operational alignment. Furthermore, a due date for the change to the usage of the new process flow should be communicated with sufficient time for training and adoption to be available for stakeholders. These findings corroborate the observations noted by Park (2018), highlighting that change management through communication within a project team, and various activities across the organization allows stakeholders involved to use the information and make decisions more efficiently.

- Training and Educating the stakeholders

  P[5], P[9], P[12] and P[21] indicated the need to provide training sessions to the stakeholders involved whenever a new process or technology is to be adopted so that proper knowledge is conveyed to them and everyone involved is known the aware of the process flow.

  > ***"Ensuring that everyone is trained and possesses the necessary knowledge is the main challenge. It's crucial to make sure that everyone has the same information and the same level of proficiency with SAP. This uniformity in knowledge and information is essential while ERP SAP is adopted"***- P[21]

  P[21] identifies a key challenge in ensuring that all stakeholders involved are equally trained and informed. This is critical in the context of adopting an ERP system for urgent flow, where consistent knowledge across the team is essential for smooth operations. The need for uniform training underscores the importance of comprehensive education programs and ongoing support mechanisms to ensure all team members are at the same competency level, thereby reducing errors and inefficiencies. P[5], P[9] and P[12] agree with P[21].

  The emphasis on training and knowledge uniformity within the organization, as highlighted in P[21] and other participants, directly corresponds to the assertions made by Gunasekaran & Ngai (2004). The successful adoption of systems like SAP hinges significantly on the comprehensive education and training of all employees involved. This necessity resonates with Gunasekaran & Ngai (2004) perspective that education and training are critical elements of any change management process within an organization. Without the uniform dissemination of knowledge and training, merely introducing advanced technologies is insufficient to enhance organizational competitiveness.

  Moreover, as Gunasekaran & Ngai (2004) notes, the cooperation of stakeholders at all levels is essential. This cooperation can only be achieved when stakeholders are not only informed but are also competent and comfortable with the new technologies and processes. This alignment ensures that the technological transitions contribute positively to the organization's strategic objectives rather than creating disruptions or resistance. This also aligns with Park (2018), who states that the goal of proper change management is to ensure no resistance from the stakeholders.

P[13] stated along with training on how the changes for ERP SAP functionalities, the base knowledge of correct input data to be filled in MN in ERP SAP should also be taken into consideration.

P[1], P[2], and P[4], the RL team members emphasize that with all the automation capabilities of ERP SAP along with all the necessary training and documentation available to the stakeholders who request urgent defects, the priority deliveries which is most of the times used unless specified for an emergency can be met and the part can be shipped to the supplier within 2 days further depending on the geographical location of the supplier.

The participants P[5], P[7], P[8], P[9], P[10], P[11], P[12], and [13] pointed out that 2 days also the expected period they consider and aim for the defective parts to reach the supplier which further is connected to their supply and demand planning for near future.

Effectively change management thus involves conveying the cumulative advantages of IS adoption, as highlighted in subsection 4.2.7, along with all necessary formalization documentation, as outlined in subsection 4.2.3, to stakeholders can facilitate the adoption of an IS-based standardized process flow for managing high-impact issues like urgent defects to all the stakeholders involved.

This answers the sub-research three: *What are the potential benefits and impacts of adopting an IS system-based standard process flow for managing high-impact issues in reverse logistics for high-tech companies?*

Participation of key stakeholders in technology adoption

P[1] mentioned the importance of involving the stakeholders from the very beginning of the process of change management which will help them better adapt to the change.

> ***"We need to start discussing change management at the very beginning by involving everyone required, this helps in faster adaption"***-P[1]

P[1] also highlights that it is important to convey the change management implementation date to the stakeholders.

P[7] stresses that before the change management occurs it is important that change is recognized and validated by all the responsible and involved stakeholders.

> ***"The new process must be finalized, agreed and validated before the change management occurs by everyone involved"***- P[7]

P[5] mentioned the role of participation of key stakeholders in the change management process flow by providing a platform for them to voice their opinions, to be acknowledged, and to contribute to the betterment of the process flow.

> ***"When introducing a new way of working that significantly impacts daily routines, I strongly recommend providing updates face-to-face. Visiting team meetings to explain the changes ensures that everyone understands their roles and has the opportunity to ask questions and give feedback on the change proposed. "***-P[5]

This is aligned to Saghafian et al. (2021) as they specify that Communicating about a technology allows key actors to share their opinions and contribute to improving the process, leading to increased participation. Participation aims to empower end users and key actors, increasing engagement and commitment (Saghafian et al., 2021). Long-term benefits include improved problem-solving and faster, cost-effective adoption (Saghafian et al., 2021).

The change management communication and strategy thus covers all the pain points suffered by the stakeholders including the availability of process documents in the form of formalization necessary, training and education, participation of all stakeholders to address their grievances, and opportunities to make improvements.

4.2.15 Resistance for Adoption and Strategies to Overcome it

P[21] mentioned that while a new process is to be adopted, there can be challenges from stakeholders in the form of resistance to change.

> *" During process change adoption there is always a challenge of resistance to change. In the current process, it's quite easy to just send an email saying, 'Hey, can you please process this urgent defect?' But when processes become formalized and move into an integrated system like SAP ERP, this casual approach changes, which can meet with resistance from those accustomed to the old ways." "*- P[21]

P[21] said the change from the existing email way of communication and notification to the usage of ERP SAP might be perceived as cumbersome by some stakeholders who will resist the change and stick to the old ways of process flow. **Therefore, the critical role of change management in the form of "Proactive Change Management and Engagement" and "Training and Education" comes into play to overcome this resistance.** This is aligned with Pan & Jang (2008) who pointed out that in their research about significant stakeholders, resistance while adopting ERP systems due to its complexity. Thus, the Technology Selection and Technology SenseMaking themes are vital for this along with the role played by change management strategies.

P[9] proposes a strategy to overcome resistance which involves highlighting the pain points that the new process is trying to resolve:

> *"The best way to overcome resistance by stakeholders is by presenting the benefits of the new to be standardized process flow of ERP adoption and how it makes their work easier"*- P[9]

The statement from P[9] is aligned with Bellantuono et al. (2021), which highlights that stakeholder's resistance to change or adopting a new process flow can lead to failure of the change management adoption. **Resistance to change often stems from a lack of understanding of why change is necessary and the benefits it will bring to their workplace Bellantuono et al. (2021); Saghafian et al. (2021).**

P[7] supports P[9] strategy and points out that the benefits of the new process flow outweigh the resistance and the process flow will adopted by the stakeholders.

> *"I believe the new process flow based on IS of SAP ERP will be welcomed within the organization. After all, it promises to be far superior to the cumbersome mix of Excel files and endless email chains we used to rely on to get things done"*- P[7]

P[7] highlights that the transition to more integrated tools like SAP-based processes indicates an effort to reduce reliance on inefficient methods (like manual Excel file management and extensive email chains). **This compatibility with current organizational needs and the practicality of new processes enhance their acceptance. By moving to a more streamlined process, the organization aims to reduce the complexity associated with manual processes. This simplification can lead to better task-technology congruence, where the technology and process fit well with the operational demands and reduce the cognitive and administrative burden on stakeholders which in this case is chasing people for getting updates and manual activities involved.**

P[5] however, presented a contrasting opinion stating that the existing process flow worked efficiently when they used it:

> *"I've used the urgent defect process a few times and didn't face any specific challenges. The urgent defect Excel form was quite easy to fill out and didn't require a lot of data, which was convenient. After filling it out, I forwarded it to Reverse Logistics for handling and the part reached the supplier on time. However, the challenge lies in the process's visibility. Once I send the urgent defect form to Reverse Logistics, I'm unsure if it will be received with the right urgency or what steps will follow."*- P[5]

P[5] states the success story of the existing process they used for urgent defects shipment. The reason for the success might be that prerequisites for the urgent defect repair processing needed for the RL team to perform their administrative activities were fulfilled, indicating that the existing process does not fail all the time.

This is aligned with Saghafian et al. (2021) who states that the new solutions may face resistance due to the success of existing ones. The literature refers to this thinking pattern as the competency trap Saghafian et al. (2021). Thus, the evident role of change management is to reduce stakeholder resistance while increasing their acceptance.

Technology sensemaking also acts a factor which acts an enabler to overcome resistance and adopt the technology. The technology sensemaking in subsection 4.2.8 showed that stakeholders understood the necessity to change and move to the new process flow. This is a proactive strategy for understanding the stakeholder adoption.

4.2.16 Impact of External Environmental Factors

The participants identified several external environmental factors that are responsible for the adoption of IS-based standard process flow. They are as follows:

Environmental Considerations

P[1] emphasizes the need to standardize the process flow for handling urgent defect repairs with proper SLAs, as frequent emergency requests disrupt routine operations, require significant resources, and have environmental impacts, despite senior management's advice against such practices. P[1] presents the following dilemma while managing urgent defects delivery and sustainability goals:

> *"We have the normal, priority, and emergency deliveries. The priority is usually 2 days while for emergencies it is supposed to be completed in a few hours. So the requester of the urgent defect repair always asks for an emergency delivery. When we get an emergency delivery request, we often find ourselves having to drop everything and focus solely on that. Handling emergencies requires much more coordination and resources, such as arranging additional truck shipments, which not only disrupts our routine flow but also has environmental repercussions.* [redacted] *"*- P[1]

The statement from P[1] highlights the external factor that impacts the adoption of a standardized process flow for managing urgent defects has environmental considerations. The RL team encounters both operational and environmental challenges when handling urgent defect repairs classified as emergencies. This situation highlights the extensive resource allocation and coordination required to expedite these emergency requests, disrupting routine operations and heightening environmental concerns due to increased transportation demands. Moreover, the categorization of shipments related to urgent defect repair requests as emergencies illustrates a complex dilemma: the need to balance adhering to senior management directive to minimize emergency requests for environmental reasons against the operational imperative to fulfill urgent demands. This tension underscores the broader challenge of reconciling operational efficiency with environmental sustainability objectives.

Thus, the importance of having a standardized process flow with clear SLAs comes into the picture to solve the dilemma. These SLAs would provide a guideline for managing the urgency levels of defect repairs, helping to balance the operational necessity of quick turnarounds with the environmental implications of expedited shipping. By defining specific timelines and procedures for each category of urgency as normal, priority, and emergency, the SLAs ensure that all stakeholders, including the RL team and requesters, have aligned expectations. The SLAs thus act as an inter-dependent factor that strikes the balance between operational effectiveness and sustainability goals. This alignment aids in mitigating unnecessary emergency requests, thereby reducing environmental impact and aligning with the ASML's sustainability and circular economy goals as mentioned in section 1.3.

Continuous Improvement through Customer Feedback

P[16] stated that at times not only for the internal streamlining of operations, process standardization takes place, but also due to the feedback and demand of the customer also influences the adoption of standardization:

> *"Last year, we received valuable customer feedback regarding some of our systems. In response to this feedback, we identified opportunities for improvement in the urgent defect flow process."*- P[16]

This quote from P[16], responsible for the quality function of the systems manufactured at ASML highlights the influence of external factors, specifically customer feedback which the organization values from the scope of continuous improvement, on the organization's decision to adopt and standardize processes for handling urgent defects. The customer's role acts as a critical external driver that prompts the company to enhance its operational frameworks to meet quality standards and customer expectations.

Market Demand Volatility

P[9] highlights the challenge of fluctuating demand and supply, suggesting that by standardizing and accelerating the urgent defect and repair processes, the company can better meet peak demands and improve supply chain responsiveness:

> ***"I think what we see a lot in the industry is significant volatility in demand and supply, particularly from our customer side, which challenges our ability to meet peak demands by ramping up our supply chain. To fill this gap, we could leverage the urgent defect process or the general repair process. By standardizing these processes and ensuring a quicker flow, we can respond more effectively than before."*** - P[9]

Thus, this statement from P[9] states that the fluctuating demands from customers create pressure on the supply chain of ASML to be more responsive and flexible. This variability necessitates the adoption of standardized processes to handle urgent defects and repairs, ensuring the supply chain can swiftly adapt to peak demands. Standardizing the urgent defect and repair processes aims to streamline operations, reduce response times, and improve overall efficiency. By reducing the response time, the defective part can be shipped more quickly to the supplier, enabling a faster return. This accelerates the repair or replacement process, minimizing production downtime and mitigating the impact on AMSL's manufacturing operations. This standard process adaptation is driven by the need to mitigate the impacts of demand unpredictability and enhance the capability to meet customer requirements promptly. This aligns with Yeh et al. (2015) assertion that organizations must employ information technology to enhance efficiency and promptly respond to global market demands. The statement from P[9] confirms the emphasis given by Yeh et al. (2015) on the importance of efficient process management and responsiveness, facilitated by robust information systems, to meet customer requirements and improve operational performance in a dynamic market environment.

Industry Leadership and Benchmarking

P[9] conveys that if the high-impact process of urgent defects is standardized effectively, reducing repair commitments, ASML can set a benchmark in the high-tech industry. This success will attract attention from other organizations, prompting them to seek insights into how ASML addressed major demand gaps and achieved such efficiency:

> ***"If we manage to standardize the urgent defect process effectively, significantly reducing our overall repair outstanding commitments, other high-tech organizations will undoubtedly look to us, as we are the industry leaders."***-P[9]

The statement from P[9] points out the potential of setting industry benchmarks by standardizing the process flow.

As ASML is a leader in the EUV lithography technology, its ability to effectively standardize critical processes sets a benchmark within the high-tech industry. This leadership role attracts attention from other organizations looking to follow the successful practices. Standardizing processes for managing repairs allows ASML to better address and fill demand gaps. This capability not only improves operational efficiency but also raises questions among peers and competitors about how such accomplishments are possible, reinforcing the ASML's position as an industry innovator and leader. This connects with the literature by H. O. Awa et al. (2017), which posits that industry players often mimic the actions of leaders to remain competitive. ASML's leadership in EUV lithography technology and its effective standardization of critical processes set a benchmark within the high-tech industry, prompting other organizations to emulate these successful practices. This mimetic behavior ensures that other enterprises tailor their programs to align with contemporary practices established by leaders like ASML, thereby reinforcing ASML's position as an industry innovator and leader.

4.2.17 Exemptions and Risk Management for Technology Adoption and Process Standardization

P[10] indicated the disadvantage of standardization is that it can result in rigid processes that do not account for unique or unexpected situations as mentioned in subsection 4.2.8.

P[10] highlights stakeholders still require personal interaction and alignment with stakeholders from cross-functional departments who understand their specific issues. There are times when, despite standard procedures, someone must address issues in a more hands-on manner. This emphasizes the importance of lateral relations.

P[2], the BPO for RL-related administrative activities considers the downside of standardization and indicates that the traditional channels of communication will be available.

> ***"If there are any specific issues, stakeholders can reach out to us through the traditional channels of communication"***-P[2]

P[1] also addresses this concern but states that traditional communication channels are available if the stakeholders need support regarding certain specific non-routine transactions.

Furthermore, any risks due to the use of IS ERP-based process flow can be countered by the availability of effective and knowledgeable technical support.

4.3 Conclusion

This chapter described the correct process flow in steps to be followed by stakeholders for managing high-impact issues, based on document analysis and qualitative analysis of the RL team. This was followed by qualitative analysis and interpretation of the findings based on the existing academic literature.

The key findings highlighted the need for business process standardization due to the impact on overall business performance as the existing processes deployed are not error-free and are subject to failure. The gap stems from the lack of a standardized process, and the use of manual methods, leading stakeholders to handle issues in their ways. Additionally, the correct steps in the form of formalization (documentation of processes, procedures, roles, and responsibilities with the urgent defect process flow) are not known to the stakeholders.

Due to the high uncertainty and equivocality of the process, formalization alone is insufficient for standardizing the process flow, adopting an information system is essential along with the availability of lateral relations. The use of IS along with formalization as a standardized process flow will increase the performance of RL considering the process is highly routine and transactional. The standard process flow should be developed using an information system and adopted across the organization. Effective change management is crucial for the smooth adoption of this new process flow. After adoption, periodic reviews of the process flow are necessary for continuous improvement.

Although standardization and formalization can hinder flexibility and agility in highly non-transactional and unique business processes, this is not the case for processes dealing with high-impact issues that are highly transactional and routine. In such instances, standardization increases the agility of the business processes that handle these issues.

IT infrastructure and maturity alone can ensure the successful adoption of IS-based process flow and needs the consideration of human factors. Stakeholders use their sensemaking to understand the need to adopt a technology, and only when their sensemaking aligns with the organization's goals and perceived benefits, will they fully support and engage in the adoption process.

Change Management communication and strategy is highly essential to achieve a successful transition towards the new process flow along with the active role and participation of the top management and the stakeholders.

Environmental factors have an influence on the adoption of new process flows and should not be neglected.

Overall, by the development and adoption of an IS-based standardized process flow for managing high-impact issues in RL, the existing challenges and their impacts can be overcome. This will eventually lead to a faster response from the RL team by meeting the goal of the urgent defect process flow. This will ensure operational continuity and contribute to the vision and goals of the organization.

The findings reveal various critical factors and inter-dependencies essential for the development and effective adoption of the standardized process flow which are described in the form of a framework in chapter 5 in Table 5.1. These findings were supported and analyzed in conjunction with the literature review.

Chapter-5: Information Systems Based Process Standardization Framework (IS-PSF)

This chapter introduces the framework designed to address the challenges of managing high-impact issues like urgent defects in the RL processes of high-tech companies through the development and adoption of standardized process flows based on Information Systems (IS). Drawing on insights from the TOE framework, Business Process Standardization and Change Management theories, and models, the framework was refined through in-depth qualitative analysis of semi-structured interviews. It identifies critical factors and inter-dependencies that influence the successful development and successful adoption and functionality of IS-based process flow, aiming to enhance operational efficiency, provide transparency and scalability, reduce response times, and improve overall organizational business performance. This approach not only remedies current inefficiencies but also offers a scalable and adaptable solution, positioning high-tech companies to thrive amid evolving business demands.

5.1 IS-based standardized process flow Framework

Framework for the development and adoption of an IS-based standardized process serves as a roadmap for guiding the design, implementation, and evaluation of factors that influence the successful integration of information systems and elements of business process standardization within high-tech companies. This framework ensures that the key contexts, such as technological, organizational, and environmental factors, are systematically considered and addressed throughout the various phases of process standardization and change management. The process standardization phase is shown in the foundation phase as seen in Table 5.1 while the change management phases are shown as Assessment and Alignment Phase, Implementation and Transition Phase, Optimization and Integration Phase as seen in Table 5.1.

By providing a structured approach, helps high-tech organizations effectively manage change, enhance RL operational efficiency, and achieve sustainable improvements in their processes. The framework is shown in Table 5.1. The framework is named as Information Systems Based Process Standardization Framework (IS-PSF).

The framework is developed based on insights gained from various change management models as discussed in subsection 2.1.9, the design science for information system research by Hevner et al. (2004), the learnings from literature review conducted on RL, information systems, the contingent theory of OIPT by Zelt et al. (2019), Business Process Management and Standardization by Goel et al. (2023); Butt (2020), the TOE framework by Tornatzky & Fleischer (1990); Baker (2012); H. O. Awa et al. (2017) and the results of the single case study qualitative analysis.

Foudation Phase

The foundation phase is the initial phase which lays the groundwork for the entire standardization process by establishing the baseline and need for change.

1. **Business Need of Standardization:** The process owner and the process champion should identify and articulate the strategic reasons behind the need to standardize the business processes. The business need should be presented in the form of a business case to the top management by providing its impact, cost-benefit analysis, and requirements in terms of IT resources, lead time for development, and implementation timeline. This is necessary to get the Top management's commitment, and support for guidance and change enforcement. This is aligned with Hevner et al. (2004) and with the need or urgency of change as proposed by the change management models explained in subsection 2.1.9 and in Appendix C.

Context	Assessment & Alignment Phase	Implementation & Transition Phase	Optimization & Integration Phase
Foundation Phase	Business Need of Standardization		
	Existing Process Flow Identification		
	Analysis of Existing Process Flow		
	Identfication of master/ standard process flow		
	Proposing the master/ standard process flow		
Technological Factors	IT Infrastructure Maturity	Technical Support Availability	Periodic Reviews
	Technological Challenges & Expectations		
	Technology SenseMaking		
	Appropriate IS Selection		
	Process Control Procedures		
	Role of Human Factors		
	Availability of IT Support		
	Nature of Business Processes		
	System integration & interoperability		
Organizational Factors	Vision & Goal Alignment	Change Management Communication & Strategy	Resistance & Strategies to Overcome them
	Organizational Strategy	Establishment of Communication Protocols	Risk Management
	KPIs & SLAs	Clarity of Roles & Responsibilities	
	Organizational Culture & Structure	Top Management Participation	
	Leadership Support & Sponsorship	Training & Capability Building	
	Cross-functional Collaboration & Alignment	Participation of Stakeholders	
	Stakeholder Mapping	Agreement & Validation of Process	
	Identification/ Define Process Owner & Champion		
Environmental Factors	Customer Feedback based improvements		Setting Industry Standards
	Environmental Compliance		
	Market Volatility		

Table 5.1: Information Systems Based Process Standardization Framework (IS-PSF)

2. **Existing Process Flows Identification:** Document the current existing processes flow chart across the organization relevant to the business need for standardization. This can be done through

business process models like BPMN. Accurate information, connections, sequence flows, and decision points are essential for the existing process flow chart. The goal is of the existing process model that facilitates communication among stakeholders (Butt, 2020). This is aligned with stages 1 and 2 of BPS as per Goel et al. (2023).

3. **Analysis of Existing Process Flows:** Conduct a detailed evaluation by subdividing each of the variants of the main process into sub-processes and steps. The evaluation should include stakeholder maps, organizational charts, procedures and Work instructions, SLAs, KPIs related to each process, and any other relevant document (Butt, 2020) This will help identify inefficiencies, uniqueness, and areas needing improvement within existing non-standardized variants to develop a master process flow. The analysis should capture every element of each process including its role and the stakeholder accountable for that. This is aligned with stage 2 of BPS as per Goel et al. (2023). The inter-dependencies of each step or business sub-processes should be evaluated critically (Butt, 2020).
4. **Identification of the Master/ Standardized process flow:** The Master/ Standard process combines the best features of each of the existing processes/ sub-processes while minimizing their inefficiencies. The improvements to be made are thenidentified and added to the process to act as a Master/ Standard process flow. This is aligned with stages 3 and 4 of BPS as per Goel et al. (2023). **As per Goel et al. (2023), the literature rarely discusses the decision-making process that leads to the derivation of the master/standard process. Therefore, it is during this phase that the different TOE factors influencing the development and adoption of an IS as a standard process flow should be identified and studied and are described in the "Assessment and Alignment Phase" of the framework.**
5. **Proposing the master/ standard process flow:** The process flow can only be deployed and adopted after it is validated and approved by all the stakeholders when the set conditions are met. The set conditions will vary from organization to organization. The set conditions include proper documentation and change management communication to all the involved stakeholders. This is aligned with stages 6 and 7 of BPS as per Goel et al. (2023).

The framework identifies various factors from the technological, organizational, and environmental contexts impacting the development and effective adoption of an IS-based standard process flow in three phases of change management namely- The assessment and alignment phase, the Implementation and Transition Phase, Optimization and Integration Phase.

1. **The Assessment and Alignment Phase:** This phase focuses on evaluating the current state of processes and determining the need for change, aligning organizational goals and vision with proposed changes, and ensuring that all stakeholders understand and agree on the need to adopt a new IS-based standard process flow. This phase is the state of organizations before the technology adoption of IS for the development of IS-based process standardization. This phase's key activities include conducting an in-depth assessment of existing workflows, determining the scope and objectives of the change, and planning the initial steps to align resources and strategies across the technological, organizational, and environmental contexts for the development of IS-based standard process flow.
2. **Implementation and Transition Phase:** This phase focuses on carrying out the planned changes and focus on adoption of the proposed process flow. It entails creating and implementing the new IS-based process flow, providing user training and support, and managing the transition towards the standardized process. This phase is critical as it involves organizational interventions and human-technology interaction necessary for streamlined adoption to take place. This phase plays a vital role in overcoming resistance to change by ensuring effective communication with internal stakeholders, training the stakeholders involved, providing them a platform to present their impressions, and tracking implementation progress. It entails continuous engagement with stakeholders to ensure a smooth transition.
3. **Optimization and Integration Phase:** This phase focuses on refining and fully integrating the new process flow into the organization. This phase can be called the outcome of the IS technology adoption process flow. It entails ongoing monitoring and evaluation to ensure that the new system is functioning properly, overcoming any resistance, and providing the anticipated benefits. Continuous improvements are made based on feedback and performance metrics. This phase's key activities include conducting periodic reviews, optimizing processes for greater efficiency, and ensuring that the system remains aligned with organizational goals while adapting to new requirements and challenges.

Each phase of the IS-PSF is analyzed from the TOE framework context, the framework ensures a holistic approach to adopting and standardizing an IS-based process flow, addressing all critical factors that influence successful implementation and integration as seen in Table 5.1 and is explained as follows:

- **IT infrastructure Maturity:** Before implementing an IS-like ERP system as a standard process flow, high-tech companies must ensure the presence of significant IT infrastructure. The robust IT infrastructure allows for seamless connectivity via information platforms and networks, encouraging collaboration between internal departments and external partners to facilitate technology adoption. High-tech companies should also assess their IT maturity, which refers to the level of development and readiness of an organization's information technology capabilities to develop and adopt any new technology or customize and optimize the existing technology.
- **Technological Challenges and Expectations:** It is crucial to understand what are the technological challenges and drawbacks of the existing technologies used and what are their impacts on the business process performance. Identifying stakeholder's expectations for these technologies helps to assess how well current technologies and processes that use them meet organizational needs and the potential areas for improvement. This understanding can help guide the selection of new technology for IS to better align with organizational goals and needs to increase overall efficiency and performance.
- **Technology SenseMaking:** Sensemaking is an important factor in determining the adoption of IS within organizations. It promotes a better understanding and relatability of new technologies, influencing stakeholder's beliefs and attitudes towards their adoption in the form of willingness. Sensemaking is important for how stakeholder perceive and use technology because it allows them to rationalize their experiences and interpret new meanings to adopt it. As a result, considering sensemaking processes during the early stages of IS adoption is critical to ensuring that the technology aligns with stakeholder expectations and organizational needs, thereby fostering successful implementation and integration.
- **Appropriate IS Selection:** It is critical to choose an appropriate IS not only from a technological but also from an organizational standpoint. It should be technologically superior to existing technologies used, integrate with existing organizational systems and interfaces, and be compatible with the organization's IT infrastructure and capable of automation that aids in meeting the process performance goals and eventually benefits the organization. While selecting the IS, the role of human factors from the perspective of the stakeholders who will be using the IS as well as the technical support necessary should be considered.
- **Process Control Procedures:** Data errors in information flow pose a risk due to their potential negative consequences. Risk can take the form of financial costs or operational inefficiencies. Therefore, control procedures are important because they are intended to prevent or detect errors in information flow. It is important to identify the data errors in the existing flow based on the challenges faced by the stakeholders in the existing flow. Each control procedure detects and corrects specific error types at task locations. Placing control procedures at different task locations in an IS and the process can reduce errors and risks. Therefore, stakeholders should identify these control procedures based on the variety of errors and place them in IS.
- **Role of Human Factors:** Human factors are equally important to consider when selecting appropriate technology along with IT infrastructure Maturity, especially for information systems. These factors ensure that the technology not only meets the organization's technical and operational needs, but also aligns with the capabilities, expectations, and requirements of its users based on the technological system familiarity, user-friendly design, and technological skills necessary. Conducting a pilot test to identify the drawbacks or shortcomings of the selected IS can serve as a user acceptance testing mechanism to better understand human factors. This will also showcase the training that needs to be provided for the stakeholders along with the drawbacks of the proposed technology to be adopted (IS in this case).
- **Availability of IT support:** The role of IT support is an essential factor in ensuring successful digitalization and IS adoption. IT department employees must understand the current IT developments, resolve organizational-level issues, and provide stakeholders with integrated solutions for their problems. IT support is essential for understanding the requirements for developing the IS to act as s standard flow as soon as the process flow is adopted, the IT support is capable of resolving any concerns raised by the stakeholders. If internal IT support is insufficient, external IT support in the form of professional network groups, consultants, or technical support teams can be looked upon for technology adoption and implementation.

- **Nature of Business Processes:** Understanding the nature of business processes that need standardization is important because it aids in understanding process differences, which necessitate different management strategies. This understanding enables managers to select appropriate management mechanisms, such as documentation, standardization, use of Information Systems, use of performance monitoring, or lateral relations, to enhance process performance. It also helps to adapt to uncertainty and equivocality, with more flexible strategies for high-uncertainty processes and standardized approaches for low-uncertainty ones. Proper process management improves performance outcomes, facilitates decision-making, and ensures resource efficiency.
- **System Integration & Interoperability:** The IS selected should pose integration and interoperability capabilities with the existing systems or interfaces used by the stakeholders. This reduces the efforts of the stakeholders to learn and adapt new interfaces or systems along with adopting the IS.
- **Vision & Goal Alignment:** Top management should establish business process goals and ensure that they are consistent with the organization's overall vision. To accomplish this, top management must communicate the goals throughout the organization, allowing stakeholders to align with them. In addition, top management should support this alignment by providing the necessary resources, such as IT and financial resources.
- **Organizational Strategy:** The organization should take a proactive strategic approach to determining the need for changes in business processes based on performance. Instead of reacting to process failures, the organization should monitor performance indicators and plan for necessary adjustments. The organizational strategy should align with the business process goals, and top management should ensure that it is consistent with the organization's overall strategic goals.
- **KPIs and SLAs:** The key performance indicators (KPIs) monitor the performance of business processes and provide a platform for the top management and stakeholders to make informed decisions about the current and future state of operations by highlighting areas in need of improvement. They serve as a tool for proactive strategic change management. Service level agreements (SLAs) establish clear performance standards and expectations for service delivery, ensuring both service providers (RL team in this case) and clients (the urgent defect repair or analysis requesters in this case) are aligned. The SLAs include information on service description, service and support hours, service availability, performance, dependability, change management protocols, billing procedures, and service reviews. Miscommunications and service delivery discrepancies can be overcome by the availability of SLA, which has a direct impact on process flow efficiency and effectiveness.
- **Organizational Culture and Structure:**Organizational culture plays a pivotal role in the successful development and adoption of IS as part of standardized process flows. The alignment of an organization's cultural values with the proposed IS is critical, differences here can lead to adoption failures. Managers must be acutely aware of and sensitive to the various cultural dynamics within their organization, utilizing tools such as metaphorical analysis to deeply comprehend and navigate the organizational context. This understanding aids in tailoring the IS implementation in a way that complements the existing cultural landscape, increasing the likelihood of successful integration and effectiveness. An organic organizational structure promotes open communication among stakeholders and encourages stakeholder engagement, communication, and knowledge sharing. These factors are critical during technology adoption, increasing acceptance and speeding up the process. Therefore, organizations should promote and establish an organic organizational structure.
- **Leadership Support & Sponsorship:** Leadership support, particularly from top management, is essential for providing the resources needed to change and standardize process flows using an IS. These resources include the budget for the development and implementation of the IT change, IT staff and external assistance if required for development and support, stakeholder training, and the enforcement of change management. The It resources are scarce and expensive and therefore, securing this support typically requires presenting a compelling business case to top management that demonstrates the return on investment and the positive impacts of the proposed changes.
- **Cross-functional Collaboration & Alignment :** Successful coordination in RL requires collaboration and alignment between stakeholders across different departments. All the stakeholders should have a shared goal and vision and be aligned with them. Formalization in the form of agreed process flow, SLAs, roles, and responsibilities play a vital role in this.
- **Stakeholder Mapping:** Stakeholder mapping is vital as it identifies the relevant stakeholders involved in the process flow. It provides an opportunity to understand their roles and responsibilities, as well as their influence on the adoption process, including their expectations and challenges

faced. This understanding offers insights into each stakeholder's way of working, which affects the nature of business processes in terms of uncertainty and equivocality. Additionally, mapping relevant stakeholders ensures efficient change management, as failing to address a stakeholder and their needs can lead to the failure of the entire change management initiative.

- **Identification / Defining Process Owner and Champion:** The process owner is responsible for monitoring the performance of a particular business process, and thus responsible for addressing any failures in it. The process champion identifies opportunities focused on the benefits of the organization and plays a crucial role from its identification to development. The role of the process owner and process champion is very vital in change management, as they are the point of contact, ensuring all the stakeholders are aligned with the change management.
- **Customer Feedback based improvements:** customer feedback are valuable external driving force for the adoption of IS-based process standardization. It enables organizations to identify pain points, improve customer satisfaction, drive innovation, reduce risks, improve operational efficiency, and align strategic goals with customer needs. Organizations can use customer feedback to develop more responsive, efficient, and customer-centric processes.
- **Environmental Compliance:** RL aims to ensure value recovery from defective or End of Life products. The urgent defective parts although need a fast transportation service in the form of special transportation are needed. However, while doing so, care should be taken for the impact, the transportation has on sustainability and overall environmental compliance. There should be strict guidelines in the form of SLAs for when to use emergency transportation and its impact.
- **Market Volatility:** To meet the fluctuating demands set by the customer and to overcome the challenges of the existing process flow, standardization of the urgent defect process flow can streamline operations, reduce response times, and enhance overall efficiency. This ensures quicker turnaround times for defect repairs, minimizes production downtime, and improves the capability to handle high-demand periods effectively. Furthermore, to counter the competitive threats, organizations need to evolve, adapt, and standardize their business processes using IS.
- **Technical Support Availability:** The availability of technical support is critical to facilitating the adoption of a process flow using IS systems during the transition toward the new process flow. It demonstrates the top management's commitment to the initiative's success while also providing important social support. This support aids in the resolution of various adoption challenges, resulting in smoother integration and increased user confidence. Stakeholders can navigate the proposed IS system-based flow more effectively with strong technical support, resolving issues more quickly and faster adoption.
- **Change Management Communication & Strategy:** The most crucial aspects of adopting and implementing IS-based standardized process flows in high-tech companies are effective change management communication and strategies to ensure smooth deployment. The change management should involve clear communication about the change and highlight the key changes, and potential benefits that can be achieved. There should be clear relevant documentation available in the form of business process models, KPIs, SLAs, communication protocols, and stakeholder mapping which are accessible to all the relevant stakeholders identified during the stakeholder mapping about the change management. The change management should be conducted through in-person meetings with visual presentations for ease of understanding of the stakeholders. Change management should establish a clear and sufficient timeline for the implementation of the new process, ensuring stakeholders are aware and adequately trained before the go-live date. This timeline allows stakeholders to prepare and ensures a smooth transition to the new process.
- **Establishment of Communication Protocols:** The change management documentation should outline communication protocols, specifying which stakeholders to contact for specific issues or feedback. By detailing these protocols and the interoperability capabilities of the IS-based process flow, stakeholders can effectively communicate about SLA breaches or any specific concerns. This ensures that relevant parties are promptly informed and involved, enhancing coordination and resolution of issues.
- **Clarity of Roles & Responsibilities:** The change management documentation should clearly define the roles and responsibilities of each stakeholder and department involved in the process flow, resolving any ambiguity. This clarity ensures that everyone understands their tasks and accountability, facilitating smoother implementation and collaboration throughout the change process.

- **Top Management Participation:** Top management should set meaningful goals and communicate the organization's priorities to stakeholders. The goals should be aligned with the vision of the organization. Furthermore, the strategies of the business process should further be aligned with the vision and set goals. This ensures that all the stakeholders develop business processes that align with these goals and vision. Top management not only provides the necessary resources for IS adoption but also plays a crucial role in enforcing change management. Their endorsement and communication ensure that stakeholders understand the importance of the change, encouraging its serious adoption and implementation and also resolving any conflicts that might arise during change adoption.
- **Training & Capability building:** Stakeholders must be trained to ensure they all possess the necessary knowledge about change management. Feedback from pilot testing, technology sense-making, and stakeholder opinions guide the development of targeted training programs. The process champion must ensure that all stakeholders receive the required training for IS adoption, understand the changes in the existing flow, and are fully aware of the process flow, roles, and responsibilities.
- **Participation of Stakeholders:** By offering a platform for stakeholders to raise concerns and provide feedback about the process flow and tasks performed in the IS, the organization facilitates a smoother transition from old ways of working. This platform ensures that stakeholders' voices are heard, promoting engagement and continuous improvement in the new system. Additionally, technical support plays a crucial role in addressing issues promptly and aiding stakeholders during this transition.
- **Agreement & Validation of process:** The new process flow based on IS adoption should be agreed upon and validated by all stakeholders involved. Upon validation, agreement, and the availability of all necessary documentation and training, the process can be adopted and implemented.
- **Periodic Reviews:** The performance of the process flow should be reviewed periodically based on the timelines established in the SLAs and agreements between stakeholders. This periodic review should be conducted by the process owner, ensuring that the process remains aligned with the agreed-upon performance metrics and objectives. Regular assessments allow for the identification of any deviations or areas for improvement, fostering continuous improvement and enhancement of the IS and the process flow. This systematic approach ensures that all stakeholders remain informed and engaged, promoting accountability and sustained efficiency.
- **Resistance & Strategies to Overcome them:** Adopting a new process using IS can encounter resistance from stakeholders. Effective change management strategies, including addressing and resolving stakeholder concerns, are essential to overcoming this resistance. Clearly communicating the benefits of the new process and how it simplifies workflows will help gain stakeholder buy-in and facilitate smoother adoption.
- **Risk Management:** Over-standardization can lead to rigidity, resulting in a potential loss of flexibility and human interaction for unique situations that arise in the process. While the urgent defect process is generally routine and benefits from IS-based standardization, unique situations require a different approach. To address these, it is essential to establish lateral relations and maintain traditional communication channels. These measures ensure effective interaction and communication between stakeholders for handling non-routine events. The role of effective technical support is further crucial if any issues arise in the IS-based process flow by mitigating them.
- **Setting Industry standards:** Setting an industry standard is critical for IS standardization because it distinguishes a company as an industry leader and benchmark. Effective standardization of critical processes draws attention from other organizations looking to replicate successful practices. This mimetic behavior ensures that competitors and peers align their programs with established standards, thereby increasing overall industry efficiency and innovation. Setting these standards not only improves a company's operational efficiency but also reinforces its position as an industry innovator and leader, resulting in the widespread adoption of best practices and a competitive advantage.

The objective of these factors spread across the different phases along with the foundation phase is to provide an overview of the insights that need to be considered when developing and effective adoption of an IS-based standard process flow. These factors and inter-dependencies studied will act as a robust foundation for improving the RL operations for managing the high-impact issues focused

on overcoming the challenges posed by existing process flows by meeting operational efficiency, customer satisfaction, and overall business performance.

The framework and the factors and inter-dependencies illustrated answer the second research question: *What are the technological, organizational, and environmental factors and inter-dependencies that influence the adoption and implementation of IS-based standardized process flow for managing high-impact issues in reverse logistics for high-tech companies?*

Chapter-6: Validation of the Information Systems Based Process Standardization Framework (IS-PSF)

In the chapter 4, several perspectives emerged regarding the factors and inter-dependencies that influence the adoption of IS-based process flow. The chapter 5 showcases the IS-PSF framework that consists of business process standardization based on the factors across various stages of change management, focusing on the adoption of an IS-based process flow. **This chapter focuses on validating the framework and assessing its practicality in developing an IS-based standard process flow. It aims to understand the extent to which the IS-PSF framework will benefit the high-tech company ASML and its stakeholders from the adoption of this standardized process to overcome the challenges and negative impacts caused by the unavailability of a standardized process flow. The goal is to mitigate challenges arising from the lack of a standardized process flow for managing high-impact issues in RL. The validation was done using a semi-structured interview protocol. The framework validation further aims to identify which factors and inter-dependencies can be adopted by other high-tech companies for generalization purposes.** The list of participants for the validation is mentioned in subsection 3.2.5.

6.1 Feedback from Validation

The expert participants, E[1] and E[2] agreed on the foundation phase of the framework as shown in Table 5.1, which involves understanding the business need for process standardization and the various phases of change management for the smooth transition and complete adoption to take place.

E[2] stated that it is important to access the IT infrastructure of the organization as it acts as the foundation for IS adoption:

> ***"IT infrastructure analysis is a must, not only for a big company like ASML but for any other company, as the smooth functioning of the standardized process using ERP adoption depends on it"***- E[2]

The statement from E[2] highlights the vital role of IT infrastructure analysis in ensuring the smooth functioning and successful standardization of processes through ERP adoption. By prioritizing IT infrastructure evaluation, organizations can lay a strong foundation for their ERP initiatives, leading to improved efficiency, consistency, and overall operational success. E[2] also emphasizes that the IT infrastructure for ERP systems should be analyzed not only in large and advanced high-tech organizations but also in other organizations. This statement from E[2] further suggests that the framework offers some generalizability, indicating that it can be utilized not only by technologically advanced and IT infrastructure-matured companies like ASML but also by other companies that may not have such established resources.

Both participants, E[1] and E[2] mentioned that the framework provides valuable insights into the factors that organizations need to consider when developing and adopting a standardized process flow. They concurred with most of the factors and inter-dependencies in the framework and suggested additional factors that could serve as an overview and guide for developing an IS-based standard process flow.

E[1] emphasized that the most critical factor influencing the adoption of IS of ERP-like systems when transitioning from a traditional email and sharing of Excel files ways of communication to ERP systems is having the right technological skills among stakeholders to manage change adoption and how they respond to the proposed change:

> ***"The most important factor is whether people have the right skill set for this change and how they will react to it, which in turn determines if there will be any resistance during adoption."***- E[1]

The statement from E[1] highlights the crucial role played by the factors of technology sensemaking and the role of human factors in adoption and also determining whether there will be any resistance from the stakeholders.

E[1] and E[2] both agreed that the change management communication and strategy is crucial while adopting to avoid any resistance from stakeholders in the future. The expert participants further stated that effective change management, with the stated strategies and communication in the framework, will facilitate the smooth adoption of the process flow to be standardized. This approach will ultimately overcome existing challenges and achieve the goal of expediting the flow of defective parts to suppliers.

Participants E[1] and E[2] agreed on the critical role of top management in providing necessary resources, including IT resources, financial support, training, and enforcement of change management, based on a valid business case.

E[1] further mentioned that it is important to monitor the performance of the process flow:

> ***"What ultimately matters is the performance management of the process flow to evaluate how well it was implemented."***- E[1]

This statement from E[1] emphasizes the need to monitor the performance of the implemented process flow to measure its success. Thus, the role of the process owner is crucial along with the periodic reviews of the process flow.

From a generalization perspective, both E[1] and E[2] agreed that the factors of IT Infrastructure Maturity, Technology Sensemaking, the role of Human Factors, Top Management Support, and effective Change Management strategies are critical. These factors are crucial for high-tech companies to consider when developing and adopting IS-based standardized process flow for managing high-impact issues.

6.1.1 Feedback for the scope of Improvement

The participants E[1] and E[2] offered valuable feedback for further research, which is discussed in detail in the following sections.

Process Maturity:

E[1] pointed out that when studying the nature of business processes, the factor of maturity of business processes should also be studied:

> ***"While assessing the nature of the business process, the maturity of a business process can also be studied to determine if it is a new or well-established process."***- E[1]

This statement from E[1] highlights the importance of understanding the maturity level of a business process. Assessing the maturity helps in determining whether the process is new and evolving or well-established and stable. This understanding can influence how the process is managed, standardized, and improved. This is aligned with the Business Process Maturity Model developed by Object Management Group (2008) which categorizes business processes into 5 categories namely initial, managed, standardized, predictable, and innovating. A detailed explanation of these is available in Appendix D. Each process area includes a set of integrated best practices that define what actions should be taken to support, create, or maintain the organizational state characteristic of each level (Object Management Group, 2008).

Identification of Key Priority Factors for IS Adoption-based Process Standardization

E[2] highlighted that organizations often face limitations in financial resources, IT resources, and time. Therefore, it is crucial to prioritize the key factors for adoption:

> ***"As an organization, we are always limited by time, resources, and budget. With around 40 criteria in the framework to assess, it's crucial to know which ones to prioritize for implementation given the available resources."***- E[2]

The statement from E[2] emphasizes the constraints organizations typically face, such as limited time, resources, and budget. Given these limitations, it highlights the need to prioritize among the many factors identified for implementation in the IS-PSP framework. With around 40 criteria to assess, the goal is to determine which ones should be given priority to make the most effective use of the available resources.

This approach ensures that the most critical and impactful factors are addressed first, optimizing the adoption and implementation process within the given constraints.

E[2] further explains that not all high-tech organizations have the size and advanced capabilities of ASML. As a result, the smaller or less advanced organizations must focus on identifying the minimum key factors required for successful adoption. By focusing on these critical elements, they can effectively allocate their limited resources and address the most important aspects, increasing their chances of successful implementation and integration of new systems.

E[2] suggests that further research could be conducted to rank the factors influencing IS adoption, distinguishing between those that are essential and those that are beneficial but not critical:

> ***"Further research can be conducted to rank these factors influencing IS adoption, distinguishing between essential elements and beneficial but non-critical ones to help organizations prioritize efforts and resources."***- E[2]

E[2] by emphasizing the ranking of the factors indicates that this would help organizations prioritize their efforts and resources, focusing first on the most crucial elements that ensure successful implementation. By understanding which factors are necessary and which are advantageous but optional, companies can make more informed decisions, ultimately enhancing their strategic planning and operational efficiency.

6.2 Conclusion

This chapter presents the validation of the framework designed to identify the factors and interdependencies influencing the development and successful adoption of an IS-based process flow. The validation process involved thorough examination and feedback from participants, which confirmed the framework's effectiveness in developing and effective adoption of the IS-based process flow. By incorporating the insights and feedback provided, the framework can guide the implementation and adoption of a standardized process flow. This approach addresses the challenges and risks associated with the existing process flows. The validation highlighted that the framework not only helps in identifying critical factors but also provides a structured approach to mitigate inefficiencies and enhance operational performance. Consequently, organizations can achieve a more efficient and reliable process for managing high-impact issues, particularly in reverse logistics.

The validation provided insights into several key factors and interdependencies from the framework that can be generalized to other high-tech companies beyond ASML. These include IT infrastructure maturity, the roles of technology sensemaking, the importance of human factors, top management support, and effective change management strategies.

In conclusion, the validation of the framework underscores the importance of adopting strategic measures to enhance the development and effective adoption of IS-based standardized process flows for managing high-impact issues in RL, especially for high-tech companies. The various key strategies include robust change management with clear communication and approach illustrating the benefits of adoption, understanding stakeholder concerns and resolving them, stakeholder mapping, comprehensive training for stakeholders, overcoming resistance, continuous monitoring and performance evaluation, and ensuring top management support. By employing these strategies, organizations can overcome existing challenges, streamline operations, and improve the overall efficiency and reliability of their reverse logistics processes.

This answers the sub-research question 4: *What strategies can be employed to enhance the adoption and effective implementation of IS-based standardized process flow for managing high-impact issues in reverse logistics for high-tech companies?*

Chapter-7: Discussion and Conclusion

The objective of this thesis is to identify the various factors and inter-dependencies that influence the adoption of an Information Systems-based standardized process flow for information sharing and communication in managing high-impact issues in Reverse Logistics. To identify these factors and inter-dependencies, the IS-PSF framework has been developed. This framework provides an overview of the various factors and inter-dependencies that must be considered when developing a standardized process using Information Systems. To achieve this, interviews were conducted and analyzed to gain insights into the implications of the framework. Additionally, a validation phase involved further interviews to assess the framework's generalizability and improve its adoption. The findings have been comprehensively presented in the Validation chapter as seen in subsection 3.2.5.

The reflection of the research findings is put forward in the form of answering the sub-research questions which can be seen in the following section 7.1. This is followed by the theoretical and practical implications of the research in section 7.2 and section 7.3. The relevance of the thesis research with the Management of Technology program is discussed in section 7.4 followed by limitations of the research and recommendations for future research in section 7.5. The research thesis concludes by addressing the main research question in the section referred to as section 7.6, providing a comprehensive summary and final insights.

7.1 Answers for the research questions

SQ: 1 What are the challenges in managing high-impact issues in reverse logistics for high-tech companies?

Answer: High-tech companies face several significant challenges in managing high-impact issues in RL. The case study of ASML showcased that the existing process flows used conflict with the urgent defects process's end goal of expediting shipments of high-impact issues to suppliers for operational continuity. These challenges primarily stem from fragmented communication and information-sharing approaches, which lead to complex and highly dependent manual information flows involving various internal stakeholders. This fragmentation results in a lack of visibility for incoming defect requests, transparency, and traceability, making the processes highly unscalable. Additionally, there is a notable lack of process awareness among stakeholders, attributed to the absence of formalized and standardized processes and the need for IS adoption. Managing successful coordination in RL requires collaboration, visibility, and trust among various entities in the reverse chain, similar to the forward chain. Effective communication is crucial for vertical coordination, ensuring the timely sharing of strategic and tactical data among stakeholders. Poor information flow and inconsistent operations are significant barriers, further complicated by the absence of robust IS tailored to accommodate the reverse flow of parts. Formalization and standardization of processes, including clear documentation of rules, procedures, and responsibilities, are critical for efficient RL operations. The lack of formalization can lead to inefficiencies, reduced transparency, and diminished trust in the process, causing delays and disruptions. Standardized performance metrics aligned with RL goals are essential for monitoring process efficiency and effectiveness. Furthermore, the lack of suitable technological advancements and reliance on manual data recording introduces risks such as errors, omissions, and inconsistencies, leading to monetary costs, and operational inefficiencies. The absence of efficient information support for authorizing, tracking, and managing returns exacerbates these challenges.

SQ: 2 What are the technological, organizational, and environmental factors and inter-dependencies that influence the adoption and implementation of IS-based standardized process flow for managing high-impact issues in reverse logistics for high-tech companies?

Answer: The framework developed based on the qualitative analysis based on the case study conducted at ASML and the literature review identifies the technological, organizational, and environmental factors and inter-dependencies that influence the adoption and implementation of IS-based standardized process flow for managing high-impact issues in reverse logistics for high-tech companies. The technological factors in this research assess the attributes of both current and prospective information systems (IS) technologies to be selected and adopted, focusing on three main aspects. First, Technological Complexity evaluates the challenges stakeholders might face when adapting to the new system, considering their existing technological skills, familiarity, and the system's ease of use. This also examines how the stakeholders who will be using the technology make sense of the technology to be adopted, and how the advantages of the technology to be adopted by the users are perceived. Second, Technological Compatibility looks into how well the proposed IS integrates with the existing IT infrastructure, scrutinizing its maturity, customization capabilities, optimization, and automation features, as well as its capacity for integration and interoperability with current technologies. Lastly, Technical Know-How addresses the availability and accessibility of technical IT support and the requisite skills needed for effective implementation and troubleshooting during the IS adoption phase. These factors are critical for gauging the organization's readiness to adopt new technologies and ensuring that such adoption enhances operational efficiency and strategic positioning. **Therefore, while a robust and mature IT infrastructure is crucial, human factors such as stakeholders' technological skills, technology sensemaking, the selection of relevant technology based on its relative advantages, familiarity with the technology, ease of adoption, and the availability of technical support are equally essential. These elements determine the suitability of a technology for adoption into the process flow.**

The organizational factors scrutinize several key dimensions within the high-tech organizations. These include the alignment of the organizational vision and goals with its business processes, and examining how strategic objectives are integrated into daily operations. It also assesses the organizational culture and structure, particularly how these influence the adoption of new technologies. **Top management support is evaluated for its role in fostering a favorable environment for technological change. Additionally, the analysis covers the extent of cross-collaboration among stakeholders, which is crucial for seamless integration and operational success. Lastly, the study considers the change management strategies implemented to facilitate the smooth adoption of the new system and to mitigate any resistance from the stakeholders. These factors collectively help to understand the organizational readiness and the systemic impact of introducing IS as a process flow.**

The external environmental factors examine key areas like customer feedback and requirements, industry standards, competition, and regulatory requirements. This helps in understanding the external pressures that influence the organization's decision to adopt an IS-based process and change its existing processes.

SQ: 3 What are the potential benefits and impacts of adopting an IS system-based standard process flow for managing high-impact issues in reverse logistics for high-tech companies?

Answer: The case study conducted at ASML revealed that the most significant benefit of adopting an IS-based standardized process flow for managing high-impact issues in RL is the creation of a centralized, reliable, and error-free source of information, embodied by the IS based on an ERP system. This centralization will enhance visibility, transparency, traceability, and accountability, enabling the RL team to respond more quickly and efficiently. Additionally, it will provide requesters with real-time progress reports, creating a win-win situation for all stakeholders involved. **The integration of an IS system, coupled with the standardization achieved through formalized procedures, rules, guidelines, and performance monitoring, ensures that the developed and adopted standardized process flow is both effective and efficient in meeting its objectives.** This approach not only aligns with the immediate goals of managing urgent defects but also supports the broader organizational goals by improving overall process efficiency by ensuring operational continuity without any performance impact on the organization. This further aligns with the necessity of a standardized process flow to expedited delivery of unserviceable and incorrectly received parts for the high-tech company's operational continuity as discussed in the literature. **Furthermore, standardization cannot be achieved by formalization alone but with the integration of relevant information systems and supported by lateral relations and best practices when needed.** This is therefore not only limited to ASML but also to other high-tech companies who want to achieve process standardization through IS adoption for managing high-impact issues.

SQ: 4 What strategies can be employed to enhance the adoption and effective adoption of IS-based standardized process flow for managing high-impact issues in reverse logistics for high-tech companies?

Answer: The IS-PSF framework provides the factors and inter-dependencies that need to be considered when developing the IS-based standardized process flow. **To achieve the smooth adoption of this IS-based standardized process flow for managing high-impact issues in reverse logistics for high-tech companies, several key strategies can be employed. Firstly, robust change management is essential, which involves clear communication and well-defined strategies to guide stakeholders through the transition and overcome any resistance from the stakeholders. Comprehensive training programs are crucial to ensure that all stakeholders are adequately prepared to handle the new processes. Continuous monitoring and performance evaluation should be implemented to track progress, identify areas for improvement, and ensure that the new processes are functioning as intended.** Additionally, strong top management support is vital to drive the initiative and allocate the necessary resources. By employing these strategies, organizations can overcome existing challenges, streamline operations, and significantly improve the efficiency and reliability of their reverse logistics processes. This holistic approach not only enhances the immediate management of high-impact issues but also contributes to the overall operational excellence and competitive edge of the organization.

7.2 Theoretical Implications

The theoretical implications of this research are profound and offer significant contributions to business process standardization in the emerging and highly uncertain field of RL and eventually to the overall supply chain management of high-tech companies. Firstly, the research by developing a conceptual framework named IS-PSF, as outlined in Table 5.1 identifies crucial factors and inter-dependencies that play a vital role in designing and implementing standardized business processes using information systems. It contributes significantly to the field of RL and SCM by addressing how the lack of standardized processes affects organizational business performance on different levels (financially, business growth, product quality) while managing high-impact and critical issues, such as expediting unserviceable and incorrectly received parts to suppliers for appropriate actions. By providing strategic insights for overcoming these challenges, the framework offers high-tech companies in the RL field a method to enhance operational efficiency and performance. This research not only outlines pathways for improved process standardization but also highlights the importance of the role of IS and change management in enhancing business efficacy within complex logistical operations.

The research through the novel IS-PSF framework provides a structured approach to understanding the necessity of the use of IS for developing a standard process flow within high-tech companies and its smooth adoption across the organization. It expands on the Technology-Organization-Environment (TOE) framework by integrating it with the concept of business process management and standardization with the change management phases and offering a dynamic view of technology-based standardized process development and adoption across the organization. By incorporating multiple dimensions (technological, organizational, external) across different phases of change management and by developing the concepts of process management, the research introduces a nuanced methodology that can be used by other researchers to study complex IS implementations in high-tech companies.

The research confirms the Zelt et al. (2019) findings that formalization in the form of documentation alone is insufficient for achieving standardization and it requires the support of IS and the establishment of lateral relationships based on the nature of business processes that need standardization and performance enhancement. This study underscores the importance of adopting a proactive strategy and the continuous monitoring of business processes through well-defined KPIs, established procedures, and comprehensive stakeholder mapping as highlighted by Price & Chahal (2006); J. Hall et al. (2013); Genchev et al. (2011); García-Sánchez et al. (2018). It also emphasizes and confirms the findings by Gunasekaran & Ngai (2004); Butt (2020); Mesgari & Okoli (2019); Saghafian et al. (2021) about the critical roles of top management's involvement, technology sensemaking, and the consideration of human factors in selecting and implementing an appropriate information system by studying the organizational IT infrastructure and maturity. Effective communication strategies for change management are vital. Together, these elements provide a framework for developing, standardizing, and adopting an information system-driven process flow across the organization. This approach helps to mitigate the adverse effects previously experienced before its implementation, enhancing overall organizational efficiency and adaptability. The research also states that external environmental factors also impact the need for standardized process flow adoption. This research underscores the importance of process standardization not only for organizational benefits but also for sustainability, environmental considerations, and setting industry standards.

This research further provides a unique methodology based on the IS research framework by Hevner et al. (2004) for the development of the framework and how this is connected with the TOE framework defined by Tornatzky & Fleischer (1990) along with business process management and standardization theories defined by Wüllenweber et al. (2009); Münstermann et al. (2010); Romero et al. (2015); Goel et al. (2023) and role of Information Systems for process standardization by Daugherty et al. (2002); Seethamraju & Seethamraju (2009); Wurm & Mendling (2020) used for the study of this research. The recommendations and strategies derived from the research findings contribute to the development of best practices and industry standards, enabling high-tech companies to optimize their reverse logistics operations, improve responsiveness, and enhance customer satisfaction.

7.3 Practical Implications

This research offers a practical guideline and overview for high-tech companies to consider the overview necessary to create, implement, and manage a standardized information system-based process flow. It addresses the challenges of non-standardized information sharing and communication practices, providing a link between theoretical concepts and practical application. This framework improves understanding of process standardization in the highly dynamic field of RL, providing actionable insights to both industry practitioners and academic researchers. It emphasizes the critical importance of timely, accurate, visible, traceable, and centralized information exchange and communication for improved business efficiency and sustainability. The conceptual framework's practical application can guide the development of an IS-based process flow and make it easier to adopt across organizational boundaries. By identifying critical factors and inter-dependencies, the framework provides managers with the knowledge they need to make informed decisions about technology investments (including optimization and customization of existing technologies) and change management strategies, which is critical for navigating rapidly changing technological landscapes and the inherent uncertainties of reverse logistics. This study describes a systematic approach to standardizing business processes, improving process performance through formalization, and integrating information systems and lateral relationships. It provides a comprehensive framework for managers to understand stakeholder perceptions of the usability of new IS implementations, bridging the gap between theoretical research and practical requirements.

7.4 Relevance to Management of Technology (MoT) Study Program

The Management of Technology (MoT) program at TU Delft emphasizes the effective management of technological resources and processes within organizations to enhance performance, foster innovation, and bolster competitive advantages. Aligned with this focus, this thesis investigates the adoption and extension of advanced Information Systems, such as ERP, specifically within the specialized and emerging field of Reverse Logistics in Supply Chain Management for high-tech companies. The research proposes the effective use of Information Systems to replace the traditional and inefficient methods of information sharing and communication owing to their risky and unreliable nature by addressing their impact on the business operations of high-tech companies. The research aims to boost sustainability and operational efficiency across organizational supply chains. It presents a comprehensive analysis of the factors and inter-dependencies spanning technological, organizational, and external environmental contexts, that influence the adoption of IS as a standardized process flow. This study meticulously examines how these factors impact the performance of Reverse Logistics and, consequently, the overall organizational performance, offering insights that are integral to strategic technology adoption and process standardization. The research categorizes these factors across various stages of change management, focusing on the adoption of an Information System-based process flow. This strategic placement helps in understanding and guiding the implementation phases effectively, ensuring a structured transition toward enhanced system integration.

7.5 Limitations of Research and Recommendations for Future Research

7.5.1 Limitations of the Research

It is important to acknowledge the limitations inherent in this study, as they have implications for interpreting the findings and may provide avenues for future research. Additionally, it is important to note that the primary objective of this study is to identify the factors and inter-dependencies that influence the development and adoption of an IS-based standard process flow. The study does not aim to develop the process flow or test its adoption. Based on the identified factors, inter-dependencies, challenges, and potential benefits, the development of a standardized process involves customization and optimization of the existing IS used by the high-tech company of ASML. This process requires extensive time and effort.

Although the suggested changes in the form of customization and formalization are underway, completing everything (process development, deployment, and user testing) within the limited timeframe of this thesis is challenging. Furthermore, after the suggested customization and optimization of the IS, and the development of formalization in the form of process flows and SLAs necessary, the change management transition for testing the adoption will take additional time and is out of the scope of this research. Therefore, the focus remains on understanding the underlying factors and relationships that impact the successful implementation of such a process flow. The limitations of the research are:

Generalizability of the Framework

The framework in this research study was developed using a qualitative analysis of a single case study at ASML, a high-tech company that focuses on high-impact reverse logistics issues. This approach, while providing detailed insights specific to ASML, has limitations in terms of generalizability. Using a single case study may limit the applicability of the findings to other contexts or industries. Due to ASML's distinct operational characteristics and business environment, the results and developed framework may not fully represent the challenges or be directly applicable to other companies with different operational, organizational, or technological settings. This limitation emphasizes the importance of cautious interpretation when applying the framework to other organizations or expanding the research to include multiple case studies to improve the robustness and transferability of the results. During the validation phase, expert participants provide some form of generalizability by suggesting that the framework could be adopted by other high-tech companies, even those without as advanced an IT infrastructure and technological maturity as ASML. However, complete generalizability will have to be further validated by conducting multiple case studies and also cross-industry studies, as this research was focused on the high-tech industry.

Application of Framework for unique and non-routine process flows

The study emphasizes that the positive impact of standardization through information systems primarily benefits highly transactional and routine processes, which can be effectively systematized to improve efficiency and reduce errors. This advantage, however, becomes a limitation for non-routine or unique processes that require flexibility and adaptability. Such processes frequently necessitate continuous improvement and adaptation, relying on best practices and regular software updates for information systems. The standardized approach may impede the performance of these non-standard, complex processes by imposing rigid structures unsuited to dynamic or innovative tasks. This limitation implies that, while information systems can provide significant benefits in standardized environments, their use in non-routine contexts must be carefully managed to avoid stifling innovation and adaptability.

Effectiveness of the IS-PSF framework

Although experts have validated the framework, only after the IS-based standard process has been implemented can its impact and effectiveness be examined by taking the factors into account. The framework offers a broad overview rather than an in-depth analysis of each component, so its applicability and results in real-world situations may differ. Rather than being a strict blueprint, the framework is meant to be used as a guide and an overview, with flexibility for customization in response to unique organizational, technological, and environmental challenges. Consequently, even though the framework is a useful beginning point, it needs to be further improved and customized during implementation to completely address the particular requirements and circumstances of each organization. This drawback emphasizes the necessity of continual assessment and modification to guarantee the framework's efficacy in enhancing process standardization and IS adoption.

7.5.2 Recommendation for future research

For future research in this context, some of the potential recommendations are as follows:

1. Identifying Core Factors for Successful IS-Based Process Standardization in Organizations: Future research should focus on identifying the critical and fundamental factors from the developed framework that organizations must consider when developing and implementing an IS-based standard process flow. This study could focus on identifying the bare minimum of critical elements required for successful implementation and sustained use of information systems in business process standardization. Such a study would provide valuable guidance to organizations on effectively prioritizing their efforts and resources to maximize the impact of their information systems investments.
2. Process Maturity: During the validation of the IS-PSF framework, experts also stated to incorporate the factor of process maturity by determining if the process that needs to change belongs to initial, managed, standardized, predictable, and innovating categories as defined by Object Management Group (2008). Therefore, studying the factor of process maturity and its impact on standardization and adoption can be further explored.
3. Comparative Studies: Conduct comparative studies that include multiple case studies from various organizations and various fields apart from reverse logistics. This would broaden the findings and provide deeper insights into the similarities and differences in IS adoption challenges and strategies across organizational settings.
4. Cross-Industry Validation: Future research could look into how the developed framework applies to industries other than the high-tech industry. This could aid in understanding the framework's versatility and adaptability in a variety of organizational contexts and technological settings.
5. Longitudinal studies: Future research can focus on conducting longitudinal research to track the evolution of IS adoption and its effects over time. This could shed light on the long-term benefits, challenges, and changes in organizational processes enabled by IS standardization.
6. Categorization of factors as per Triple bottom line framework: The various factors and inter-dependencies identified in the IS-PSF framework as seen in Table 5.1 can be further clustered into key criteria identified in the triple bottom line framework. The triple bottom line framework is discussed in Appendix H. These factors and inter-dependencies can be further clustered into the criteria identified as per the triple bottom line framework. The factors and inter-dependencies can act as the sub-criteria for each of the criteria. This categorization will not only aid in the evaluation of RL performance but also bolster the implementation of the IS-based standard process flow, ensuring a comprehensive assessment of economic, environmental, and social criteria of the factors and inter-dependencies identified in Table 5.1.

7.6 Conclusion

This section aims to explore how high-tech companies can address challenges arising from the lack of standardized processes for managing high-impact issues in RL. It will elucidate how addressing the sub-research questions contributes to answering the main research question, ultimately guiding companies toward effective resolutions and improvements in process management.

- **How can high-tech companies standardize their information-sharing and communication processes to address the challenges and impacts of managing high-impact issues in reverse logistics?**

  Answer:

  The primary challenge in managing high-impact issues, such as urgent defects process flow, for a high-tech company like ASML is the delay in shipping defective parts to suppliers for necessary actions like repair, reconditioning, remanufacturing, or analysis. This delay can severely hamper operational continuity, leading to stoppages in manufacturing operations and adversely affecting ASML's overall business performance.

Similarly, the process flow requirements for expedited delivery of urgent defective parts apply to unserviceable and incorrectly received parts, which also need to be shipped to suppliers promptly. The failure to meet these expedited delivery requirements negatively impacts operational continuity and overall business performance across high-tech companies. Therefore, the challenges faced by ASML in managing urgent defects highlight broader issues relevant to the handling of unserviceable and incorrectly received parts in the high-tech industry.

The inability to meet the goal of ensuring expedited shipment of these parts is due to the challenges arising from the lack of a standardized process flow and reliance on risky, manual, and fragmented communication and information-sharing processes. These challenges were exacerbated by complex coordination and interdependence between different stakeholders, unawareness of the correct procedural steps, inaccurate input data, and lack of formalization. To overcome these challenges, there is a need to develop and adopt a standardized information system-based process flow for managing these high-impact issues.

For this, each sub-research question was thoroughly investigated, and the findings were crucial in developing a comprehensive response. Through rigorous analysis, it was determined that for high-tech companies to develop and standardize their information-sharing and communication process for addressing the challenges and impacts of managing high-impact issues in reverse logistics, a comprehensive approach is needed. This approach must consider technological, organizational, and environmental factors that influence the development and effective adoption of such process flow.

The case study performed at ASML, along with the literature review conducted, revealed the following factors:

Firstly, they need to adopt robust information systems, such as ERP, to centralize data and streamline information flows by providing visibility, transparency, traceability, scalability, and meeting the performance metrics set. Integration capabilities should ensure seamless data flow between existing systems, and effective data control procedures to maintain data integrity and accuracy overcoming any risks. The nature of business processes and process maturity should be further considered when developing and adopting such process flows.

Organizationally, strong leadership from top management is essential to drive the standardization initiative. Planning effective change management by engaging all relevant stakeholders in the planning and implementation process ensures buy-in and support, while comprehensive training programs equip stakeholders with the necessary technological skills to use the new systems effectively.

From an environmental perspective, standardizing processes must align with customer expectations, market volatility, and environmental compliance while setting industry standards. This approach helps the company stay competitive by improving efficiency and customer satisfaction. Additionally, it supports sustainability and environmental initiatives by reducing waste and enhancing resource utilization.

While not all the factors and inter-dependencies identified in the case of ASML apply universally to all high-tech companies, the validation of the IS-PSF framework revealed that certain factors are broadly applicable. These include IT Infrastructure Maturity, the roles of Technology Sensemaking, the importance of Human Factors, Top Management Support, and effective Change Management Strategies. These factors are relevant and beneficial for other high-tech companies as well.

Effective change management strategies are crucial for a smooth transition. Clear communication informs stakeholders about the changes, the reasons behind them, and the expected benefits. A phased implementation approach manages the transition smoothly, addressing any issues as they arise. Continuous monitoring and improvement ensure the new processes meet the desired performance standards.

The benefits of standardization encompass improved efficiency, enhanced visibility and traceability, and better coordination and collaboration. This promotes expedited shipment of the unserviceable and incorrectly received parts to the suppliers thereby allowing cost savings through increased process efficiency and reduced delays. By focusing on these aspects, high-tech companies can overcome existing challenges, streamline operations, and significantly enhance the efficiency and reliability of their reverse logistics processes, ultimately leading to higher organizational business performance.

References

Aberdeen, T. (2013). "Yin, R. K. (2009). Case study research: Design and methods (4th ed.). Thousand Oaks, CA: Sage.". *The Canadian Journal of Action Research*, *14*(1), 69–71. https://doi.org/10.33524/cjar.v14i1.73.

Adaileh, M., & Abu-Alganam, K. (2010). The role of ERP in supply chain integration. *International Journal of Computer Science and Network Security*, *10*(5), 274–279.

Agrawal, S., Singh, R. K., & Murtaza, Q. (2015). A literature review and perspectives in reverse logistics. *Resources, conservation and recycling*, *97*, 76–92.

Agrawal, S., Singh, R. K., & Murtaza, Q. (2016). Triple bottom line performance evaluation of reverse logistics. *Competitiveness Review*, *26*(3), 289–310.

Alarcón, F., Cortés-Pellicer, P., Pérez-Perales, D., & Mengual-Recuerda, A. (2021). A reference model of reverse logistics process for improving sustainability in the supply chain. *Sustainability*, *13*(18), 10383.

Alexwells. (2023, August). *What is reverse logistics & repair?* https://www.vergentproducts.com/what-is-reverse-logistics-repair/.

Álvarez-Gil, M. J., Berrone, P., Husillos, F. J., & Lado, N. (2007). Reverse logistics, stakeholders' influence, organizational slack, and managers' posture. *Journal of business research*, *60*(5), 463–473.

Amini, M., Retzlaff-Roberts, D., & Bienstock, C. C. (2005). Designing a reverse logistics operation for short cycle time repair services. *International Journal of Production Economics*, *96*, 367-380. doi: 10.1016/J.IJPE.2004.05.010

Andersen, T. K. (2016). Beyond acceptance and resistance: a socio-technical approach to the exploration of intergroup differences in ict use and non-use at work. *Systemic practice and action research*, *29*(3), 183–213. doi: https://doi.org/10.1007/s11213-015-9360-5

Ardeshirilajimi, A., & Azadivar, F. (2015). Reverse supply chain plan for remanufacturing commercial returns. *The International Journal of Advanced Manufacturing Technology*, *77*, 1767–1779.

Armitage, A., & Keeble-Allen, D. (2008). Undertaking a structured literature review or structuring a literature review: Tales from the field. In *Proceedings of the 7th european conference on research methodology for business and management studies: Ecrm2008, regent's college, london* (p. 35).

ASML. (2023). *2023 annual report.* https://www.asml.com/en/investors/annual-report/2023#2023-annual-report.

ASML. (2024a). *Circular economy - minimizing waste, maximizing resources.* https://www.asml.com/en/company/sustainability/circular-economy.

ASML. (2024b). *Designing for circularity.* https://www.asml.com/en/news/stories/2022/designing-for-circularity.

ASML. (2024c). *Making euv: from lab to fab.* https://www.asml.com/en/news/stories/2022/making-euv-lab-to-fab.

ASML. (2024h). https://www.asml.com/en/company/about-asml/locations/veldhoven.

ASML Netherlands B.V. (2024a). *Monetary impact.* (Confidential document accessed on May 15, 2024)

ASML Netherlands B.V. (2024b). *Summary of udf requests.* (Confidential document accessed on May 15, 2024)

ASML Netherlands B.V. (2024d). *Response time for urgent defect flow requests resolution by rl team.* (Confidential document accessed on May 15, 2024)

ASML Netherlands B.V. (2024e). *Funnel analysis of resolution time for urgent defect flow requests.* (Confidential document accessed on May 15, 2024)

Awa, H., Baridam, D., & Nwibere, B. (2015). Demographic determinants of e-commerce adoption: A twist by location factors. *Journal of Enterprise Information Management*, *28*(3), 325–346. doi: https://doi.org/10.1108/JEIM-10-2013-0073

Awa, H. O., Uko, J. P., & Ukoha, O. (2017). An empirical study of some critical adoption factors of ERP software. *International Journal of Human–Computer Interaction*, *33*(8), 609–622. doi: https://doi.org/10.1080/10447318.2016.1265828

Awasthi, A., & Chauhan, S. (2012). An rfid integrated quality management system for reverse logistics networks. In *Quality management in reverse logistics: A broad look on quality issues and their interaction with closed-loop supply chains* (pp. 113–129). Springer.

Badenhorst, A. (2016). Prioritising the implementation of practices to overcome operational barriers in reverse logistics. *Journal of Transport and Supply Chain Management*, *10*(1), 1–12.

Bai, X., Krishnan, R., Padman, R., & Wang, H. J. (2013). On risk management with information flows in business processes. *Information Systems Research*, *24*(3), 731–749.

Baker, J. (2012). The technology–organization–environment framework. *Information Systems Theory: Explaining and Predicting Our Digital Society, Vol. 1*, 231–245. doi: https://doi.org/10.1007/978-1-4419-6108-2_12

Barrett, M., Grant, D., & Wailes, N. (2006). *Ict and organizational change: Introduction to the special issue* (Vol. 42) (No. 1). Sage Publications Sage CA: Thousand Oaks, CA. doi: https://doi.org/10.1177/0021886305285299

Bellantuono, N., Nuzzi, A., Pontrandolfo, P., & Scozzi, B. (2021). Digital transformation models for the i4. 0 transition: Lessons from the change management literature. *Sustainability*, *13*(23), 12941. doi: https://doi.org/10.3390/su132312941

Blackburn, J. D., Guide Jr, V. D. R., Souza, G. C., & Van Wassenhove, L. N. (2004). Reverse supply chains for commercial returns. *California management review*, *46*(2), 6–22.

Boronoos, M., Mousazadeh, M., & Torabi, S. A. (2021). A robust mixed flexible-possibilistic programming approach for multi-objective closed-loop green supply chain network design. *Environment, Development and Sustainability*, *23*, 3368–3395.

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative research journal*, *9*(2), 27–40. doi: https://doi.org/10.3316/QRJ0902027

Boykin, R. F. (2001). Enterprise resource planning software: a solution to the return material authorization problem. *Computers in Industry*, *45*(1), 99–109. doi: https://doi.org/10.1016/S0166-3615(01)00083-5

Butt, J. (2020). A conceptual framework to support digital transformation in manufacturing using an integrated business process management approach. *Designs*, *4*(3), 17. doi: https://doi.org/10.3390/designs4030017

Chang, Y.-W. (2020). What drives organizations to switch to cloud ERP systems? the impacts of enablers and inhibitors. *Journal of Enterprise Information Management*, *33*(3), 600–626. doi: https://doi.org/10.1108/JEIM-06-2019-0148

Cheng, J. C., & Ma, L. Y. (2013). A bim-based system for demolition and renovation waste estimation and planning. *Waste management*, *33*(6), 1539–1551. doi: https://doi.org/10.1108/BIJ-08-2018-0238

Coronado Mondragon, A. E., Coronado Mondragon, C. E., Coronado, E. S., et al. (2015). Understanding transferable supply chain lessons and practices to a "high-tech" industry using guidelines from a primary sector industry: A case study in the food industry supply chain. *The Scientific World Journal*, *2015*.

Daugherty, P. J., Myers, M. B., & Richey, R. G. (2002). Information support for reverse logistics: the influence of relationship commitment. *Journal of business logistics*, *23*(1), 85–106. doi: https://doi.org/10.1002/j.2158-1592.2002.tb00017.x

Davenport, T. H. (2005). The coming commoditization of processes. *Harvard business review*, *83*(6), 100–108.

Davenport, T. H., Short, J. E., et al. (1990). The new industrial engineering: information technology and business process redesign.

Doorey, D. J. (2011). The transparent supply chain: From resistance to implementation at nike and levi-strauss. *Journal of business ethics*, *103*, 587–603.

Färber, F., Cha, S. K., Primsch, J., Bornhövd, C., Sigg, S., & Lehner, W. (2012). Sap hana database: data management for modern business applications. *ACM Sigmod Record*, *40*(4), 45–51.

FasterCapital. (2024, Mar). *Standardization in supply chain management: Streamlining operations.* "https://fastercapital.com/content/Standardization-in-Supply-Chain-Management--Streamlining-Operations-update.html.".

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International journal of qualitative methods*, *5*(1), 80–92. doi: https://doi.org/10.1177/160940690600500107

Galbraith, J. (1973). Designing complex organizations. *Reading, Mass.*

García-Sánchez, E., Guerrero-Villegas, J., & Aguilera-Caracuel, J. (2018). How do technological skills improve reverse logistics? the moderating role of top management support in information technology use and innovativeness. *Sustainability*, *11*(1), 58.

Garg, C. P., & Sharma, A. (2020). Sustainable outsourcing partner selection and evaluation using an integrated bwm–vikor framework. *Environment, Development and Sustainability*, *22*(2), 1529–1557.

Genchev, S. E., Glenn Richey, R., & Gabler, C. B. (2011). Evaluating reverse logistics programs: a suggested process formalization. *The International Journal of Logistics Management*, *22*(2), 242–263.

Goel, K., Bandara, W., & Gable, G. (2023). Conceptualizing business process standardization: a review and synthesis. *Schmalenbach Journal of Business Research*, *75*(2), 195–237. doi: https://doi.org/10.1007/s41471-023-00158-y

Goodhue, D. L., Wybo, M. D., & Kirsch, L. J. (1992). The impact of data integration on the costs and benefits of information systems. *MIS quarterly*, 293–311.

Gordon, R. L. (2012, Autumn). Reverse logistics management: Beyond 3.4 defects per million: Quarterly journal. *S.A.M.Advanced Management Journal*, *77*(4), 12-18,59,2. "https://www.proquest.com/scholarly-journals/reverse-logistics-management-beyond-3-4-defects/docview/1287958466/se-2".

Govindan, K., & Hasanagic, M. (2018). A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective. *International Journal of Production Research*, *56*(1-2), 278–311. doi: https://doi.org/10.1080/00207543.2017.1402141

Gunasekaran, A., & Ngai, E. W. (2004). Information systems in supply chain integration and management. *European journal of operational research*, *159*(2), 269–295. doi: https://doi.org/10.1016/j.ejor.2003.08.016

Hart, C. (1998). Doing literature review. *London: Sage.*

Hartline, M. D., Maxham III, J. G., & McKee, D. O. (2000). Corridors of influence in the dissemination of customer-oriented strategy to customer contact service employees. *Journal of marketing*, *64*(2), 35–50.

Haußmann, C., Dwivedi, Y. K., Venkitachalam, K., & Williams, M. D. (2012). A summary and review of galbraith's organizational information processing theory. *Information Systems Theory: Explaining and Predicting Our Digital Society, Vol. 2*, 71–93. doi: https://doi.org/10.1007/978-1-4419-9707-4_5

Hazen, B. T., Overstreet, R. E., Hall, D. J., Huscroft, J. R., & Hanna, J. B. (2015). Antecedents to and outcomes of reverse logistics metrics. *Industrial Marketing Management*, *46*, 160–170.

Henriksen, H. Z. (2006). Motivators for ios adoption in denmark. *Journal of Electronic Commerce in Organizations (JECO)*, *4*(2), 25–39. doi: http://dx.doi.org/10.4018/jeco.2006040102

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS quarterly*, 75–105.

Hong, S., Thong, J. Y., & Tam, K. Y. (2006). Understanding continued information technology usage behavior: A comparison of three models in the context of mobile internet. *Decision support systems*, *42*(3), 1819–1834. doi: https://doi.org/10.1016/j.dss.2006.03.009

Hsu, C.-L., & Lin, J. C.-C. (2016). Factors affecting the adoption of cloud services in enterprises. *Information Systems and e-Business Management*, *14*, 791–822. doi: https://doi.org/10.1007/s10257-015-0300-9

Huang, Y.-C., & Yang, M.-L. (2014). Reverse logistics innovation, institutional pressures and performance. *Management research review*, *37*(7), 615–641.

Jackson, S. (2011). Organizational culture and information systems adoption: A three-perspective approach. *Information and Organization*, *21*(2), 57–83. doi: https://doi.org/10.1016/j.infoandorg.2011.03.003

Jacobsson, M., & Linderoth, H. C. (2010). The influence of contextual elements, actors' frames of reference, and technology on the adoption and use of ict in construction projects: a swedish case study. *Construction Management and Economics*, *28*(1), 13–23. doi: https://doi.org/10.1080/01446190903406154

Jayasinghe, R. S., Chileshe, N., & Rameezdeen, R. (2019). Information-based quality management in reverse logistics supply chain: A systematic literature review. *Benchmarkinsg: An International Journal*, *26*(7), 2146–2187.

J. Hall, D., R. Huscroft, J., T. Hazen, B., & B. Hanna, J. (2013). Reverse logistics goals, metrics, and challenges: perspectives from industry. *International Journal of Physical Distribution & Logistics Management*, *43*(9), 768–785. doi: https://doi.org/10.1108/IJPDLM-02-2012-0052

Karhunen, H., Eerola, A., & Jantti, M. (2006). Improving service management in supply chains. In *2006 international conference on service systems and service management* (Vol. 2, pp. 1415–1420). doi: https://doi.org/10.1109/ICSSSM.2006.320719

Kazancoglu, I., Sagnak, M., Kumar Mangla, S., & Kazancoglu, Y. (2021). Circular economy and the policy: A framework for improving the corporate environmental management in supply chains. *Business Strategy and the Environment*, *30*(1), 590–608. doi: https://doi.org/10.1002/bse.2641

Kembro, J., Selviaridis, K., & Näslund, D. (2014). Theoretical perspectives on information sharing in supply chains: a systematic literature review and conceptual framework. *Supply chain management: An international journal*, *19*(5/6), 609–625.

Kettenbohrer, J., Beimborn, D., & Kloppenburg, M. (2013). Developing a procedure model for business process standardization. In *Icis.*

Khor, K. S., Udin, Z. M., Ramayah, T., & Hazen, B. T. (2016). Reverse logistics in malaysia: The contingent role of institutional pressure. *International Journal of Production Economics*, *175*, 96–108.

King, S. A., Kostewicz, D., Enders, O., Burch, T., Chitiyo, A., Taylor, J., ... Reid, M. (2020). Search and selection procedures of literature reviews in behavior analysis. *Perspectives on behavior science*, *43*, 725–760.

Kodhelaj, I., Chituc, C.-M., Beunders, E., & Janssen, D. (2019). Designing and deploying a business process for product recovery and repair at a servicing organization: A case study and framework proposal. *Computers in Industry*, *105*, 80–98. doi: https://doi.org/10.1016/j.compind.2018.11.002

Kohlbacher, M. (2010). The effects of process orientation: a literature review. *Business process management journal*, *16*(1), 135–152. doi: https://doi.org/10.1108/14637151011017985

Kuan, K. K., & Chau, P. Y. (2001). A perception-based model for edi adoption in small businesses using a technology–organization–environment framework. *Information & management*, *38*(8), 507–521. doi: https://doi.org/10.1016/S0378-7206(01)00073-8

Lamba, D., Yadav, D. K., Barve, A., & Panda, G. (2020). Prioritizing barriers in reverse logistics of e-commerce supply chain using fuzzy-analytic hierarchy process. *Electronic Commerce Research*, *20*(2), 381–403.

Lambert, S., Riopel, D., & Abdul-Kader, W. (2011). A reverse logistics decisions conceptual framework. *Computers & Industrial Engineering*, *61*(3), 561–581.

Laudon, K. C. L., & Laudon, J. P. (2014). *Management information systems: Managing the digital firm, global edition*.

Lee, C. K. M., & Lam, J. S. L. (2012). Managing reverse logistics to enhance sustainability of industrial marketing. *Industrial Marketing Management*, *41*(4), 589–598.

Lee, C.-P., & Shim, J. P. (2007). An exploratory study of radio frequency identification (rfid) adoption in the healthcare industry. *European Journal of Information Systems*, *16*, 712–724. doi: https://doi.org/10.1057/palgrave.ejis.3000716

Lee, H. L., & Whang, S. (2000). Information sharing in a supply chain. *International journal of manufacturing technology and management*, *1*(1), 79–93.

Letunovska, N., Offei, F. A., Junior, P. A., Lyulyov, O., Pimonenko, T., & Kwilinski, A. (2023). Green supply chain management: The effect of procurement sustainability on reverse logistics. *Logistics*, *7*(3), 47. doi: https://doi.org/10.3390/logistics7030047

Li, Q., Luo, H., Xie, P.-X., Feng, X.-Q., & Du, R.-Y. (2015). Product whole life-cycle and omni-channels data convergence oriented enterprise networks integration in a sensing environment. *Computers in Industry*, *70*, 23–45.

Lowhorn, G. L. (2007). Qualitative and quantitative research: How to choose the best design. In *Academic business world international conference. nashville, tennessee.*

Mahmoodzadeh, E., Jalalinia, S., & Yazdi, F. N. (2009). A business process outsourcing framework based on business process management and knowledge management. *Business Process Management Journal*, *15*(6), 845–864. doi: https://doi.org/10.1108/14637150911003748

Mai, E. S., Chen, H., & Anselmi, K. (2012). The role of returns management orientation, internal collaboration, and information support in reverse logistics. *Journal of Transportation Management*, *23*(1), 5.

Matende, S., & Ogao, P. (2013). Enterprise resource planning (erp) system implementation: a case for user participation. *Procedia Technology*, *9*, 518–526.

Mathiyazhagan, K., Rajak, S., Sampurna Panigrahi, S., Agarwal, V., & Manani, D. (2021). Reverse supply chain management in manufacturing industry: a systematic review. *International Journal of Productivity and Performance Management*, *70*(4), 859–892.

Melnyk, S. A., Stewart, D. M., & Swink, M. (2004). Metrics and performance measurement in operations management: dealing with the metrics maze. *Journal of operations management*, *22*(3), 209–218. doi: https://doi.org/10.1016/j.jom.2004.01.004

Mesgari, M., & Okoli, C. (2019). Critical review of organisation-technology sensemaking: towards technology materiality, discovery, and action. *European Journal of Information Systems*, *28*(2), 205–232. doi: https://doi.org/10.1080/0960085X.2018.1524420

Minner, S. (2001). Strategic safety stocks in reverse logistics supply chains. *International Journal of Production Economics*, *71*, 417-428. doi: 10.1016/S0925-5273(00)00138-9

Mishra, A. R., Rani, P., & Pandey, K. (2022). Fermatean fuzzy critic-edas approach for the selection of sustainable third-party reverse logistics providers using improved generalized score function. *Journal of ambient intelligence and humanized computing*, 1–17.

Moon, Y. B. (2007). Enterprise resource planning (erp): a review of the literature. *International journal of management and enterprise development*, *4*(3), 235–264.

Morgan, T. R., Richey Jr, R. G., & Autry, C. W. (2016). Developing a reverse logistics competency: The influence of collaboration and information technology. *International Journal of Physical Distribution & Logistics Management*, *46*(3), 293–315.

Muenstermann, B., & Weitzel, T. (2008, 01). What is process standardization?

Münstermann, B., Eckhardt, A., & Weitzel, T. (2010). The performance impact of business process standardization: An empirical evaluation of the recruitment process. *Business Process Management Journal*, *16*(1), 29–56. doi: https://doi.org/10.1108/14637151011017930

Münstermann, B., & Weitzel, T. (2008). What is process standardization? doi: https://aisel.aisnet.org/confirm2008/64

Narayanan, S., Jayaraman, V., Luo, Y., & Swaminathan, J. M. (2011). The antecedents of process integration in business process outsourcing and its effect on firm performance. *Journal of operations management*, *29*(1-2), 3–16. doi: https://doi.org/10.1016/j.jom.2010.05.001

New, S. (2010). The transparent supply chain. *Harvard Business Review*, *88*(10).

New, S. (2015). Mcdonald's and the challenges of a modern supply chain. *Harvard Business Review Digital Articles*.

Nunes, D. R. d. L., Nascimento, D. d. S., Matos, J. R., Melo, A. C. S., Martins, V. W. B., & Braga, A. E. (2023). Approaches to performance assessment in reverse supply chains: A systematic literature review. *Logistics*, *7*(3), 36. doi: https://doi.org/10.3390/logistics7030036

Object Management Group. (2008). *Business Process Maturity Model (BPMM), Version 1.0.* http://www.omg.org/spec/BPMM/1.0/.

Oliveira, T., & Martins, M. F. (2011). Literature review of information technology adoption models at firm level. *Electronic journal of information systems evaluation*, *14*(1), pp110–121. https://academic-publishing.org/index.php/ejise/article/view/389.

Olorunniwo, F. O., & Li, X. (2010). Information sharing and collaboration practices in reverse logistics. *Supply Chain Management: An International Journal*, *15*(6), 454–462.

Oltra-Badenes, R., Gil-Gomez, H., Guerola-Navarro, V., & Vicedo, P. (2019). Is it possible to manage the product recovery processes in an erp? analysis of functional needs. *Sustainability*, *11*(16), 4380.

Pan, M.-J., & Jang, W.-Y. (2008). Determinants of the adoption of enterprise resource planning within the technology-organization-environment framework: Taiwan's communications industry. *Journal of Computer information systems*, *48*(3), 94–102. doi: 10.1080/08874417.2008.11646025

Park, K. O. (2018). The relationship between bpr strategy and change management for the sustainable implementation of erp: An information orientation perspective. *Sustainability*, *10*(9), 3080. doi: https://doi.org/10.3390/su10093080

Prahinski, C., & Kocabasoglu, C. (2006). Empirical research opportunities in reverse supply chains. *Omega*, *34*(6), 519–532.

Prakash, C., & Barua, M. K. (2015). Integration of ahp-topsis method for prioritizing the solutions of reverse logistics adoption to overcome its barriers under fuzzy environment. *Journal of Manufacturing Systems*, *37*, 599–615.

Prasad, C. V., Govindan, K., & Kulkarni, D. (2010). Role of it in scm environment. *International Journal of Business Performance and Supply Chain Modelling*, *2*(1), 81–94.

Price, A. D., & Chahal, K. (2006). A strategic framework for change management. *Construction management and economics*, *24*(3), 237–251. doi: https://doi.org/10.1080/01446190500227011

Pugh, D. S., Hickson, D. J., Hinings, C. R., & Turner, C. (1968). Dimensions of organization structure. *Administrative science quarterly*, 65–105.

Ravi, V., & Shankar, R. (2005). Analysis of interactions among the barriers of reverse logistics. *Technological Forecasting and Social Change*, *72*(8), 1011–1029. doi: https://doi.org/10.1016/j.techfore.2004.07.002

Ravichandran, M., Vimal, K., Kumar, V., Kulkarni, O., Govindaswamy, S., & Kandasamy, J. (2023). Environment and economic analysis of reverse supply chain scenarios for remanufacturing using discrete-event simulation approach. *Environment, Development and Sustainability*, 1–42.

R. Huscroft, J., T. Hazen, B., J. Hall, D., B. Skipper, J., & B. Hanna, J. (2013). Reverse logistics: past research, current management issues, and future directions. *The International Journal of Logistics Management*, *24*(3), 304–327.

Richey, R. G., Chen, H., Genchev, S. E., & Daugherty, P. J. (2005). Developing effective reverse logistics programs. *Industrial Marketing Management*, *34*(8), 830–840.

Romero, H. L., Dijkman, R. M., Grefen, P. W., & van Weele, A. J. (2015). Factors that determine the extent of business process standardization and the subsequent effect on business performance. *Business & Information Systems Engineering*, *57*, 261–270. doi: https://doi.org/10.1007/s12599-015-0386-0

Saghafian, M., Laumann, K., & Skogstad, M. R. (2021). Stagewise overview of issues influencing organizational technology adoption and use. *Frontiers in Psychology*, *12*, 630145.

SAP. (2023). *What is SAP HANA.* urlhttps://www.sap.com/products/technology-platform/hana/what-is-sap-hana.html: :text=SAP

SAP. (2024). *About SAP SE.* `https://www.sap.com/about/company.html`. (Company information | about SAP SE)

Savoy, A., & Salvendy, G. (2016). Factors for customer information satisfaction: User approved and empirically evaluated. *International Journal of Human–Computer Interaction*, *32*(9), 695–707. doi: https://doi.org/10.1080/10447318.2016.1190137

Schäfermeyer, M., Rosenkranz, C., & Holten, R. (2012). The impact of business process complexity on business process standardization: An empirical study. *Business & Information Systems Engineering*, *4*, 261–270. doi: https://doi.org/10.1007/s12599-012-0224-6

Seethamraju, R., & Seethamraju, J. (2009). Enterprise systems and business process agility-a case study. , 1–12. doi: https://doi.org/10.1109/HICSS.2009.196

Sekaran, U., & Bougie, R. (2016). *Research methods for business: A skill building approach (7th edition).* Wiley Publishers. `https://lccn.loc.gov/2015051045`.

Sellitto, M. A. (2018). Reverse logistics activities in three companies of the process industry. *Journal of Cleaner Production*, *187*, 923–931.

Sikka, V., Färber, F., Lehner, W., Cha, S. K., Peh, T., & Bornhövd, C. (2012). Efficient transaction processing in sap hana database: the end of a column store myth. In *Proceedings of the 2012 acm sigmod international conference on management of data* (pp. 731–742).

Sodhi, M. S., & Tang, C. S. (2019). Research opportunities in supply chain transparency. *Production and Operations Management*, *28*(12), 2946–2959.

Starostka-Patyk, M. (2017). Reverse logistics of defective products in management of manufacturing enterprises. *Wydawnictwo Naukowe Sophia: Katowice, Poland*.

Starostka-Patyk, M. (2021). The use of information systems to support the management of reverse logistics processes. *Procedia Computer Science*, *192*, 2586–2595.

Starostka-Patyk, M., & Nitkiewicz, T. (2014). Lca approach to management of defective products in reverse logistics channels. In *2014 international conference on advanced logistics and transport (icalt)* (p. 216-221). doi: 10.1109/ICAdLT.2014.6866315

Team, T. B. G. (2019, April). *Supply chains for high-tech companies: Unique challenges and solutions.* Retrieved from `https://www.blumeglobal.com/learning/high-tech-supply-chains/`

Tiwari, R. (2013). Identification of factors affecting reverse chain performance in relation to customer satisfaction using ism modelling & micmac analysis. *Uncertain Supply Chain Management*, *1*(4), 237–252.

Tornatzky, L. G., & Fleischer, M. (1990). The processes of technological innovation. *Lexington, MA: Lexington Books*.

Tregear, R. (2015). Business process standardization. In *Handbook on business process management 2: Strategic alignment, governance, people and culture* (pp. 421–441). Springer. doi: 10.1007/978-3-642-45103-4_18

Trkman, P. (2010). The critical success factors of business process management. *International journal of information management*, *30*(2), 125–134. doi: https://doi.org/10.1016/j.ijinfomgt.2009.07.003

Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision sciences*, *39*(2), 273–315. doi: https://doi.org/10.1111/j.1540-5915.2008.00192.x

Vlachos, I. P. (2016). Reverse logistics capabilities and firm performance: the mediating role of business strategy. *International Journal of Logistics Research and Applications*, *19*(5), 424–442.

Wen, K.-W., & Chen, Y. (2010). E-business value creation in small and medium enterprises: a us study using the toe framework. *International Journal of Electronic Business*, *8*(1), 80–100. doi: https://doi.org/10.1504/IJEB.2010.030717

Wong, C. W., Lai, K.-h., & Cheng, T. (2011). Value of information integration to supply chain management: roles of internal and external contingencies. *Journal of Management Information Systems*, *28*(3), 161–200.

Wüllenweber, K., Koenig, W., Beimborn, D., & Weitzel, T. (2009). The impact of process standardization on business process outsourcing success. *Information systems outsourcing: enduring themes, global challenges, and process opportunities*, 527–548. doi: https://doi.org/10.1007/978-3-540-88851-2_23

Wurm, B., & Mendling, J. (2020). A theoretical model for business process standardization. In *Business process management forum: Bpm forum 2020, seville, spain, september 13–18, 2020, proceedings 18* (pp. 281–296). doi: https://doi.org/10.1007/978-3-030-58638-6_17

Xu, B., & Lin, B. (2018). Investigating the role of high-tech industry in reducing china's co2 emissions: A regional perspective. *Journal of Cleaner Production*, *177*, 169–177.

Xu, W., Liu, L., Zhang, Q., & Liu, P. (2018). Location decision-making of equipment manufacturing enterprise under dual-channel purchase and sale mode. *Complexity*, *2018*, 1–16.

Yamaguchi, S. (2022). *Securing reverse supply chains for a resource efficient and circular economy.* `https://www.oecd-ilibrary.org/content/paper/6ab6bb39-en`.

Yeh, C.-H., Lee, G.-G., & Pai, J.-C. (2015). Using a technology-organization-environment framework to investigate the factors influencing e-business information technology capabilities. *Information Development*, *31*(5), 435–450. doi: https://doi.org/10.1177/0266666913516027

Yin, R. K. (2003). *Case study research: Design and methods* (Vol. 5). Sage.

Yoon, T. E., & George, J. F. (2013). Why aren't organizations adopting virtual worlds? *Computers in Human Behavior*, *29*(3), 772–790. doi: https://doi.org/10.1016/j.chb.2012.12.003

Zelt, S., Recker, J., Schmiedel, T., & vom Brocke, J. (2019). A theory of contingent business process management. *Business Process Management Journal*, *25*(6), 1291–1316. doi: https:/10.1108/BPMJ-05-2018-0129

Zheng, S., Yen, D. C., & Tarn, J. M. (2000). The new spectrum of the cross-enterprise solution: the integration of supply chain management and enterprise resources planning systems. *Journal of Computer Information Systems*, *41*(1), 84–93. doi: https://doi.org/10.1080/08874417.2000.11646980

Zhou, H., & Benton Jr, W. (2007). Supply chain practice and information sharing. *Journal of Operations management*, *25*(6), 1348–1365.

Zhu, K., Kraemer, K., & Xu, S. (2003). Electronic business adoption by european firms: a cross-country assessment of the facilitators and inhibitors. *European journal of information systems*, *12*, 251–268. doi: https://doi.org/10.1057/palgrave.ejis.3000475

Zhu, Y., Li, Y., Wang, W., & Chen, J. (2010). What leads to post-implementation success of ERP? an empirical study of the chinese retail industry. *International Journal of Information Management*, *30*(3), 265–276. doi: https://doi.org/10.1016/j.ijinfomgt.2009.09.007

Zimon, D., & Madzík, P. (2020). Standardized management systems and risk management in the supply chain. *International Journal of Quality & Reliability Management*, *37*(2), 305–327.

Appendix-A: Stakeholder Mapping in Urgent Defects Flow

The stakeholder mapping for the stakeholders across various cross-functional departments involved in the urgent defect flow process as per the interviews of the participants involved in the process flow and as per Figure 4.3 is as follows:

- **Factory- Production Team:** The Production Team manufactures lithography machines based on EUV and DUV technologies. Operators in this team initiate the urgent repair process when a part or product is rejected, and there is no available stock in the inventory. This process starts with the creation of a Material Notification (MN) in the ERP system. The operators then inform the Supply Planner about the stock shortage, as the Supply Planner is responsible for managing inventory levels.
- **Factory- Supply Chain Planner:**
  - The Supply Chain Planners have two roles:
    * Volume Products Planner: Focuses on high-volume parts and products used as raw materials.
    * Product Lifecycle Manager: Manages new product introductions still in the development phase.
  - They check if a new version of the rejected part or product is available from the supplier or in stock.
  - For urgent defect repairs, their responsibilities include:
    * Placing an urgent repair order.
    * Ensuring the defective part is removed from the clean room and accessible to the Reverse Logistics (RL) team.
    * Confirming the Material Review Board (MRB) has completed its quality inspection and updated relevant details, including actions to be taken by the supplier (repair/recondition/remanufacture).
    * Deciding with the MRB team whether the urgent defective part needs to be repaired, reconditioned, or remanufactured.
  - After MRB completion and removal from the clean room, the Supply Chain Planner emails the RL team about the urgency, identifying the defective product as urgent.
- **Factory- Process Improvement and Material Quality Team:**
  - They participate in confirming the nature of the defect and are called as Material Review Board (MRB) and update the relevant information about the actions to be taken in the ERP system.
  - If the defective part is critical and has stopped the production operations for extreme long delays (XLDs), the Process Improvement and Material Quality can raise an urgent defect analysis request.
  - If the received part is non-functional or in a defective state on its reception called Dead on Arrival (DOA) causes the quality team to raise an urgent repair analysis request.
  - If the entire batch of received parts as raw materials is defective, an urgent defect analysis request is placed.
  - These urgent defect analysis requests are placed by the Process Improvement and Material Quality Team similarly as the urgent defect repair requests are placed.
- **Factory- Clean Room Logistics:** They are responsible for locating and arranging the transfer of the defective parts internally in the factory and delivering them to the Dispatch area called as Pack is shipped to the supplier by the packaging team appropriately.

- **Reverse Logistics:**
  - The RL team is the parts of the Reuse Department responsible for completing all the administrative work needed to ship the part to the supplier.
  - The inputs for the RL team to perform their administrative activities are completion of the MRB inspection, the correct information updated by the MRB team, the urgent defective part is out of the clean room, and the email from either the Supply Chain Planner for urgent defect repair or from the Process Improvement/ Material Quality team for urgent defect analysis requests.
  - The administrative activities include getting return merchandise authorization (RMA), and purchase requisition (PR), and ensuring an approved purchase order (PO) is in place.
  - Create a delivery note (DN) that contains the relevant details for where to ship the part (which supplier needs to receive this part), and how fast it needs to be shipped.
- **Factory- Dispatch Team:** They engage in the final packing stages before shipment and collaborate with third-party logistics (3PL) for the transfer of urgent defective parts to a supplier based on the information provided by the RL team.

Appendix-B: Observations based on the existing Information System used

There are multiple MRB and OSC teams (refer for Appendix A for roles and responsibilities) dedicated to different categories of parts or products based on their types and based on the supplier who manufactures them. As mentioned earlier, each stakeholder in the MRB and OSC departments in the RL flow has a different way of notifying the urgent defective products/ parts. The flow or trigger required to be raised for the defective products belonging to the urgent defect category are flagged or communicated by various means of communication process email messages, Microsoft Forms, and Microsoft Teams messages and calls. For the defective products to fall in the urgent defects resolution category, it has to match several different criteria mentioned (shortages and RCA). There is an IS based on ERP called SAP which is the centralized mode of communication and data storage for ASML, and also has the option to raise defects on various urgency levels. This option is also at times not filled by the departments while notifying urgent defects.

SAP is an organization that is the market leader in providing and developing ERP systems (SAP, 2024). It specializes in software for the management of business processes, facilitating effective data processing and information flow across organizations. SAP's products are used to manage business operations and customer relations (SAP, 2024). The company's ERP (Enterprise Resource Planning) system, which is its most well-known product, helps companies manage the supply chain, manufacturing, operations, and financial management (SAP, 2024).

HANA (High-Performance Analytic Appliance) is a database management platform of the SAP ERP system (Sikka et al., 2012; Färber et al., 2012; SAP, 2023). SAP HANA is an in-memory, column-oriented relational database management system created and marketed by SAP (SAP, 2023). Its primary function is to store and retrieve data as specified by applications. In addition to database management, SAP HANA offers advanced analytics processing, data integration, and application development capabilities. It enables businesses to analyze large amounts of data in real-time, resulting in faster decisions and insights. SAP HANA is intended to handle both high transaction rates and complex query processing on a single platform (Färber et al., 2012).

Appendix-C: Change Management Models

The The most well-known change management models can be seen in Table C.1 and is explained as follows:

Kurt Lewin's Change Management Model	Kotter's 8 Step Change Model	GE's Change Acceleration Process (CAP)	Prosci 3-Phase Change Management Process
Unfreeze	• Establish a sense of urgency • Build a powerful guiding coalition	• Lead the change • Create a shared need	• Prepare for change: • Define change management strategy • Prepare change management team • Develop a sponsorship model
Change	• Create a shared vision • Communicate the vision • Empower others to act on the vision • Plan for and create short-term wins	• Shape a vision • Mobilize commitment • Make change last	• Manage the change: • Develop change management plans • Take action and implement plans
Refreeze	• Consolidate improvements and produce still more change • Institutionalize new approaches	• Monitor the progress • Change Systems and Structures	• Reinforce the change: • Collect and analyze feedback • Diagnose gaps and manage resistance • Implement corrective actions and celebrate success

Table C.1: Overview of change management models (Bellantuono et al., 2021)

C.1 Kurt Lewin's Change Management Model

The "three-step model" known as Kurt Lewin's Change Management Model is credited with inspiring the development of change management models (Bellantuono et al., 2021). The fundamental idea is that new behaviors follow changes, so members of an organization must give up old habits before implementing new ones. In this way, the following is a description of the three steps in the model (Bellantuono et al., 2021):

1. Unfreeze: The equilibrium supporting current behaviors and attitudes shifts at the outset when members of the organization become aware of the need for change and the reasons behind it. This step should take into account the potential risks that people may associate with change as well as the necessity of motivating those who will be impacted.
2. Change: The behavior of the department, the organization, or the individual is altered to a new degree. This entails stepping in to modify organizational structures and procedures to introduce new behaviors, values, and attitudes. In light of the possibility of employee resistance, leaders of the organization must make clear to all parties involved—whether directly or indirectly—the reasons behind the change, its nature, and the anticipated advantages of it.
3. Refreez: The organization is brought into a new state of equilibrium in this step, and the new behaviors and procedures that were introduced in the preceding steps are combined and integrated into the organization. People are at ease and confident in the new methods of working.

C.2 Kotter's 8-Step Change Model

Kotter's 8-Step Change Model is a widely used framework for guiding organizations through successful change implementations (Bellantuono et al., 2021). The model consists of the following eight steps Bellantuono et al. (2021):

1. Establish a Sense of Urgency: The first step involves recognizing the need for change and effectively communicating this urgency to all members of the organization. Leadership must examine market conditions, competitors, and potential threats and opportunities to create a compelling case for change, thereby increasing organizational awareness and readiness.
2. Build a Powerful Guiding Coalition: Form a team with enough authority and influence to lead the change effort. This coalition should be composed of individuals who are capable of driving the change and gaining support from other members of the organization.
3. Create a Shared Vision: The guiding coalition develops a clear vision to direct the organization's change efforts. This vision ensures that the transformation remains focused and coherent, preventing it from becoming a series of unrelated projects. A strategic plan is also created to outline the change goals and implementation timeline.
4. Communicate the Vision: The guiding coalition must communicate the vision and strategies effectively to the entire organization. This step helps to minimize resistance by ensuring that all members understand and buy into the change process.
5. Empower Others to Act on the Vision: Beyond communication, the coalition must remove obstacles that hinder change. This involves identifying resistant individuals, understanding their concerns, and encouraging their active participation in the change process.
6. Plan for and Create Short-term Wins: Achieving short-term, impactful results (quick wins) early in the change process demonstrates that the initiative is on the right track. These wins help to engage reluctant individuals and allow the guiding coalition to test the vision under real conditions.
7. Consolidate Improvements and Produce More Change: Kotter warns against declaring victory prematurely. Organizations should build on their initial successes, consolidate gains, and continue to seek opportunities for further improvements to ensure the change is sustainable.
8. Institutionalize New Approaches: To ensure lasting change, it is essential to integrate the new practices into the organizational culture. This involves ongoing communication about the changes and successes, and embedding the roles responsible for leading the change processes within the organization.

C.3 Prosci 3-Phase Change Management Process

Prosci, a global consulting firm established in 1994 and specializing in change management, emphasizes the importance of integrating both individual and organizational change management to ensure the success of change initiatives (Bellantuono et al., 2021). The foundation of their approach is the ADKAR model, which outlines key milestones individuals must achieve for successful change Bellantuono et al. (2021):

1. **Awareness** of the need for change
2. **Desire** to support the change
3. **Knowledge** of how to change
4. **Ability** to implement desired skills and behaviors
5. **Reinforcement** of the change

According to Prosci, a change initiative succeeds only when every affected employee has achieved these five ADKAR milestones, ensuring they understand the need and urgency for change, desire to make the change, and possess the necessary skills and knowledge to operate effectively post-change Bellantuono et al. (2021).

Prosci's 3-Phase Process offers a strategic, step-by-step approach to managing organizational change, comprising the following phases Bellantuono et al. (2021):

1. **Prepare for Change:**
   (a) Design Change Management Plans: The project team develops plans to manage the change.
   (b) Develop Awareness: Create awareness about the need for change.
   (c) Define Change Characteristics: Outline the change's size, scope, timeline, and impact.
   (d) Appoint Change Management Team: Assign clear roles and responsibilities to the team.
   (e) Identify a Sponsor: Choose a leader to champion the change and allocate resources.
   (f) Identify Impacted Groups: Determine which individuals or groups will be affected by the change.
   (g) Develop Strategy: Formulate a comprehensive change management strategy.
2. **Manage the Change:**
   (a) Develop and Implement Plans: Create and execute various plans, including:
      i. Communication Plan
      ii. Training Plan
      iii. Sponsor Roadmap
      iv. Coaching Plan
      v. Resistance Management Plan
3. **Reinforce the Change:**
   (a) Collect and Analyze Feedback: Gather feedback from those impacted by the change.
   (b) Measure Change Adoption: Develop mechanisms to assess how well the change is being adopted.
   (c) Monitor Performance: Ensure employees are performing their tasks according to the new procedures.
   (d) Identify and Correct Gaps: Detect and address any gaps in the change implementation.
   (e) Celebrate Success: Acknowledge and celebrate achievements to reinforce the change.

This structured methodology supports organizations in navigating change by ensuring that both individual and collective needs are addressed, thus facilitating a smoother and more effective transition (Bellantuono et al., 2021).

C.4 GE's Change Acceleration Process (CAP)

In the 1990s, General Electric (GE), under the direction of Jack Welch, commissioned a team of consultants to study the best practices of change management. The result of these studies was crystallized in the Change Acceleration Process (CAP).

The team emphasized that implementing high-quality technical solutions does not always guarantee the success of a change initiative. Failure often occurs when the organization focuses primarily on the technical aspects and neglects the people affected by the change. This concept is summarized by the equation

$$E = Q \times A \tag{C.1}$$

where the effectiveness (E) of any initiative is the product of the quality (Q) of the technical strategy and the acceptance (A) of that strategy. In other words, successful change management requires equal attention to both the technical and people sides of the equation.

The Change Acceleration Process includes seven steps:

1. **Lead Change:** Identify strong and committed leadership to oversee the change initiative.
2. **Create a Shared Need:** Clearly define and communicate the reason for change to all stakeholders involved in the initiative.
3. **Shape a Vision:** Articulate a clear and legitimate vision of the post-change world. This vision must be described in observable and measurable terms and shared with all stakeholders.
4. **Mobilize Commitment:** Foster a sense of commitment and involvement among all individuals affected by the change.
5. **Make Change Last:** Begin with pilot projects, using successes and lessons learned to inform future initiatives. Identify factors that help or hinder the change.
6. **Monitor the Process:** Measure progress and identify problems.
7. **Change Systems and Structures:** Realign the organizational structure to support and sustain the change, making it permanent.

Appendix-D: Business Process Maturity Mode

The Business Process Maturity Model (BPMM) developed by Object Management Group (2008) is structured around five maturity levels, each representing different stages of organizational transformation as processes and capabilities are enhanced. Here is a breakdown of these stages:

- Level 1: Initial — At this stage, business processes are typically inconsistent and ad hoc, leading to unpredictable outcomes.
- Level 2: Managed — Processes are stabilized within local work units to ensure repeatable performance that meets the primary commitments of the workgroup. It's common for different work units performing similar tasks to employ varied procedures.
- Level 3: Standardized — This level involves the synthesis of common, standardized processes from the best practices identified across work groups. Tailoring guidelines are provided to accommodate various business needs. Standardized processes enable economies of scale and form a basis for organizational learning through common metrics and shared experiences.
- Level 4: Predictable — At this mature stage, the capabilities provided by standardized processes are fully leveraged back into the work units. Process performance is managed statistically across the workflow to understand and control variations, allowing outcomes to be predicted based on intermediate states.
- Level 5: Innovating — This final level focuses on both proactive and opportunistic improvement efforts that seek innovations to bridge the gap between the organization's current capabilities and the capabilities needed to achieve its business objectives.

For maturity levels 2 through 5, each is defined by specific process areas that collectively support the achievement of that level's capability. Each process area comprises a set of integrated best practices outlining what should be done to support, create, or sustain the organizational state characteristic of each level (Object Management Group, 2008).

Appendix-E: Stage of BPS

The different stages involved as proposed by Goel et al. (2023) are explained as follows and can be seen in Figure E.1.

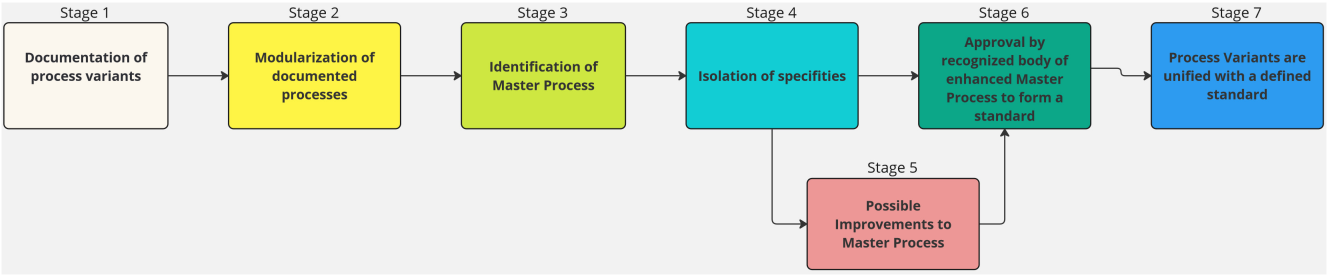


Figure E.1: Stages of Business Process Standardization (BPS) (Goel et al., 2023)

1. Documentation of Individual Process Variants:

   - Document all the variants of the business process in the form of business process models and supporting text.
   - Ensure that the documentation captures the complete process flow for each variant of the process.

   This stage is aligned with the process identification and discovery phases of the integrated business-process management framework (IBPM) by Butt (2020). Butt (2020) further highlights the requirements of expectations of internal (employees) and external stakeholders (customers) by f tools such as organizational charts, SWOT analysis, stakeholder maps, context diagrams, and business-case diagrams.
2. Modularization of Documented Processes:

   Modularization involves subdividing each process variant into sub-processes and steps, potentially part of stage 1. This stage captures essential process details, including task responsibilities and accountability, considering organizational boundaries, process logic, and project contexts. The process-oriented approach to formalization, as mentioned by Genchev et al. (2011), requires detailed documentation of RL processes to reduce ambiguity and uncertainties. By doing so, this stage identifies potential flaws and improvement opportunities. Additionally, formalizing each process allows for a more accurate measurement of RL performance. Businesses are interconnected and rely on one another. Process dependency analysis identifies interdependence among processes based on information, materials, or execution (Butt, 2020). Identifying and analyzing interdependence within a business process is critical (Butt, 2020).
3. Identification of a Master Process: Once all the process variants are documented in a modularized manner, they are reviewed to identify a master process. A master process is a process that contains or combines the best steps that were identified during the modularization phase. The master process serves as a reference model for other processes. Typically, process performance indicators like time, cost, and quality are used to select the best practice among multiple master process candidates. As per Goel et al. (2023), the current BPS literature rarely discusses the decision-making process that led to the derivation of the Master process.
4. Isolation of Specificities: During this stage, isolate master process specifics that are unique to each variant. Specificities are activities that are unique to a particular process instance or variant. Some process variants may have unique characteristics that do not apply to other variants. To reduce variability across process variants, isolate specificities to a minimum. By implementing these changes, an improved version of the master process is obtained. The literature on isolation and its associated activities is limited.

5. Possible Improvements to the Master Process: After the master process is identified, improvements are made to it while the process is being standardized and varies from organization to organization.

   The stages of identification of the master process, isolation of specificities, and possible improvements to the master process are aligned with the process analysis and process redesign phases of the IBPM framework by Butt (2020).
6. Approval/Acceptance of an Enhanced Master Process as a 'standard: The enhanced master process derived in the previous stage(s), only becomes a standard process when it is approved by a recognized body. As per Goel et al. (2023), the current literature lacks clarity on who is responsible for approval and what forms of approval are required for a Master process to be considered standard.
7. Unifying Process Variants with the Standard (Enhanced and Approved Master Process): The processes become standardized once the process variants are unified with a defined standard. This procedure is also referred to as the 'homogenization' of existing variants against the standard process (Münstermann et al., 2010; Muenstermann & Weitzel, 2008).

Along with these, Butt (2020) in their IBPM framework, highlights a few necessary stages to be considered while doing business process management and standardization, they are as follows:

1. Risk Management: When digital technologies are incorporated into processes, the IBPM team examines and pinpoints potential risks. To conduct a risk assessment, brainstorming sessions and the creation of a risk register—which measures the impacts and probabilities of each—can be used.
2. Analysis of Skill Gaps. The IBPM team evaluates the workforce in terms of necessary and existing skills through a skill-gap analysis.
3. Change Management: The IBPM team creates a change management plan to gradually alter senior management's and the workforce's perspectives and instill the notion that change is inevitable. The group can select a change management model (such as the ADKAR model, Lewin's change management model, or Kotter's change management model) to achieve this.
4. Cost-Benefit Evaluation: The IBPM focuses on the evaluation of every single benefit resulting from the adoption of the technologies that should be considered.
5. Process Implementation and Validation: The IBPM states to plan and carry out a pilot run to validate the to-be processes before proceeding with a full-scale implementation. This will help to reduce the risk of failure and identify areas for further improvement. Following the pilot, a full-scale implementation is carried out.
6. Process Control and Monitoring. Following the launch of the future business process, continuous process monitoring and control should be focused on continuously improving the process.

Appendix-F: Case Study Interview Protocol

F.1 Title of Case Study Interview

Interview Protocol for identifying the critical factors that impact the adoption of Information System based Standard Process flow for managing high-impact issues like urgent defects.

F.2 Purpose of Case Study Interview

The interview session aims to identify and understand the factors that impact the adoption and implementation of an Information System based standardized process flow for managing time-sensitive, critical, and high-impact issues like urgent defects flow in a high-tech company like ASML. By understanding these factors a framework will be designed which will act as an overview for developing an Information System based standardized process for managing high-impact issues like urgent defects process flow.

F.3 Questionnaire for Case Study Interview

F.3.1 Introduction of Participant

1. Could you please describe your role and responsibilities within the Organization?
2. Could you please describe your role and responsibilities within the Reverse Logistics and Reuse Department?
3. Could you please share the possible reasons for which an Urgent Defect Process flow is used?
4. What criteria are used to prioritize urgent defective products, such as customer impact, product criticality, cost implications, or any other?
5. Can you describe the current process/ workflow for managing the communication and information sharing for urgent defective products within ASML's reverse logistics operations?

F.3.2 Technological Context

1. What are the current systems and technologies used (SAP, emails, Spotfire, or any other) for managing urgent defects process flow?
2. What are the main limitations or challenges of these systems related to urgent defects flow?
3. What are the key challenges in terms of information sharing and communication related to urgent defects management across departments?
4. Do you think using an Information System platform can act as a standardized platform for urgent defects process flow?
   (a) If yes, which IS should be selected?
   (b) Can we integrate this IS with existing systems to ensure seamless information flow and standardization?
   (c) If not, please elaborate on the reason and suggest a suitable technology or tool to be used.
5. What specific features or capabilities do you expect from the selected IS to improve the management of urgent defective products based on the overall impact it will have?
6. What are the critical success factors, and strategies for successful adoption and implementation of IS systems as a standardized process for urgent defects management?

F.3.3 Organizational Context

1. Can you describe a recent instance where you encountered significant challenges while managing an urgent defective product? What specific bottlenecks did you face in this situation?
2. What are the challenges you have faced previously in terms of cycle time taken to ship the part from ASML to the respective supplier?
3. What are the possible reasons for the delay of the shipment?
4. From your perspective, what challenges does an organization face when standardizing processes similar to urgent defects?
5. What challenges does an organization face when standardizing process flows using IS for high-impact issues like urgent defects with respect to the following factors:
   (a) Organizational Culture:
   - How does the alignment (or lack thereof) of organizational and process goals and vision impact the standardization process?
   - What role do organizational strategy, values, and norms play in facilitating or hindering process standardization?
   (b) Organizational Structure:
   - What are the challenges faced in an organic structure versus a mechanistic structure when standardizing processes?
   - How does the flexibility or rigidity of the organizational structure impact the adoption of standardized processes using IS?
   (c) Top Management Participation and Support:
   - How crucial is the participation and support of top management in the standardization process?
   - What specific challenges arise if top management is not actively involved in the process?
   (d) Technological Resources Needed for IS Adoption:
   - What technological resources are essential for successfully adopting IS for process standardization?
   - What are the challenges related to the availability and integration of these technological resources?
6. Are roles and responsibilities clearly defined for managing urgent defects? If not what improvements do you suggest?
7. What are SLAs and KPIs available and monitored regarding urgent defects?
8. Who is the process owner for managing the urgent defects flow, and is accountability ensured?
9. Do you think a periodic review of process flows is required?
10. What role does top management play in change management for the adoption of an IS-base process flow?
11. What are the change management practices followed in the organization?
12. What approaches or strategies should be considered while implementing change management?
13. Do you think there will be any stakeholder resistance to the adoption of IS-based process flow?
14. What tactics should be used for successful stakeholder acceptance for the adoption of IS-based process flow?

F.3.4 External Environmental Context

1. What external forces do you think necessitate and influence ASML to standardize critical processes like urgent defect management? Consider the following factors:
   (a) EU Regulations (e.g., WEEE): How do European Union regulations such as the Waste Electrical and Electronic Equipment (WEEE) directive impact the need for standardized processes?
   (b) Competitive Pressures: In what ways do competitive pressures from other companies in the industry drive ASML to standardize its processes?
   (c) Market Demands: How do market demands and expectations influence the need for standardized process flows for urgent defect management?
   (d) Supplier Relations: How important are strong and standardized processes in maintaining and improving supplier relations?
   (e) Customer Satisfaction: How does standardizing processes impact customer satisfaction, particularly in terms of timely and efficient defect resolution?

F.3.5 Survey Questions

The survey was conducted during the semi-structured interview sessions. The following are the survey questions asked:

1. Rate on a scale of 1 to 5, where 1 means you completely disagree and 5 means you completely agree:
   - The current process is efficient in terms of timely management of shipping urgent defective parts or products out of the organization.
2. Rate on a scale of 1 to 5, where 1 means you completely disagree and 5 means you completely agree:
   - The current process is transparent in terms of traceability and visibility of the necessary information flow required for managing urgent defective parts or products to ship out of the organization.
3. Rate on a scale of 1 to 5, where 1 means you completely disagree and 5 means you completely agree:
   - The current process is transparent in terms of handling the number of urgent defective repair requests.
4. Rate on a scale of 1 to 5, where 1 means you completely disagree and 5 means you completely agree:
   - There is a need for an IS-based standardized process flow to manage urgent defect repairs considering efficiency, transparency, and scalability.

Appendix-G: Framework Validation Interview Protocol

G.1 Title of Framework Validation Interview

Interview protocol for validation of the Framework developed to identify the different factors that impact the adoption of Information System based Standard Process flow for managing high-impact issues like urgent defects.

G.2 Purpose of Framework Validation Interview

The interview session aims to validate the developed framework designed for identifying the factors for the adoption and implementation of an Information System-based standardized process flow for managing time-sensitive, critical, and high-impact issues like urgent defect management in a high-tech company like ASML. By gathering feedback and insights on the developed framework, the aim is to ensure the framework's effectiveness, practicality, and alignment with organizational needs.

G.3 Questions for Framework Validation Interview

G.3.1 Introduction of Participant

1. Could you please describe your role and responsibilities within the Organization?
2. Could you please describe your role and responsibilities within the Reverse Logistics and Reuse Department?
3. Have you had a chance to review the developed framework for managing urgent defects using an IS-based standardized process?
4. Can you briefly describe your understanding of the framework?
5. Do you think the framework addresses the key aspects of managing urgent defects in your organization?
6. Are there any critical areas or factors that you feel are missing from the framework?
7. How practical do you find the proposed framework for implementation within your department or organization?
8. What potential challenges do you foresee in implementing this framework?
9. Do you have any specific suggestions or recommendations to improve the framework?
10. Do you think this framework and its factors are useful for other high-tech companies?
11. Are there any additional comments or feedback you would like to provide?

Appendix-H: Triple bottom line performance evaluation of RL

A sustainability framework known as the Triple Bottom Line assesses a high-tech company's performance using three main citeria: social, environmental, and economic. This strategy encourages companies to think about their wider impact on society and the environment in addition to traditional financial metrics (Agrawal et al., 2016).

Therefore to evaluate the performance of RL business process, the various factors in the technological context, organizational context, and external environmental context identified in Table 5.1 can be further clustered into three key criteria: economic performance, environmental performance, and social performance considering sustainability and are categorized as follows:

1. Economic Performance: The financial performance of an organization is the main emphasis of this dimension. It takes into account metrics like cost effectiveness, profitability, and return on investment. Making sure the business makes enough money to support its operations and give shareholders their money back is the aim (Agrawal et al., 2016).
2. Environmental Performance: This facet evaluates how high-tech companies affect the environment. It comprises standards like energy usage, waste minimization, and recycled material utilization. High-tech companies are urged to implement strategies that reduce their environmental impact and support the conservation of natural resources (Agrawal et al., 2016).
3. Social Performance: This aspect assesses how high-tech companies affect society. It covers things like stakeholder participation and stakeholder benefits. The goal is to guarantee that the high-tech company conducts its operations in a socially responsible manner, improving the welfare of its customers, employees, and the community at large (Agrawal et al., 2016).

The Triple bottom line framework is particularly relevant in the context of RL, as it helps companies assess and improve their performance across all the three criteria mentioned. By integrating Triple bottom line framework, high-tech companies can achieve sustainable development and long-term success (Agrawal et al., 2016).

The Triple bottom line framework as per Agrawal et al. (2016) can be seen in Figure H.1.

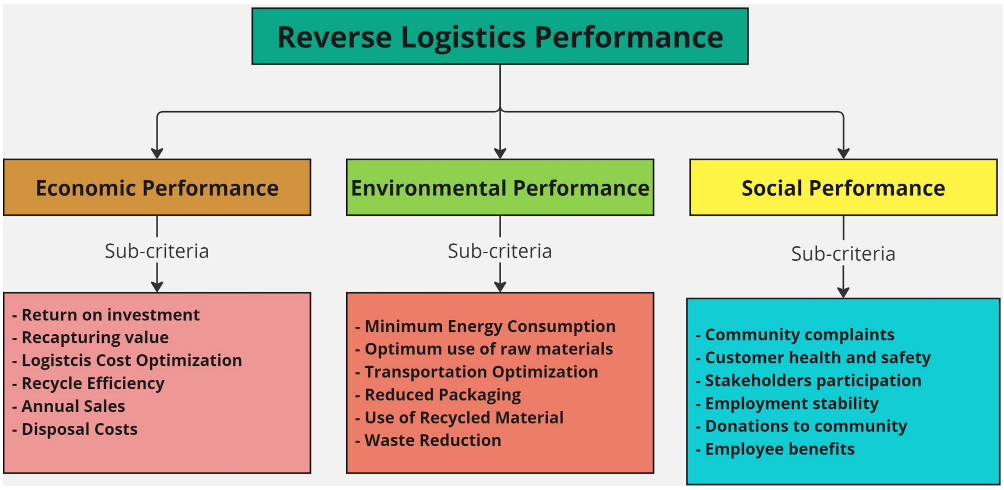


Figure H.1: Triple bottom line performance evaluation of RL (Agrawal et al., 2016)

The Triple bottom line framework in Figure H.1 provides evaluation of RL performance in three criteria namely the economic,environmental, and social performances. The various sub-criteria considered under each criteria can also be seen in Figure H.1.