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ENHANCING MULTI-PROJECT MANAGEMENT THROUGH PRODUCT MANAGEMENT INTEGRATION

Case study

Master of Science Thesis
Faculty of Management and Business
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May 2024

ABSTRACT

Jesse Marttila: Enhancing Multi-Project Management Through Product Management Integration
Master of Science Thesis
Tampere University
Master's Degree Programme in Industrial Engineering and Management
May 2024

This research focuses on the integration of product and project management in manufacturing companies operating within a multi-project environment. This integration is crucial for enhancing efficiency, reducing resource conflicts, and aligning project activities with organisations' strategic goals. The study addresses the problem of inefficient project and product management integration within MPEs, where multiple projects compete for shared resources, often leading to conflicts and suboptimal outcomes in projects and in the new product development. The scope includes examining current project and product management practices, identifying areas for optimisation, and proposing a framework that integrates product and project management processes to better support companies' strategic objectives.

The key focus areas of this research include identifying the existing challenges in project management practices, optimising resource management, and examining the integration of a new approach to product management and the project management process in the target company of this research. Through targeted interviews and analysis, the study highlights the importance of structured management practices and adaptive strategies to align internal processes with external stakeholder requirements. The findings underscore the critical role of communication and collaboration in managing multi-project environments, ensuring successful project outcomes and competitive advantage.

The research was conducted as a qualitative case study with a deductive approach. Data was collected by semi-structured interviews with key persons of the target company. The interview questions were developed based on the research objectives and the insights gained from the literature review. Interviews were recorded, transcribed, and thematically coded to identify recurrent patterns and unique responses. In the analysis the findings of the interviews were compared with the existing literature in order to draw up concrete insights and recommendations.

The study identified several key findings, including the critical need for clear communication and collaboration both internally and with customers to optimize the integration of project and product management. Effective resource allocation and schedule management were found to be necessary to align parallel projects and new product development schedules, reduce resource overload and increase efficiency. In addition, the introduction of predetermined evaluation practices and structured management frameworks was emphasised as necessary to improve process discipline and thereby also to ensure operation in accordance with the goals of product management.

This research contributes to the body of knowledge by providing a comprehensive framework for integrating project and product management within MPEs. It highlights the importance of clear communication, flexibility, and structured management practices. Practically, the findings offer actionable recommendations for organisations to enhance their project and product management processes, ensuring better alignment with strategic goals and improved project outcomes. The study also lays the groundwork for future research to further refine and build upon this integration model.

Keywords: project management, multi-project management, product management, multi-project environment, new product development.

TIIVISTELMÄ

Jesse Marttila: Moniprojektinhallinnan tehostaminen tuotehallinnan integroinnin avulla
Diplomityö
Tampereen yliopisto
Tuotantotalouden diplomi-insinöörin tutkinto-ohjelma
Toukokuu 2024

Tämä tutkimus keskittyy tuote- ja projektinhallinnan integrointiin valmistavissa yrityksissä, jotka toimivat moniprojektiympäristössä. Tämä integraatio on ratkaisevan tärkeää tehokkuuden parantamiseksi, resurssikonfliktien vähentämiseksi sekä projektitoiminnan ja organisaatioiden strategisten tavoitteiden yhteensovittamiseksi. Tutkimus käsittelee ongelmaa, joka liittyy tehottomaan projekti- ja tuotehallinnan integraatioon moniprojektiympäristöissä, joissa useat projektit kilpailevat jaetuista resursseista, mikä usein johtaa konflikteihin ja epäoptimaalisiin lopputuloksiin projekteissa sekä uusien tuotteiden kehittämisessä. Tutkimuksen laajuus kattaa projekti- ja tuotejohtamiskäytäntöjen tarkastelun, optimointikohteiden tunnistamisen sekä tuote- ja projektinhallintaprosessit yhdistävän, paremmin yritysten strategisia tavoitteita tukevan viitekehyksen ehdottamisen.

Tämän tutkimuksen keskeiset painopistealueet ovat olemassa olevien projektinhallintakäytäntöjen haasteiden tunnistaminen, resurssienhallinnan optimointi sekä tuotehallinnan uuden lähestymistavan ja projektinhallintaprosessin integroinnin tarkastelu tämän tutkimuksen kohdeyrityksessä. Kohdennettujen haastattelujen ja analyysin kautta tutkimus korostaa jäsenneltyjen hallintakäytäntöjen ja sopeutuvien strategioiden merkitystä sisäisten prosessien linjaamiseksi ulkoisten sidosryhmien vaatimusten kanssa. Tulokset korostavat viestinnän ja yhteistyön kriittistä roolia moniprojektiympäristöjen hallinnassa, onnistuneiden projektien tulosten ja kilpailuedun varmistamisessa.

Tutkimus toteutettiin laadullisena tapaustutkimuksena deduktiivisella lähestymistavalla. Data kerättiin puolistrukturoiduilla haastattelemalla kohdeyrityksen keskeisiä henkilöitä. Haastattelukysymykset kehitettiin tutkimustavoitteiden ja kirjallisuuskatsauksesta saatujen tietojen perusteella. Haastattelut nauhoitettiin, litteroitiin ja koodattiin teemoittain toistuvien mallien ja ainutlaatuisten vastausten tunnistamiseksi. Analyysissä verrattiin haastatteluiden löydöksiä olemassa olevaan kirjallisuuteen konkreettisten näkemysten ja suositusten laatimiseksi.

Tutkimuksessa tunnistettiin useita keskeisiä löydöksiä: kriittinen tarve selkeälle viestinnälle ja yhteistyölle sekä yrityksen sisällä että asiakkaiden kanssa projekti- ja tuotehallinnan integraation optimoimiseksi, tehokas resurssien allokointi ja aikataulun hallinta ovat välttämättömiä projektien ja uusien tuotteiden kehittämisen aikataulujen linjaamiseksi, resurssien ylikuormituksen vähentämiseksi ja tehokkuuden parantamiseksi; ja ennalta määrättyjen tarkastuskäytäntöjen ja jäsenneltyjen hallintakehysten käyttöönotto korostui prosessikurin parantamiseksi ja tuotehallinnan tavoitteiden linjaamiseksi.

Tutkimuksessa tunnistettiin useita keskeisiä havaintoja, mukaan lukien kriittinen tarve selkeään viestintään ja yhteistyöhön sekä sisäisesti että asiakkaiden kanssa projektin ja tuotehallinnan integroinnin optimoimiseksi. Tehokas resurssien allokointi ja aikataulujen hallinta todettiin tarpeellisiksi rinnakkaisten projektien ja uusien tuotteiden kehitysaikataulujen yhteensovittamiseksi, resurssien ylikuormituksen vähentämiseksi sekä tehokkuuden lisäämiseksi. Lisäksi ennalta määrättyjen arviointikäytäntöjen ja strukturoitujen johtamisen viitekehysten käyttöönottoa korostettiin välttämättömänä prosessikurin parantamiseksi ja sitä kautta myös tuotehallinnan tavoitteiden mukaisen toiminnan varmistamiseksi.

Tämä tutkimus edistää tietämystä tarjoamalla kattavan viitekehyksen projekti- ja tuotehallinnan integroimiseksi moniprojektiympäristöissä. Se korostaa selkeän viestinnän, joustavuuden ja jäsenneltyjen hallintakäytäntöjen merkitystä. Käytännössä löydökset tarjoavat toimivia suosituksia organisaatioille projekti- ja tuotehallintaprosessien parantamiseksi, strategisten tavoitteiden paremman linjaamisen ja projektitulosten parantamisen varmistamiseksi. Tutkimus luo myös pohjan tulevalle tutkimukselle tämän integraatiomallin edelleen kehittämiseksi sekä laajentamiseksi.

Avainsanat: projektinhallinta, moniprojektinhallinta, tuotehallinta, moniprojektiympäristö, uusien tuotteiden kehittäminen.

PREFACE

The journey to this point has been both challenging and rewarding, shaped by numerous individuals who have provided invaluable support and guidance along the way. I would like to take this opportunity to express my deepest gratitude to those who have made this work possible.

Firstly, I would like to extend my deepest thanks to my academic advisor, Tuomas Ahola, whose expertise and encouragement have been essential throughout this research process. Your insights and guidance have profoundly shaped the direction and quality of this work.

I would also like to acknowledge the participants from the target company and other stakeholders involved in my research. Your willingness to share your experiences and insights has been crucial to the success of this study. Without your cooperation, this research would not have been possible.

Conducting this research has offered a valuable opportunity to deepen my expertise in project and product management. My personal motivation for this research stems from a longstanding interest in improving organisational efficiency through effective management practices. This journey has not been without its challenges, but each obstacle has provided valuable learning experiences and contributed to the depth and overall quality of this study.

As I present this thesis, I hope it serves as a meaningful contribution to the field of project and product management and inspires future research and innovation. This work is dedicated to everyone who provided their support and encouragement throughout this journey, enabling me to reach this milestone.

Tampere, May 19th, 2024

Jesse Marttila

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LIST OF SYMBOLS AND ABBREVIATIONS

BOM	Bill of Material
CAE	Computer Aided Engineering
CFD	Computational Fluid Dynamics
CPM	Critical Path Method
C&L	Collaborative and Lean
DFMEA	Design Failure Mode and Effect Analysis
DMAIC	Define, Measure, Analyse, Improve, and Control
DVP	Delivery Versus Payment
ETO	Engineering-to-Order
GAGR	Compound Annual Growth Rate
IRIS	International Railway Industry Standard
JIT	Just-In-Time
MPE	Multi-project Environment
MSA	Measurement System Analysis
NPD	New Product Development
OEM	Original Equipment Manufacturer
PFD	Process Flow Diagram
PFMEA	Process Failure Mode and Effects Analysis
PLM	Product Lifecycle Management
QA	Quality Assurance
RCMPSP	Resource-Constrained Multi-Project Scheduling Problem
RCPSP	Resource-Constrained Project Scheduling Problem
RFQ	Request for Quote
VA	Value Analysis
VSM	Value Stream Mapping

1. INTRODUCTION

Globalisation has significantly increased competition, fostered international collaboration, and amplified reliance on complex supply chains in the rolling stock industry (Milewicz et al., 2023). It has driven market growth and adaptation to global opportunities (Gardner et al., 2023). The industry, crucial for economic growth and sustainable transport, is transforming through technological advancements and the demand for efficient, sustainable solutions (Gardner et al., 2023). This reshaping introduces new challenges and opportunities.

The global rolling stock market is projected to grow until 2030, driven by urbanisation, network extensions, technological progress, and a focus on sustainable transport, with an expected CAGR of 4%-6% from 2023 to 2030. The European market is expected to grow by 2%-3% annually (Gardner et al., 2023). Globalisation also brings complex challenges in **multi-project environments** (MPEs), requiring nuanced project management and strategic decision-making (Habibi et al., 2023).

Supplier companies, crucial to **original equipment manufacturers** (OEMs), face challenges and opportunities. Success requires understanding of market dynamics, strategic planning, and developing a competitive edge (Mahapatra et al., 2019). Suppliers must cultivate advantages through technological upgrades, robust stakeholder relationships, product innovation, and adapting to global market demands (Mahapatra et al., 2019).

Operating in MPEs is the norm for OEMs suppliers. The simultaneous management of multiple projects poses unique challenges, such as project scheduling and material ordering problems, resource allocation challenges, scheduling conflicts, and communication across diverse teams (Habibi et al., 2023). This dynamic setting demands a nuanced approach to project management and strategic decision-making to ensure the successful delivery of projects amid global complexities.

Suppliers must create and maintain a competitive advantage for sustainable growth and profitability (Mahapatra et al., 2019). They should focus on technological advancements, building strong stakeholder relationships, fostering product innovation, and adapting to global market demands (Mahapatra et al., 2019). A holistic approach combining technological and operational excellence with strategic partnerships will strengthen their position in the dynamic industry landscape.

1.1 Background of the study

In the rolling stock industry, currently undergoing significant transformations due to global collaboration and investments, key trends such as sustainability, digitalisation, safety, enhanced customer experiences, and stronger global connections, which are shaping the future (Moment, 2023). The market (Table 1), dominated by about 20 key companies holding 80% of the rolling stock market, is consolidating through strategic acquisitions and alliances (Mordor Intelligence, 2023). This volatility increases pressure on OEM suppliers to maintain competitive advantages.

Table 1. Global forecast for rolling stock industry (adapted from Gardner et al., 2023, p. 36).

Region	Share Demand for Rolling Stock 2017-2019	CAGR 2021-2023	CAGR 2023-2030
Europe	29%	2.30%	**4.2-6.0%**
Asia Pacific	44%	2.60%	
Middle East and Africa	4%	4.00%	
CIS	8%	n. a.	
North America	14%	2.50%	
Latin America	1%	4.10%	

Suppliers face environmental pressures, technological advances, and complex interfirm relationships (Habibi et al., 2023). The demand for sustainable technologies, like those reducing noise and emissions, benefits suppliers moving towards greener solutions (Milewicz et al., 2023). Multi-tier supply chain dynamics, business contingencies, and dependencies impact suppliers' bargaining power and governance (Mahapatra et al., 2019). Supplier strategies must adapt to product life cycles, complexity, and supply chain structures to enhance their market position. Suppliers often face collaboration issues with OEMs, affecting their operational responsibilities and supply chain coordination, especially with urgent orders or shifts in demand (Gardner et al., 2023; Habibi et al., 2023).

Contractual ambiguities often lead to disputes, highlighting the need for balanced OEM-supplier relations. Increasing competition pushes suppliers to seek cost-effective and environmentally friendly solutions (Habibi et al., 2023; Gardner et al., 2023). Product innovation is essential for quality and competitive advantage, while managing material delivery schedules and controlling demand variations is crucial for maintaining market positioning (Osadchiy et al., 2021; Shurrab & Jonsson, 2023). In conclusion, the diverse factors influencing OEM suppliers necessitate robust product and project management practices.

1.2 The target company of this study

This study examines a company that supplies mainly interior train door systems to OEMs in the rolling stock industry, specialising in clients that range from regional to global scale operations. This places the company within a diverse and extensively global business environment, dealing with clients of varying sizes, cultural backgrounds, and geographic locations. Within the rolling stock industry's value chain, depicted in Table 2, the target company is a Tier 2 supplier, providing components to Tier 1 companies that assemble the final rolling stock. The chain includes suppliers from raw materials to system integrators who produce the final trains for leasing companies and operators.

Table 2. Generic overview of the value chain of the rolling stock industry (adapted from Gardner et al., 2023 p. 18).

Tier 3	Tier 2 (the target company)	Tier 1	Customer
• Raw materials and alloys suppliers (e.g. metals, glass, plastic, rubber) • Intermediate products suppliers (i.e. brake parts, wirings, sensors)	• Structural component (bodies, brakes, suspensions) • Electrical, electronic, and diagnostic components (transformers, inverters, rectifiers) • Traction components (engines, generators, cooling equipment)	• System integrators of self-propelled and non-self-propelled vehicles. System integrators are also original equipment manufacturers (OEM), namely firms that take all the subcomponents from tiers 2 and 3 and produce and sell the train.	• Rolling stock leasing companies • Passenger and freight rail operators

Despite its modest size compared to the large, global OEMs it serves, the target company plays a crucial role in supporting innovation and manufacturing efficiency with its project deliveries. The significant size disparity often challenges the company's influence over operational methodologies, requiring adaptability to the OEM clients' diverse workflows (Mahapatra et al., 2019). This dynamic and challenging situation also presents opportunities to secure a competitive edge (Osadchiy et al., 2021).

In many cases, the deliveries of the target company are of significant size and the products are customised during the projects to meet the specific needs of each customer. The company's operational processes are often strongly centred around new product development, which underscores the need for the company to focus on their product management in addition to their project management process. The following section outlines the different types of projects identified within the company.

The company's projects can be classified into three distinct categories:

- Projects involving the resale of previously developed products. These projects do not place much of a load on the design and project organisation, and their schedules and costs are highly predictable.
- Projects involving the resale of previously developed products with minor modifications. These projects impose a moderate load on the design and project organisation, with schedules and costs being relatively predictable. These projects often include new product development on component level.
- Projects involving the design of entirely new products, i.e., new product development projects. These projects impose a significant load on the design and project organisation, making the prediction of schedules and costs challenging.

Projects are generally well-recognised according to the above categorisation, allowing for workload anticipation and enabling the company to accommodate potential forecasting errors reasonably well. However, the greatest challenge lies in the projects with product development, where workload predictability is currently very difficult. When multiple product development centric projects are running concurrently or in parallel, as they typically are in MPE, it poses challenges in operational forecasting.

Project management, product management, and MPE are closely interlinked within the company. Effective project management ensures that individual projects are delivered on time, within budget, and to the desired quality. Product management, on the other hand, focuses on the lifecycle of a product from conception through to delivery and beyond, ensuring that the product meets market needs and generates value for the company. In an MPE, where several projects are executed simultaneously, the complexity increases. Coordination and prioritisation become crucial to avoid resource conflicts, manage dependencies, and ensure that strategic objectives are met.

Integrating project and product management practices is essential for handling the demands of an MPE. This integration allows for a holistic approach to managing the development and delivery of products, balancing short-term project goals with long-term product strategy. It also provides a framework for better decision-making and resource allocation, enhancing the company's ability to respond to changes and uncertainties.

As previously mentioned, the company's customers are primarily large OEM companies. Consequently, the company's own business is relatively small compared to the major players in the industry, making it a part of a long supply chain. This situation typically leads to significant fluctuations in the company's workload. Additionally, the size disparity

between the company and its customers creates a dynamic where it is challenging for the smaller company to influence the operational models of the larger corporate clients. As a result, the necessary changes must occur within the company itself. The challenge, therefore, is to determine the methods by which the situation can be better managed within project and product management.

In conclusion, addressing these challenges requires a comprehensive understanding of the interplay between project management, product management, and the dynamics of a multi-project environment. Developing effective strategies to manage these areas will enable the company to improve operational efficiency, better predict workloads, and ultimately deliver greater value to its customers.

1.3 Research problem, objective, and scope

This study evaluates how the target company can enhance its project management process in anticipation of a new product management approach that has been decided to be adopted. As the company refines its product management, it is essential to assess and possibly refine the project management process. This proactive adjustment ensures that both systems support and enhance each other, promoting growth and competitive advantage.

Problem definition: The target company faces challenges in maintaining predictable timelines and budget control, especially in projects demanding extensive product development. Managing multiple ongoing projects at various stages of maturity adds complexity. With the adoption of a new product management strategy, reassessing the existing project management process is crucial to mitigate these challenges and improve project execution.

Research objective: The primary objective is to explore necessary adjustments and developments within the project management process to support the new product management approach. The study aims to identify key elements and strategies to ensure alignment between project management processes and the new product management approach, enhancing efficiency and project success.

To achieve this, the research addresses the following question and sub-questions:

Research question and its sub-questions:

- What specific elements of the current project management process can be optimised to better support the integration and effectiveness of new product management approach?

- What are the key components of the company's existing project management process, and how effectively do they align with and support the goals of current product management practices?
- Which aspects of the project management process require proactive modifications to better accommodate and enhance the effectiveness of the new product management practices?
- What proven project management best practices should the company consider adopting or adapting to effectively complement and maximise the benefits of its new product management practices?

The main question sets the broad agenda for the research by focusing on optimisation of the project management process in the context of supporting new product management strategies. It asks for specific elements to be identified, which directs the study towards actionable insights that can improve the integration and effectiveness of project and product management. Additionally, by addressing these specific elements, the research can pinpoint strategic changes that directly influence the success of product management initiatives.

The first sub-question aims to analyse the structure and operation of the current project management process, focusing on its compatibility and integration with existing product management practices. This question aims to give a comprehensive baseline for the latter part of this study and a point of comparison. This evaluation is crucial for understanding where optimisations might be needed and forms the basis for subsequent recommendations.

The second sub-question is dedicated to pinpointing specific areas within the project management process that need adjustments or enhancements to support the newly adopted product management approach effectively. This sub-question also dives deeper into the proactive aspect of optimisation. It looks for areas within the project management process that not only need adjustments but should also anticipate future demands. This proactive approach ensures that the process remains relevant and effective in supporting evolving product management strategies.

The third sub-question seeks to identify and evaluate external project management best practices that could be integrated into the company’s existing process, ensuring it is well-equipped to support the new product management approach. This sub-question extends the main question by seeking specific, proven best practices that could be integrated into

the current process. The focus on practices that complement and maximise benefits directly supports the aim of optimising the process to enhance new product management strategies.

Together, these questions are designed to guide a comprehensive analysis of the company's project management process. By examining the current situation, identifying areas for improvement, and looking for external best practices to implement, this study aims to create a solid foundation for enhancing the company's project management practices. The goal is to ensure that the project management process not only fits, but also actively supports and promotes the new product management approach, which drives the company towards greater efficiency, effectiveness, and competitive advantage in the global market.

Research scope: This study aims to thoroughly examine the project management process of the target company that serves as a supplier to large OEMs and give enchantment suggestions to target company. It will assess current project and product management practices, identify effective areas and challenges, and explore the impact of OEM client demands. The goal is to propose strategic modifications to the project management process, supporting a more effective product management approach and considering both internal and external operational environments.

This study specifically focuses on optimising the project management process in relation to product management practices and external OEM influences. It excludes organisational change management strategies and psychological aspects of project management, such as team dynamics and employee satisfaction. These areas are beyond the scope of this research, which aims to link operational practices with client demands and strategic product development outcomes.

1.4 Structure of this research report

This sub-chapter outlines the research report, detailing the structure and linkage of subsequent chapters. It highlights how each chapter addresses the research issue and meets established goals, aiding readers in navigating the research narrative and preparing them for detailed discussions and analyses. The report provides a comprehensive analysis of the project management process within the target company, organised into key chapters for logical flow and clear understanding.

Chapter one sets the context with background information on the company’s operating environment, its positioning, and its relationship with OEMs. It defines the research problem, objectives, significance, and scope. Chapter two continues from there and reviews

relevant theories and previous research on project management frameworks, multi-project management, and product management dynamics, establishing the study's context and identifying gaps this research aims to address. This theoretical foundation helps establish the study's context and highlights gaps in the existing literature that this research aims to address.

Chapter three describes the research design, strategy, and methods for data collection and analysis, ensuring robustness and reproducibility. It covers participant selection, interview template development, and data analysis techniques. After this, chapter four introduces findings from interviews with key stakeholders, organised by themes identified during analysis, providing a structured presentation of the data.

Chapter five discusses the results, linking them back to the literature review and the research questions. This chapter interprets and contextualises the findings within the framework of the existing literature and theories previously discussed in the thesis. It examines the implications of the findings, exploring how the data contributes to our understanding of optimising project and product management processes in supplier-OEM contexts.

The sixth and final chapter provides a comprehensive summary of the research conducted, highlighting the key findings and their implications. It synthesises the research process, discusses contributions to both theoretical and practical knowledge, and offers practical recommendations for enhancing project management and product development within the target company. Additionally, it reflects on the research journey, acknowledging the study's limitations and suggesting directions for future research to further explore and address the complexities identified.

2. LITERATURE REVIEW

As it was presented in the introduction chapter of this study, in a modern business management landscape, the confluence of project and product management emerges as a critical point for the successful implementation of innovative efforts and strategic goals especially in the manufacturing industry. This theory part of this study serves as a foundation that lays the groundwork for a more in-depth study of the fundamentals and advanced principles of both project and product management. Through a carefully structured review, we delve into the complexities and best practices of these areas, at the same time observing their confluences.

In the realm of project management, focusing on the management of a single project requires a detailed understanding of the specific challenges and methodologies that ensure successful project completion (Artto & Kujala, 2008). In a modern project environment with its uncertainties and complexities, project management is a cornerstone discipline that focuses on the planning, implementation, and completion of projects (Apaolaza & Lizarralde, 2020). It includes a wide range of different methodologies and frameworks designed to ensure that projects are delivered within defined scope, time, and budget constraints (Project Management Institute, 2017, p.10-11). Nowadays the nature of MPEs has also added complexity to project management, therefore also requiring more sophisticated strategies to manage concurrent projects without compromising efficiency or effectiveness (Habibi et al., 2023). However, before examining the special features of a multi-project management, it is worth examining project management from the perspective of an individual project.

2.1 Project management

Understanding the foundation of project management is essential for any project manager aiming to lead successful projects. One of the features of modern project management environment are uncertainty and change, which are strongly influencing the way that project management works (Apaolaza & Lizarralde, 2020). In addition to uncertainty and an atmosphere of change, project management needs to consider several other environmental factors that have an effect on the way that projects needs to be managed. Project managers must be able to navigate through challenges through, for example, careful scheduling, managing overlapping tasks, and possibly managing internal resource limitations (Wauters et al., 2015). As Artto and Kujala (2008) highlight, the importance of integration management, scope management, schedule management, cost

management, resource and personnel management, communication management, risk management, procurement management, and quality management are all important for effective project management.

Based on the basic principles of project management, it is important to also recognise the dynamic challenges of modern project environments, which are characterised by uncertainty and rapid change. As Apaolaza and Lizarralde (2020) point out, these factors require a shift towards more flexible and adaptive project management practices. Environmental factors, technological advances, and internal resource constraints force project managers to further refine their strategies to ensure effective scheduling and resource management (Wauters et al., 2015). This chapter deals with the basic principles of project management, starting with the basics, followed by careful planning and implementation, and finally looks at the management of project risks and quality, which are one of the most critical overall picture factors to secure project results.

2.1.1 Foundation of project management

Project management is an essential discipline that is used in various industries to ensure the systematic planning, implementation, and delivery of projects. This chapter examines the basic concepts of project management, defines what a project is, its importance in achieving business goals, and the critical roles and responsibilities of the project manager. In addition, it outlines five key process groups that structure the project management lifecycle.

Project management is planning, organising, and tracking company initiatives called projects that generate revenue or contain costs (Dinsmore, & Cabanis-Brewin, 2014, p. 19-20). A project is defined as a temporary attempt to create a unique product, service, or result. Projects differ from routine activities due to their limited duration and certain goals, which, when achieved, mean completion. Projects are driving change in organisations and bring added value by enabling adaptation to market requirements and new technologies. (Project Management Institute, 2017, p. 4-8; Dinsmore, & Cabanis-Brewin, 2014, p. 19-20.) All this creates a starting context of a project, which is setting the goals for project (presented in Figure 1).

Project management plays a crucial role, as it provides a framework that guarantees efficient use of resources, efficient handling of constraints, and alignment of project goals with the organisation's strategic goals. Effective project management leads to the successful completion of projects, meeting the expectations of stakeholders and achieving business goals. It also minimises risk, manages complexity, and maximises value creation throughout the project life cycle. (Kerzner, 2017, p. 2-6.)

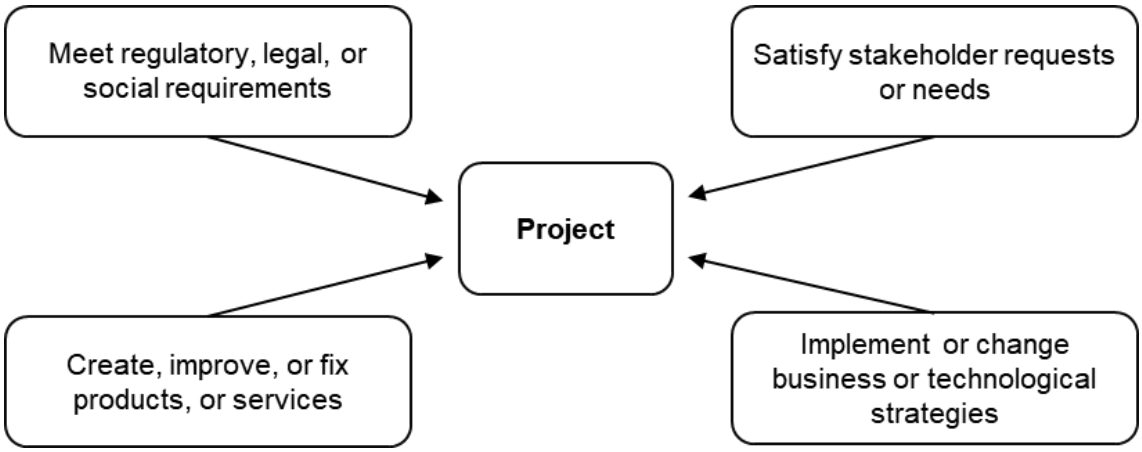

Figure 1. Project initiation context (adapted from: Project management institute, 2017, p. 8).

While project management itself provides the **project management framework for functions and operations**, project manager is responsible of leading the team to achieve the project objectives and to meet stakeholder expectations (Project Management Institute, 2017, p. 51-57). Project management is the interface among general management, operations management, and technical management, and it integrates all aspects of the project and causes the project to happen, and all this is managed by the project manager (Dinsmore, & Cabanis-Brewin, 2014, p. 22-23). Therefore, the project manager plays a key role in guiding the project from start to finish, and this role is clearly visible throughout the project. If one should describe project management with one word, the word would be integration (Dinsmore, & Cabanis-Brewin, 2014, p. 22-23).

The project manager navigates through challenges and ensures the project stays on track by modifying plans when it is needed to manage delays or scope changes. Project management competence can be divided in to the three different sections, which are technical project management, strategic and business management, and leadership. To support all these, especially leadership, communication, negotiation, and problem solving are important skills for a project manager. (Project Management Institute, 2017, p. 51-57.)

Projects are the driving force of many organisations in most industries, and project management's purpose is to control the time, resources, and budget of these projects (Dinsmore, & Cabanis-Brewin, 2014, p. 28). Project can be divided into five key subprocess groups, which are initiating, planning, executing, monitoring, and controlling and finally closing. The initiation process includes defining a new project or a new phase of an existing project by obtaining a permit to initiate the project. Key activities include identifying stakeholders, determining initial scope, and securing project sponsorship. In the planning phase, the scope, goals, and methods of operation needed to achieve the goals

for which the project was implemented are defined. Planning involves developing a management plan that integrates cost, timing, and resource allocation. The implementation process puts the project plan into action. It is characterised by the development of the team and the sharing of the information necessary for the performance in accordance with the project specifications. Monitoring and control involves monitoring, checking, and regulating project progress and performance. It identifies the areas where changes need to be made to the plan and initiates the corresponding changes. Finally, the project is concluded when all project goals have been achieved and the client or sponsor approves the final product. This group of processes ensures that all project work is completed, all contracts are closed, and the project evaluation is completed to capture lessons learned. (Project Management Institute, 2017, p. 18-20.) Throughout the whole process project management needs to ensure that project scope, time, cost, quality, resources, communication, risks, and procurement are managed with controlled manner (Dinsmore, & Cabanis-Brewin, 2014, p. 28).

To control all project management tasks previously mentioned, the communication infrastructure is the backbone of effective coordination, collaboration, and the overall success of project execution. This enables project managers to address the challenges posed by diverse project requirements and stakeholder expectations, ensuring that all parties are aligned and informed throughout the project lifecycle. (Nyameke et al., 2020.) . In order to successfully manage competing constraints such as project scope, quality, resources, costs, schedule and risks, project management must be able to support good communication between all stakeholders involved in these issues (Figure 2).

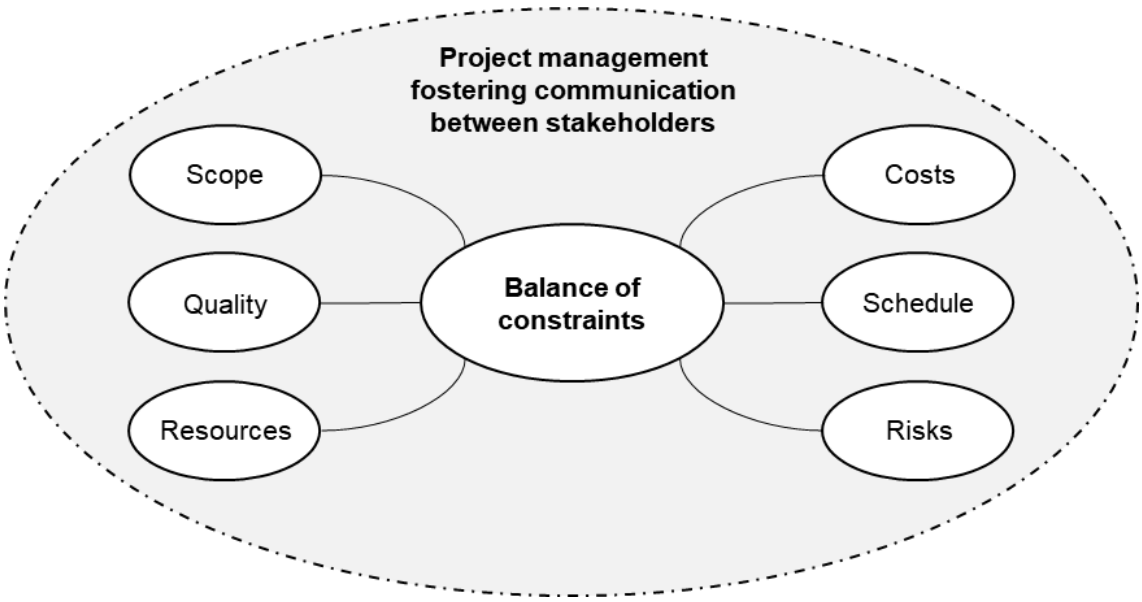

Figure 2. Competing project constraints (adapted from: Project Management Institute, 2017, p. 542).

All in all, project management is a complex entity that includes a large number of different competing constraints that must be efficiently handled parallel to each other by project management.

2.1.2 Planning and execution in project management

Effective planning and implementation form the basis of successful project management. These elements ensure that projects are not only structured but are also executable and align with broader business goals. Accurately defining the scope and objectives is foundational in project management, setting the stage for all future project activities. This clarity is crucial for guiding all subsequent decision-making and resource allocation. To be able to create this foundation for managing a project, project manager should be able to consider for example planning, resource allocation and budgeting, to be able to manage the project towards achieving the goals set for the project.

Aqlan and Al-Fandi (2018) highlight the importance of a systematic approach in planning by using a prioritisation framework that assesses workplace areas based on several criteria, including process time variation and workmanship defects. This enables project managers to identify key areas that offer the greatest potential for improvement, thereby aligning project selection with strategic business objectives (Aqlan & Al-Fandi, 2018). Furthermore, their research underscores the execution phase by providing a mechanism to assign personnel to projects, factoring in their skills and the resource constraints of the organisation. Such strategic personnel assignment is instrumental in maximising efficiency and enhancing project outcomes. This approach ensures that the planning and execution phases are interconnected, facilitating a seamless transition from project conception to realisation (Aqlan & Al-Fandi, 2018).

To consider the resource allocation from the perspective of total costs, Carvalho et al. (2015) discuss resource planning and budgeting within project management as a strategic process that requires a careful alignment of resources with project needs to optimise performance and cost-efficiency. Resource planning in this context involves not only scheduling and allocating workforce and materials, but also integrating flexible capacity options such as overtime, subcontracting, and adjustments through hiring or firing, directly affecting the project's budget (Carvalho et al. 2015).

When talking about project planning and resource allocation in projects, it does not end at the initiation phase, but adapting project plans and resources based on insights gained through monitoring is a very important skill for a project manager. This continuous adaptation is pivotal in maintaining project relevance and efficiency in dynamic environments. For example, Habibi et al. (2023) emphasise the importance of dynamic adjustment of

project plans and resources by incorporating the monitoring of real-time insights during project execution. They highlight that the integration of project scheduling and material ordering allows for ongoing adjustments to be made based on actual project needs and conditions, therefore optimising resource allocation and minimising risks associated with material shortages, resource allocation, and project delays.

2.1.3 Project scope, cost, and procurement management

Effective project management relies on the balanced integration of scope, cost, and procurement processes. Each of these elements plays a critical role in ensuring project success, as defined by the Project Management Institute (2017, p. 23-25) and Dinsmore and Cabanis-Brewin (2014, p. 28). This chapter delves into these three crucial areas, providing insights and practical approaches to managing them effectively.

Properly defining and understanding the project scope, especially in complex manufacturing environments, is essential for aligning team efforts and ensuring project success (Pacagnella, 2017). Project scope management involves defining and controlling what is and is not included in the project. It ensures that all necessary work is accounted for, and unnecessary tasks are excluded, thereby preventing scope to expand too much. The process begins with planning how the scope will be managed throughout the project lifecycle. This planning sets the foundation for gathering detailed requirements from stakeholders, which is critical for aligning the project's outputs with stakeholder expectations. (Project Management Institute, 2017, p. 129-131.)

A well-defined scope statement is then developed, which includes the project's objectives, deliverables, and boundaries, which is clarifying and helping in avoiding misunderstandings and ensures that all team members are on the same page (Project Management Institute, 2017, p. 154-155). By clearly defining the boundaries and goals of each project, alignment with the overall organisational objectives is ensured (Aqlan & Al-Fandi, 2018). The creation of a work breakdown structure further breaks down the deliverables into smaller, more manageable components, facilitating better control and oversight (Project Management Institute, 2017, p. 157-162).

Validating the scope involves obtaining formal acceptance of the completed deliverables from stakeholders, ensuring that the project outcomes meet the defined requirements (Project Management Institute, 2017, p. 163-167). Apaolaza and Lizarralde (2020) also note that maintaining the scope of the project under the pressures of changing conditions and unforeseen challenges is critical throughout the project. Continuous monitoring and control of the project scope are essential to manage any changes and keep the project within the agreed boundaries (Project Management Institute, 2017, p. 167-171).

Cost management ensures that the project is completed within the approved budget, which involves several key processes It begins with planning how to manage and control costs throughout the project, which includes establishing the necessary policies and documentation to guide cost-related activities. (Project Management Institute, 2017, p. 231-239.) This aspect is crucial in project management as it ensures that the project remains financially viable and cost-efficient, preventing cost overruns and enabling better budget control (Martín et al., 2020).

Estimating costs involves determining the monetary resources required for the project. Various techniques, such as analogous estimating, parametric estimating, and bottom-up estimating, are employed to derive accurate cost estimates (Project Management Institute, 2017, p. 240-247). Once the costs are estimated, they are aggregated to form the project budget, which also includes managing cash flow and funding requirements. Controlling costs in accordance with the budget is an ongoing process that involves monitoring project expenditure and performance against the budget. Earned value management, for example, is a widely used method to assess project performance, helping project managers to make informed decisions and take corrective actions as necessary. (Project Management Institute, 2017, p. 257-270.)

Closely linked with project cost management, procurement management deals with acquiring goods and services from external sources necessary to complete the project. The process starts with planning how procurements will be managed, including identifying potential sellers and documenting procurement decisions. (Project Management Institute, 2017, p. 459-461.) Procurement management is enhanced through strategic scheduling of material orders based on the specific needs of the project and the capabilities of suppliers. This approach includes managing lead times and leveraging quantity discounts offered by suppliers, effectively reducing both the risks and costs associated with procurement. (Habibi et al., 2023.) Conducting procurements involves obtaining responses from potential sellers, evaluating their proposals, and selecting the most suitable one. This stage may include advertising the procurement opportunity, conducting bidder conferences, and negotiating contracts (Project Management Institute, 2017, p. 483-483).

Once the contracts are awarded, controlling procurements becomes critical. This involves managing relationships with vendors, monitoring their performance, and making necessary adjustments to ensure compliance with the contract terms (Project Management Institute, 2017, p. 492-494). Finally, closing procurements involves completing and settling each contract, ensuring all work is finalised, and resolving any remaining issues (Project Management Institute, 2017, p. 499). By optimising the procurement schedule

with the production schedule, the demand for raw materials and components can be predicted more accurately, which aids in timely procurement, ensuring that materials are available when needed without excess inventory that can tie up capital (Martín et al., 2020).

Effective management of project scope, cost, and procurement is essential for the successful completion of any project. By adhering to the structured processes, project managers can ensure that projects are completed on time, within budget, and to the satisfaction of stakeholders. Integrating these processes harmoniously allows for better control, improved stakeholder satisfaction, and overall project success.

2.1.4 Risk and quality management in projects

Risk and quality management are also key areas in project management, and their goal is to anticipate potential challenges and maintain achievable standards throughout the project's lifecycle. To facilitate this, project managers utilise a variety of tools and techniques that align with industry best practices for thorough risk analysis and quality control. These practices enable project managers to effectively identify, analyse, and mitigate risks while ensuring that all project deliverables meet or exceed established quality criteria. The synergetic application of these practices not only enhances project security but also boosts stakeholder confidence in project outcomes. Combining controlled risk assessment with strict quality assurance measures is critical to avoiding uncertainties and achieving consistent project success. Through strategic planning and execution, these project management activities secure project outcomes and ensure that stakeholder expectations are satisfactorily met. (Project Management Institute, 2017, p. 271-276; Project Management Institute, 2017, p. 395-400.)

In their study on project management within manufacturing environments, Pacagnella et al. (2019) discuss the crucial roles of risk identification and risk management. The authors argue that successful project outcomes are greatly enhanced by the proactive identification and continual monitoring of potential risks. This is particularly crucial in environments where the cost of failure is high and the need for precision is highly important. Such strategic risk management practices significantly mitigate uncertainties and improve project outcomes by enabling effective planning and response mechanisms (Pacagnella et al., 2019). Additionally, their paper highlights the importance of maintaining strict control over technical performance to ensure adherence to project quality standards. Together, these practices show how essential risk and quality management is to achieving project efficiency and effectiveness.

Also, the article by Koppenhagen & Held (2021) provides valuable insights regarding risk and quality management in projects through its discussion on balancing economies of scale with the mitigation of risks associated with over-dependence on single suppliers. They propose a dual-focused awarding process for both development services and production volumes, which emphasises the strategic distribution of contracts to prevent supplier monopolisation and ensure supply chain resilience. This method underscores the delicate balance required in project management to maximise operational efficiency while managing potential vulnerabilities. This approach also reflects an integrated strategy that aligns risk management with quality assurance, demonstrating how projects can manage supplier relationships to both maximise efficiency and minimise risk (Koppenhagen & Held, 2021).

In summary, risk and quality management are not only supportive components of project management but they are central to its success. As we conclude this exploration of project management foundations, it is clear that integrating risk management and quality assurance into every phase of a project is essential for aligning with business objectives and satisfying stakeholder expectations. These practices form the foundation of effective project management, fostering resilience, ensuring compliance, and driving continuous improvement. As we transition into discussing multi-project environments in the next chapter, it's important to note that these environments introduce additional complexities and considerations that further necessitate refined planning, resource allocation, and risk and quality management strategies.

2.2 Fundamentals of multi-project management

To remain competitive in a dynamic project environment, which is changing with an accelerating rate, companies must embrace project management to constantly be able to create value for their customers (Project Management Institute, 2017, p.10-11). Today’s competitive markets also require companies to be able to constantly improve their operation processes (Aqlan & Al-Fandi, 2018). Constant development of processes and operations within the company is indeed one of the key factors to success in a modern project management environment.

The importance of continuous improvement, systematic planning, and effective resource allocation in achieving process efficiency and quality enhancements in manufacturing environments has been highlighted in many studies (Aqlan & Al-Fandi, 2018). In the core of project management is also different scheduling techniques, which together with effective resource management is minimising the duration of the project and maximising the resource efficiency (Ben Issa et al, 2021). Establishing clear project objectives in

single projects is crucial to guide the team, prevent unnecessary tasks, and mitigate conflict, directly enhancing project efficiency and success in multi-project managements point of view (Pacagnella et al., 2019).

Timely and accurate decision-making related to these different project management related tasks can significantly impact project success. For project-driven organisations managing this requires tactical planning, which includes medium-term decisions that align recourses with different project demands in different phases of the project. (Bzdyra et al., 2015.) While conducting a variety of tasks like scheduling, resource allocation and cost calculation, at the same time project management needs to be adaptive, flexible, and ready to react for the changes during the different phases of the project and consider their consequences to every area of the project (Chen et al., 2022; Carvalho et al, 2015).

When considering that companies need to be able to navigate in a constantly changing dynamic project environment (Project Management Institute, 2017, p.10-11), while simultaneously managing a vast variety of different tasks to ensure process efficiency and quality enhancements (Aqlan & Al-Fandi, 2018), it becomes quite clear that study proofed project management concepts, methodology and frameworks needs to be utilised to ensure successful project management.

2.2.1 Complexity created by a multi-project environment

When a company evaluates the project management practices that best suit them, considering their operating environment, MPE creates a completely new perspective on project management, because the parallel management of several projects has its own challenges. Usually, these parallelly ongoing projects share common resources, which increases the complexity of managing planning, scheduling, and resource allocation (He et al., 2022; Ben Issa et al., 2021). Therefore, the challenge of scheduling in multi-project environments, especially under uncertainty, requires innovative approaches (Chen et al., 2022). Managing this uncertainty is crucial for project success, especially in highly competitive and unpredictable environments (Apaolaza & Lizarralde, 2020).

Addressing uncertainty, especially concerning activity durations, is a fundamental aspect of project risk management (You et al., 2023). This involves the identification and strategic management of potential risks that could impact the project’s timeline, budget, or quality (Pacagnella et al., 2017; Vos et al., 2016). Effective risk management is crucial in MPEs, where uncertainty can significantly affect the project's ability to meet its objectives (Chen et al., 2022). By proactively managing risks, project managers can mitigate potential harmful effects on the project, ensuring a smoother path towards project completion and success (You et al., 2023; Pacagnella et al., 2017; Vos et al., 2016).

When company's operating environment includes uncertainty, the complexity of scheduling increases (Bzdyra et al., 2015). One of the keys to successfully managing scheduling of multiple parallel projects in the presence of this uncertainty is to categorise project activities based on their resource requirements and flexibility (Ben Issa et al., 2021). After successfully classifying different project tasks, resource management, which is critical part of project management, becomes easier and more predictable (He et al., 2022; Narayanan et al, 2020). To effectively manage this task-related decision making is crucial, especially in MPE (Ben Issa et al., 2021; Narayanan et al, 2020).

The challenges of managing projects in a multi-project environment highlight the necessity for robust communication systems. These systems are instrumental in facilitating the flow of information among project teams, stakeholders, and within the organisation. (Nyameke et al., 2020.) Especially in MPEs, where the exact operation times of different projects and tasks aren't always available, the communication between shareholders is important (Bzdyra et al., 2015). Effective communication is identified as a foundational element of successful project management, particularly in environments characterised by multiple concurrent projects (Nyameke et al., 2020).

The communication aspect of project management ensures that all project participants are equipped with the necessary information to make informed decisions and to address issues as they arise, thereby facilitating a collaborative and efficient project management environment (Nyameke et al., 2020). This communication aspect is a critical part of company project management control framework. Especially in MPE, the ability to develop a standardised project management control framework, considering different cultural environments present, is emphasised in achieving the efficiency and consistency of project results (de Waal & de Boer, 2017).

Figure 3 provides a detailed overview to clarify the challenges and complexities MPE in project management. At the centre, multi-project management symbolises the coordination of multiple projects, integrating activities, resources, and stakeholder interactions for successful outcomes. Surrounding this core are five key elements. First, project activity categorisation defines and categorises tasks based on their requirements, streamlining processes, and aiding efficient resource allocation and scheduling. Next, scheduling of parallel tasks involves planning and organising tasks executed simultaneously, ensuring optimal resource use and timely completion of projects. Internal and external resource allocation focuses on distributing resources among projects to prevent bottlenecks and conflicts, ensuring smooth progression.

Moreover, addressing communication challenges is vital. This emphasises robust communication systems for effective information flow among teams and stakeholders, which is crucial for alignment and informed decision-making. Finally, risk and control management identifies, assesses, and mitigates risks affecting timelines, budgets, or quality, which is essential for navigating uncertainties. Continuous monitoring and corrective actions are crucial for managing project complexities.

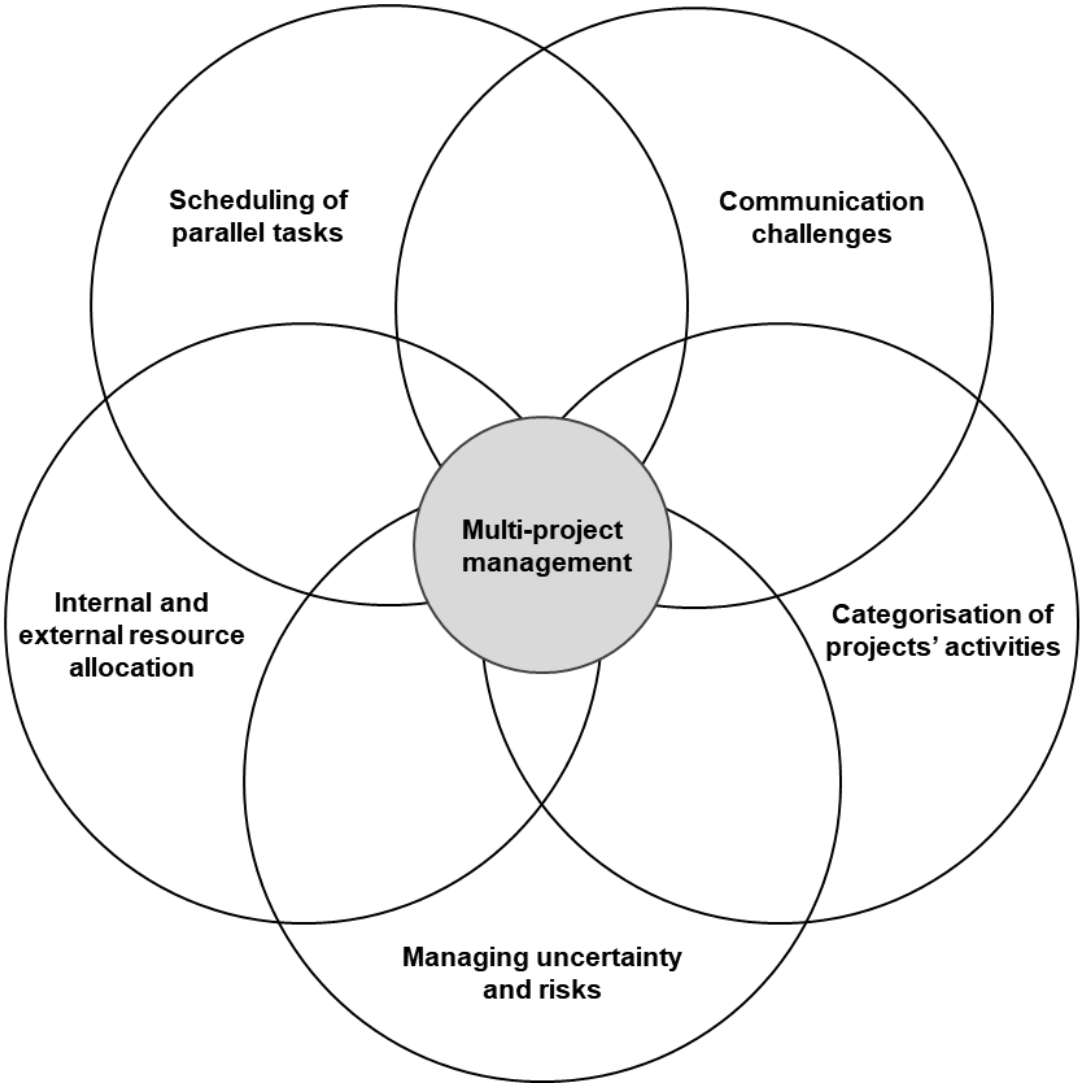

Figure 3. Overview of multi-project management characteristic (authors own elaboration).

By standardising the company's internal project management framework, resource costs can be minimised, and project delivery requirements can be met more efficiently through integrated planning and scheduling (He et al., 2022). Efficient multi-project management is shown to accelerate product development, reduce costs, and enhance quality, necessitating careful scheduling to manage overlapping tasks and competing resource demands (Wauters et al., 2015). One of the fundamental challenges in project management is indeed to efficiently allocate resource across projects (He et al., 2022).

2.2.2 Multi-project management challenges and solutions

Multi-project management practices must continually evolve to address the changing dynamics of project environments effectively (Apaolaza & Lizarralde, 2020). One of the key points is multi-project scheduling, which involves strategically coordinating multiple overlapping projects, each with distinct functions and shared resources, to optimise both individual project outcomes and overall resource utilisation (Wauters et al., 2015). The findings of Wauters et al. (2015) suggest that integrating learning-based methods can significantly enhance multi-project scheduling, offering a more dynamic and adaptive approach to managing complex project portfolios. This aligns with the fundamental project management principle of continuous improvement and adaptation to changing conditions, and also eases the resource allocation between different projects (Vos et al., 2016).

Embracing flexibility in project management methodologies to accommodate changes in project scope, timelines, and objectives is crucial in today's dynamic project environments (Vos et al., 2016). Most of the commonly known problems in project management are scheduling and resource allocation related problems (Gómez Sánchez et al., 2023). This combination of dynamic operating environment and challenges in scheduling and resource allocation further highlights the need for using researched project management methods when company is operating in an MPE.

Effective project management in a MPE requires combining local project scheduling with global resource coordination to ensure that projects are aligned with overall company goals and that resources can be allocated across multiple projects in the best possible way (You et al, 2024). To effectively manage projects in this kind of environment, companies need to recognise the challenges of their operations and seek for proven solutions. The challenge of scheduling is common, especially in environments where the duration of projects and the availability of resources are dynamic and can change, such as in the construction industry and other custom manufacturing industries (Ben Issa et al., 2021).

One of the most common scheduling challenge is resource-constrained project scheduling problem (RCPSP), which is a foundational problem in project management especially in MPE, where operation times are inherently imprecise (Bzdyra et al., 2015). Based on Bzdyra et al. (2015), it involves planning and scheduling project activities that are subject to limitations on resources and time. RCPSP refers to looking at the situation from the perspective of a single project, but in the case of operating in MPE, there are multiple parallel projects competing for the same resources. For example, Ben Issa et al. (2021) and Gómez Sánchez et al. (2023) have expanded the view in their studies to observe

the complexity added to the RCPSP by managing multiple projects simultaneously. This problem, where the view changes from a single-project view to a multi-project view, is called resource-constrained multi-project scheduling problem (RCMPSP) (Wauters et al., 2015; Ben Issa et al., 2021; Gómez Sánchez et al., 2023). The RCMPSP extends the RCPSP to multiple projects, including factors like local and global resources, priority relations, and varying project start times between projects (Wauters et al., 2015).

Bzdyra et al. (2015) propose a novel approach that addresses the complexity and uncertainty of scheduling in multi-project environments by incorporating imprecise operation times into the decision-making process. Gómez Sánchez et al. (2023) have suggested that the situation must be evaluated on case-by-case basis, and the most suitable option/options to be selected from algorithm-based exact methods, heuristic approaches, and metaheuristic approaches. In more detailed level Ben Issa et al. (2021) have proposed to categorise project activities to achieve greater flexibility in scheduling, potentially leading to more efficient use of resources and shorter project durations.

Based on the studies by Bzdyra et al. (2015), Ben Issa et al. (2021), Gómez Sánchez et al. (2023), and Wauters et al. (2015), it is clear that there is not one common solution for every situation, but the company's situation must be evaluated on case-by-case basis. After the evaluation, based on experience, a decision must be made about the best possible approach or combination of approaches to solve RCMPSP. Gómez Sánchez et al. (2023) also emphasise the constant need to develop more robust and efficient solution methods that can respond to increasing multi-project scheduling problems with increasing complexity, which highlights the need of constantly ongoing evolvement of project management operations (Apaolaza & Lizarralde, 2020).

Wauters et al. (2015) have highlighted that the decentralised decision-making would make notable improvements in scheduling efficiency and resource allocation across multiple projects compared to centralised scheduling approaches. However, this fragmentation of information and goals can lead to suboptimal decisions from a global perspective, as each project manager may not have access to or consider the global resource constraints and needs of other projects (You et al., 2024). This might evidently lead to conflicts and competition for resources between different projects (Wauters et al., 2015; You et al., 2024).

Wauters et al. (2015) present as a solution the role of a mediator, whose goal is to guide the decentralised decision-making process by evaluating tasks and arranging them on a timeline, also considering the global perspective in addition to the local perspectives of

single projects. You et al. (2024) propose a similar solution based on a two-layer decision-making model, where the local level makes independent scheduling, and then the global coordinator optimises these at the global level considering resources to minimise the total delay cost. In practice, this could mean that project managers of individuals projects make scheduling decisions on single project level (local level), and upper management reviews the scheduling suggestions presented by project managers and optimises the combined scheduling of multiple projects (global level) to minimise delay costs (You et al., 2024). You et al. (2023) have also studied this two-layer model and it is highlighted that the critical resources should be allocated to where they are most needed, thus reducing resource conflicts and improving project delivery times.

By integrating local and global decision-making layers, the allocation of shared resources is effectively manageable, conflicts can be reduced, and cooperation among decentralised units can be enhanced (Wauters et al., 2015; You et al., 2023; You et al., 2024). Through a two-layer decision making method project efficiency can be enhanced through innovative scheduling methods that considers also a multi-skilled staff (You et al., 2023).

The evolving landscape of multi-project management demands methodologies that adapt to dynamic project requirements and optimise resource allocation. Research highlights the shift from traditional project scheduling problems to the more complex multi-project contexts, necessitating a mix of solutions tailored to specific multi-project environments. The core challenges and innovative solutions for these are presented in Figure 4 below.

Decentralised multi-project scheduling emerges as a key strategy, addressing the challenges of distributed projects through decentralised decision-making and the critical role of two-level decision-making method in aligning local and global project objectives. This approach aims to minimise resource conflicts and enhance project efficiency by effectively managing shared resources and fostering cooperation among decentralised units. It acknowledges the potential for conflicts and competition for resources while proposing a framework that seeks to minimise these challenges through effective coordination and resource allocation.

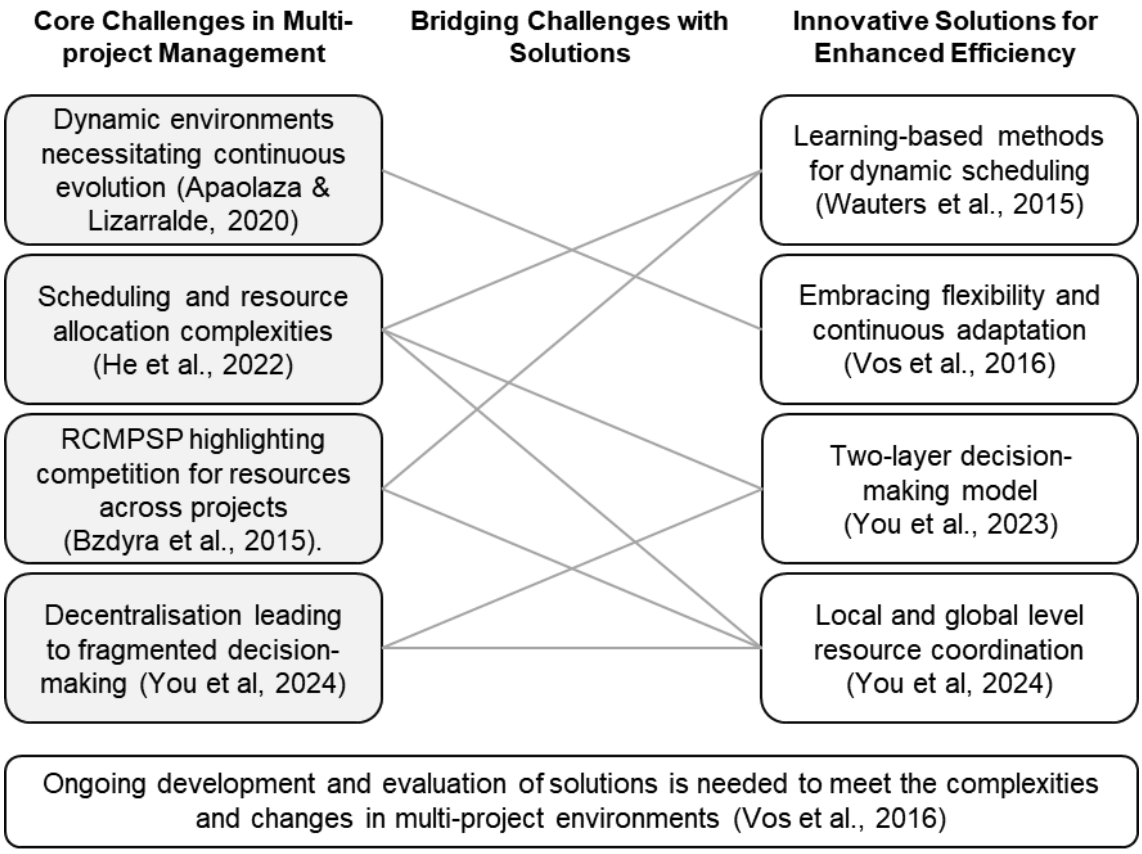

Figure 4. Multi-project management: challenges and evolution of solutions (authors own elaboration).

Overall, the research underscores the critical importance of evolving project management methodologies to address the complex, dynamic challenges of MPEs. The continuous advancement of project management techniques is vital for tackling the complexities of managing multiple projects. Leveraging innovative scheduling methods and strategic resource allocation, organisations can achieve greater project efficiency, aligning with overall company goals while adapting to the changing dynamics of project environments.

2.2.3 Best practices for multi-project management

The transition from identifying problems to applying specific solutions and practices encompasses the key principle of continuous improvement and adaptation. It involves embracing innovative strategies to address the complex and dynamic nature of multi-project environments. The history of project scheduling, from waterfall and Gantt charts to critical path methods, shows the foundational role of scheduling in project management, also emphasising consideration of resource limitations (Gómez Sánchez et al., 2023). The latest research emphasise the increasing importance of adaptive and flexible project management approaches, highlighting that the ability to adjust plans and processes in

response to evolving project demands and external factors is crucial for maintaining relevance and achieving success in rapidly changing environments (Vos et al., 2016).

Two out of the most widely known project management philosophies which support continuous improvement and adaptation are Lean and Six Sigma. Integrating Lean and Six Sigma philosophies in process improvement efforts has been underscored by Aqlan & Al-Fandi (2018) as a pivotal strategy for organisations aiming to enhance their operational efficiency and competitiveness in global markets. Lean, with its roots in minimising waste and optimising processes, coupled with Six Sigma's focus on reducing process variation and defects, offers a comprehensive approach to improving business processes. The combination of these methodologies not only emphasises their individual strengths but also addresses their limitations through a hybrid model known as Lean Six Sigma (Aqlan & Al-Fandi, 2018). This model combines the effectiveness of Lean in process flow optimisation with the rigorous statistical tools of Six Sigma to achieve superior process capabilities, further improving organisational performance across sectors.

The DMAIC (Define, Measure, Analyse, Improve, and Control) framework, a systematic procedure integral to Six Sigma, has been particularly highlighted by Aqlan & Al-Fandi (2018) for its effectiveness in identifying causes of defects and implementing corrective actions. Complementarily, Tuli & Shankar (2015) have demonstrated that the application of lean principles in new product development (NPD) processes, particularly in collaborative settings, significantly reduces non-value-adding activities. This reduction leads to shortened cycle times and less effort during NPD, supporting faster and more cost-effective product development.

The study by Tuli & Shankar (2015) also reveals quantitative and qualitative benefits such as improvements in design quality, team motivation, knowledge creation, schedule adherence, time to market, and risk mitigation. Furthermore, Apaolaza & Lizarralde (2020) add that when lean methodologies are properly implemented, they can significantly enhance project performance. This enhancement manifests through improved flow, reduced cycle times, and more effective management of uncertainty, illustrating the broad applicability and substantial benefits of integrating lean principles into project management and development practices (Apaolaza & Lizarralde, 2020).

This cross-pollination of ideas and methodologies between Lean and Six Sigma, enriched by the contributions of Tuli & Shankar (2015) and Apaolaza & Lizarralde (2020), underscores a holistic view towards process improvement and efficiency. By drawing on the strengths of each approach and applying them across different contexts, from manufacturing and service sectors to new product development and project management,

organisations can navigate the complexities of business environments more effectively. The findings of Apaolaza & Lizarralde (2020) suggest that lean methodologies, when properly implemented, can significantly enhance project performance by improving flow, reducing cycle times, and managing uncertainty more effectively. The collective insights from these studies present a compelling case for the adoption of Lean and Six Sigma methodologies, not only as tools for process improvement, but also as strategic imperatives for sustaining competitive advantage in today's dynamic business environment.

Additionally, methodologies such as Kanban, Just-In-Time (JIT), and Standard Work are pivotal within the Lean framework, which is playing a critical role in minimising variations and boosting consistency in processes, as Aqlan and Al-Fandi (2018) have outlined. Kanban, a scheduling system used in lean and just-in-time production, is designed to enhance work efficiency by restricting the number of work-in-progress items and improving flow within production processes (Hassan et al., 2023). This system also cuts operating costs by optimising inventory management and boosting supply chain efficiency (Hassan et al., 2023). Furthermore, the implementation of on-demand scheduling methods like Kanban markedly increases the speed and efficiency of project delivery (Apaolaza & Lizarralde, 2020). In their research, Apaolaza and Lizarralde (2020) highlight Kanban as a recommended on-demand scheduling practice for project management in highly uncertain and complex environments. JIT on the other hand is a strategic approach that focuses on improving manufacturing efficiency and reducing waste by timing the receipt of goods to only when they are needed in the production process, thus lowering inventory costs (Baals et al., 2023). JIT systems enable companies to swiftly adjust to changes in customer demands or market conditions, freeing them from the constraints of excessive inventory levels (Baals et al., 2023).

Another project management method which has lean-oriented components is Critical Chain Project Management (CCPM). It incorporates lean-oriented components to significantly improve upon traditional project management systems. This approach, highlighted by Apaolaza and Lizarralde (2020), is known for enhancing on-time delivery, visibility, simplicity of use, and effectiveness in handling uncertainty. By optimising resource allocation and prioritising the critical chain, CCPM can notably shorten project durations (Sembiring & Putra, 2020). Furthermore, managing project flow and reducing cycle times are crucial for responding effectively to market demands, as noted by Apaolaza and Lizarralde (2020).

One of the major contributors to project inefficiency is multitasking, which CCPM addresses by strategically sequencing tasks to prevent conflicts and encourage focused task execution. This approach not only enhances productivity but also decreases the

time needed to complete tasks (Sembiring & Putra, 2020). Additionally, the use of decoupling points and buffers in CCPM aligns with **Agile's** iterative and incremental approach, which helps manage uncertainty and improve project flow (Apaolaza & Lizarralde, 2020). Adopting CCPM, especially when integrated with lean principles like Kanban, requires significant organisational changes. These include developing new roles and responsibilities, implementing management training, and fostering a shift in organisational behaviour (Apaolaza & Lizarralde, 2020). Their study also underscores the importance of management commitment and the necessity for behavioural changes to fully realise the benefits of CCPM.

CCPM's buffer management techniques are also particularly effective for the early identification of potential delays and issues, enabling preventive corrective actions that prevent these challenges from significantly impacting the project timeline (Sembiring & Putra, 2020). Moreover, agility in project management enhances an organisation's ability to adapt to disruptions, thereby improving resilience (Marnada et al., 2021; Kadenic & Tambo, 2023). Agile practices, as highlighted by Apaolaza and Lizarralde (2020) and further explored by Kadenic and Tambo (2023), emphasise rapid response capabilities and adaptability, which are vital for operational resilience. They also stress the value of iterative development, a focus on delivering value, and the importance of considering human aspects in project management. This philosophy aligns with the core Agile principle of embracing change and delivering value in uncertain contexts (Apaolaza & Lizarralde, 2020).

The study by Apaolaza & Lizarralde (2020) highlights the necessity for project management approaches that are capable of adapting to the rapidly changing needs and high uncertainty inherent in project environments. Marnada et al. (2021) have recognised that clearly determining objectives, roles, and responsibilities is crucial for agile project management. Emphasised as crucial for fostering a resilient organisation, agile leadership supports decentralised decision-making and empowers teams to act swiftly in response to disruptions (Kadenic & Tambo, 2023).

Agile frameworks like **Scrum** are part of the strategies employed to adapt and respond flexibly to changes and disruptions, which is a key aspect of building resilience within organisations (Kadenic & Tambo, 2023). In fact, Scrum is the most widely adopted agile project management methodology especially in software industries, but also widely used and regarded as efficient method in non-software industries, including manufacturing and service sectors (Patrucco et al., 2022). These industries face unique challenges, such as the need for handling tangible products and complex, cross-functional team coordination, which Scrum methodologies help to address.

Scrum offers strategic benefits such as increased agility, better stakeholder engagement, and improved responsiveness to market changes (Patrucco et al., 2022). Scrum supports decentralised decision-making, which is essential for rapid response capabilities in dynamic environments (Kadenic & Tambo, 2023). Operationally, Scrum encourages transparency, continuous feedback, and iterative learning, all of which contribute to more effective project management and execution (Patrucco et al., 2022). The iterative nature of scrum, with its regular sprints and reviews, fosters continuous improvement and learning within teams, and this ongoing learning process is vital for adapting to and managing changes effectively, which are core aspects of resilience in project management (Kadenic & Tambo, 2023).

In conclusion, the landscape of project management is continually evolving, shaped by the adoption of methodologies such as Lean, Six Sigma, and Agile practices that stress the importance of adaptability, efficiency, and collaborative problem-solving. These frameworks are not just methodologies but transformative processes that drive organisations to thrive in the face of complexity and rapid market changes. By leveraging these approaches, companies can optimise their operational processes, reduce waste and variation, and enhance overall project performance. The adoption and integration of these practices across industries underscore a shift towards more dynamic, resilient, and customer-focused business models. Ultimately, organisations that embrace these continuous improvement philosophies are better positioned to lead, innovate, and excel in an increasingly competitive and unpredictable global environment.

2.3 Principles of product management in new product development

Product management encompasses strategic planning and execution aimed at enhancing operational efficiency and extending the lifecycle of products (Kulbovskyi et al., 2020). It is fundamentally efficiency-oriented, leveraging methodologies such as Lean principles and tools like Value Stream Mapping (VSM) to meticulously analyse and enhance every phase of the product development process (Tuli & Shankar, 2015). Product management does not focus solely on achieving short-term performance or financial gains but rather it aims to sustain long-term value creation, ensuring that products remain viable and competitive over time (Kulbovskyi et al., 2020). It’s important to recognise, that even though product management is strongly involved in development of new products, in many cases this is conducted during a project, when also project management is involved in the process. Kulbovskyi et al. (2020) highlight the necessity of managing

both, the project lifecycle, and the product lifecycle, showing how strategic project management decisions influence long-term product success and sustainability, and product management is strongly involved in the product related decision-making process.

Effective product management relies on robust **communication and collaboration**, particularly in the initial phases of NPD. This early emphasis is essential to prevent quality issues, minimise rework, and ensure adherence to timelines and budgets (Tuli & Shankar, 2015). Tuli & Shankar (2015) underscore the importance of open communication and collaborative efforts early in the development process. Similarly, Yassine et al. (2017) highlight the challenges faced when projects share a limited pool of resources and the necessity for iteration due to precedence and feedback constraints among activities. These factors underscore the need for managing constraints and iterations efficiently for successful project outcomes.

In the field of NPD, the application of **lean principles**, which aim to reduce non-value-adding activities, is extremely beneficial (Tuli & Shankar, 2015). In recent years, Lean thinking has been highlighted in product management, in addition to project management, due to the benefits it brings, which are improved productivity, performance and waste reduction (El Faydy & El Abbadi, 2023). The lean approach together with communication and collaboration efforts presented by Tuli & Shankar (2015) is fundamental to streamlining processes and enhancing overall efficiency in NDP and in product management in general.

In Figure 5, this is presented in a form of Venn diagram, where communication refers to the exchange of information, ideas, and feedback among parties, which is a fundamental activity that enables understanding and coordination. Collaboration involves joint efforts by individuals or groups to achieve common goals, which typically builds on effective communication but focuses more on shared activities and teamwork. In the context of product development, in the third section of the Venn diagram, the lean processes means streamlining operations, accelerating workflows, and improving the quality of outcomes with less effort and fewer resources.

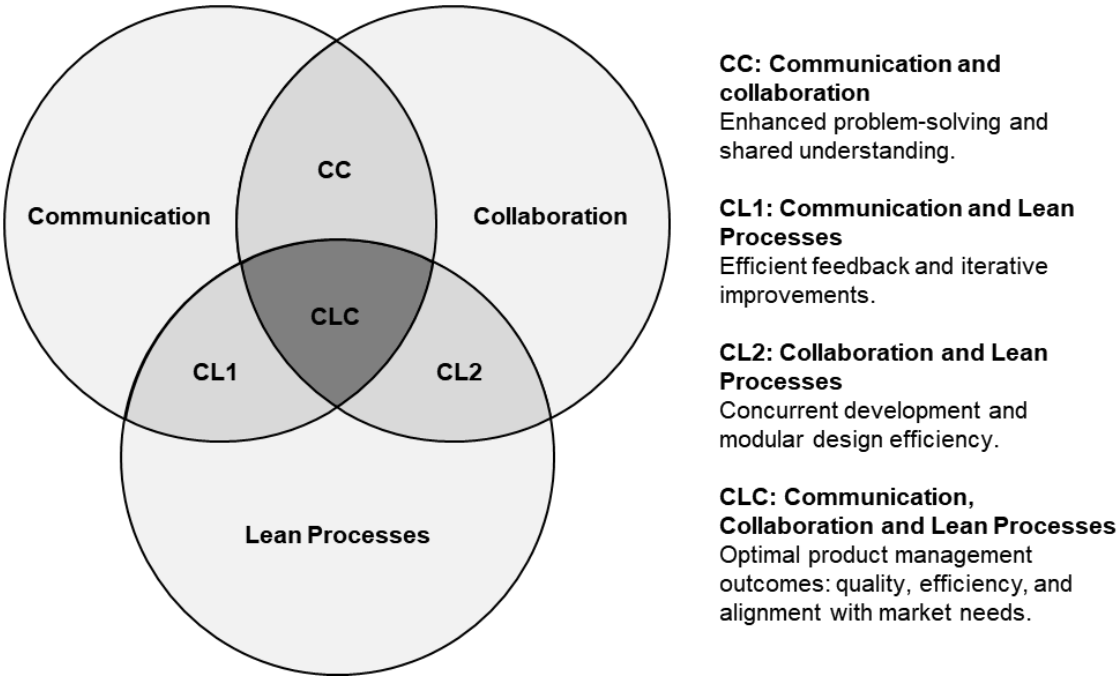

Figure 5. Key concepts in new product development in manufacturing industry (authors own elaboration).

Additionally, processes that facilitate communication and decision-making, such as reviews, cross-functional teams, and early supplier involvement, are vital. Matheus et al. (2017) note these processes raise issues, develop shared understandings, and integrate diverse knowledge bases in complex product development. Further enhancing collaboration, Koppenhagen & Held (2021) propose a new model for interaction between original equipment manufacturers (OEMs) and suppliers, especially those lower in the value chain. The model advocates for direct collaboration with suppliers to standardise components and modules across products, which not only enhances interoperability but also reduces costs through economies of scale. The restructuring of the development process to support modular systems, as noted by Koppenhagen & Held (2021), is critical. This restructuring facilitates the concurrent development of individual modules and the complete product system, optimising design for modularity and enhancing production efficiency and flexibility. Techniques like the use of reinforcement learning to optimise activity scheduling, discussed by Wauters et al. (2015), improve efficiency and adaptability to changes.

Management of OEM-supplier collaboration when designing new products for customer is important. As Belkadi et al. (2017) explain, such collaborations enable companies to leverage combined competencies and resources, innovate, and respond more effectively to market opportunities, gaining a competitive edge. These collaborations ensure that power dynamics are managed to foster knowledge sharing and integration, enhancing problem-solving and decision-making in innovation projects (Matheus et al., 2017).

To ensure overall continuity and effectiveness, aligning product goals with business objectives and understanding user needs are central. Raja et al. (2018) suggest that servitisation strategies and organisational structures must be adaptable to different market conditions and customer needs. Moreover, engaging stakeholders, including suppliers and OEMs, early in the development process is crucial for aligning product features with technical skills and ensuring efficient knowledge sharing and problem-solving (Tuli & Shankar, 2015). In conclusion, the principles of product management discussed highlight the critical aspects of communication, collaboration, learning, problem-solving, lean processes, strategic vision, and customer-centric approaches. These elements are essential for the successful management of product development projects, ensuring that products meet market demands while staying on schedule and within budget.

2.3.1 Responsibilities of product management

Planning and prioritisation of product features and milestones by utilising for example product road mapping is needed to be able to meet the market demands. Especially in custom engineering-to-order (ETO) settings, it is crucial to implement structured yet flexible methods for planning and prioritising product features and milestones in NPD (Carvalho et al., 2015). Effective planning and prioritisation requires early involvement of all key stakeholders including suppliers and OEMs (Tuli & Shankar, 2015).

Early involvement of several stakeholders creates a need to control the product development carefully from the very beginning. Companies must also be able to respond dynamically to changes in project requirements or customer requirements, and all aspects of the product must be processed at a corresponding pace, following pre-defined milestones (Carvalho et al., 2015). To control this, the study by Tuli and Shankar (2015) presents a collaborative and lean (C&L) NPD approach for VSM, as a tool to identify and eliminate waste in the product development process. This tool helps in outlining the entire process flow from concept to completion, which is vital for planning and prioritising the key features and milestones. VSM also allows the teams to visualise where delays might occur and where processes can be streamlined (Tuli & Shankar, 2015). This new approach presented by Tuli and Shankar (2015) has three phases, which are presented in Figure 6, Figure 7, and Figure 8.

VSM phase 1 (Figure 6): during this stage the supplier plans and defines the purpose to provide a solution to the customer requirement. This phase is critical for setting the project's parameters, including scope definition, requirements understanding, and the establishment of foundational planning. The phase involves continuing discussions between suppliers and OEMs to synchronise expectations, finalise business feasibility, and

obtain necessary approvals to proceed. The primary aim is to delineate a clear project roadmap that outlines timelines, cost estimates, and resource allocations. This analysis helps optimise the flow from conceptualisation to approval, which reduces lead times and improves project responsiveness. Through VMS, inefficiencies such as delays in understanding, or processing RFQs, and prolonged approval procedures are identified.

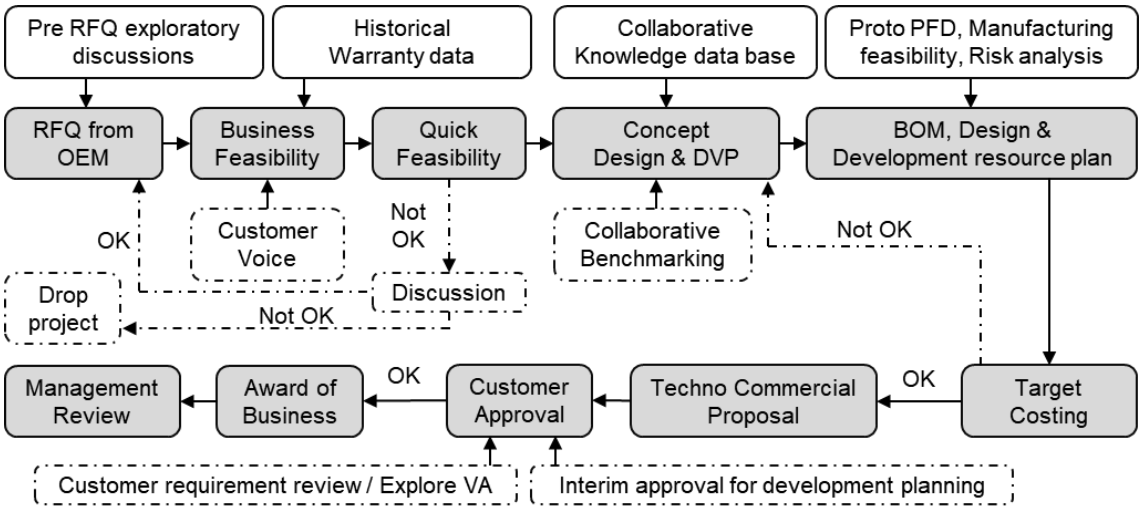

Figure 6. VSM phase 1, Planning and definition (adapted from: Tuli & Shankar, 2015).

VSM phase 2 (Figure 7): at this stage, all functions of product design and development are aligned according to the requirements. At the core of the product development lifecycle, this phase focuses on the complicated processes of design and development. It includes detailed engineering, prototype creation, and iterative testing to refine the product in accordance with specified requirements. Iterative adjustments based on testing outcomes are critical for adapting the design promptly to meet specific OEM requirements and specifications. VSM during this phase monitors the flow of information and materials through the stages of design and development.

VSM phase 3 (Figure 8): this phase involves product validation as it passes through various inspection, durability, and reliability tests. This decision stage involves strict validation of the product design through extensive testing to ensure compliance with industry standards and OEM specifications, culminating in the start of production. Validation activities, including durability testing, compliance verification, and final adjustments based on test results, ensure the product's readiness for mass production and its ability to perform reliably under real-world conditions. The mapping in this phase focuses on pinpointing delays in validation processes, inefficiencies in final adjustments, and any issues potentially impacting product quality and production ramp-up.

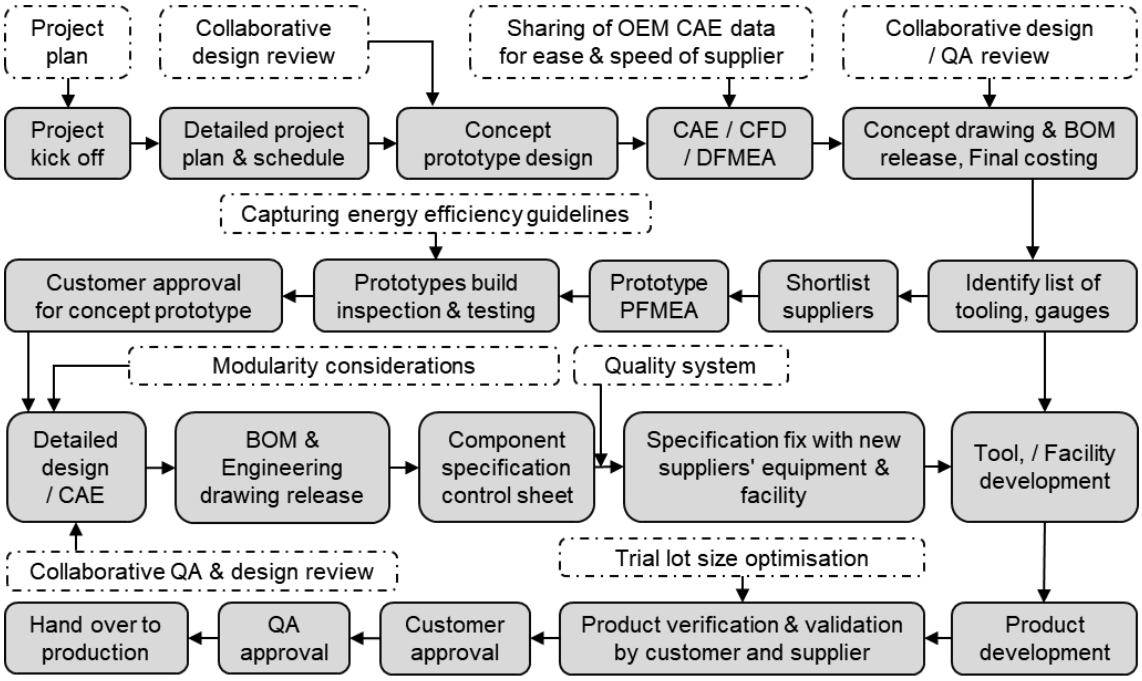

Figure 7. VSM phase 2, Product design and development (adapted from: Tuli & Shankar, 2015).

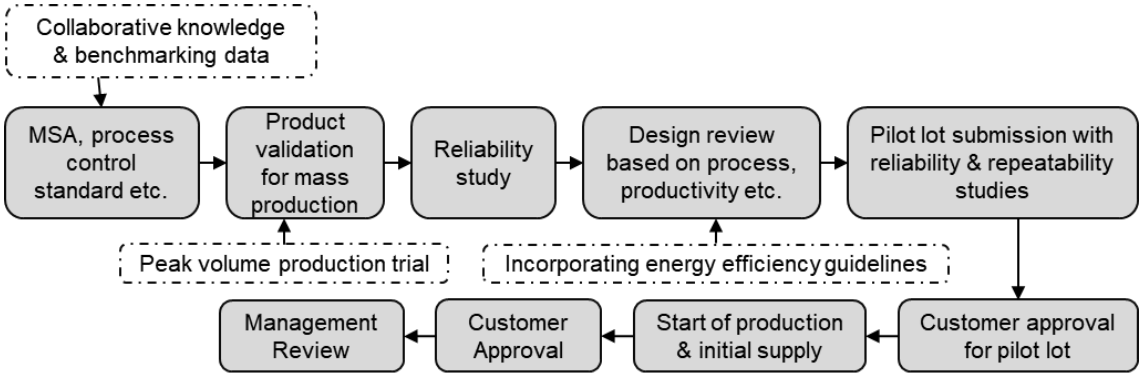

Figure 8. VSM phase 3, Product validation and standard operating procedures (adapted from: Tuli & Shankar, 2015).

These kinds of predetermined specific procedures to systematically prioritise user requirements are crucial for accurately capturing and addressing customer needs (Marnada et al., 2021). For example, regular reviews and feedback loops involving all stakeholders can ensure that the product development remains on track and that features and milestones are continually assessed and prioritised based on the latest information and project dynamics (Tuli & Shankar, 2015; Marnada et al., 2021). These kinds of protocols require flexibility, which is vital for maintaining efficiency in production schedules and meeting delivery commitments without compromising on the quality or specifications demanded by customers (Carvalho et al., 2015).

Tuli and Shankar (2015) and Marnada et al. (2021) state in their studies that by involving suppliers early and deeply in the NPD process, their capabilities and innovations can be

integrated into the planning of product features. This approach ensures that the final product not only meets the desired specifications but also incorporates the best available technology and materials (Tuli & Shankar, 2015). This together with the iterative approach helps in adjusting the product features according to changing customer needs and market conditions, ensuring that the product management process is aligned with customer expectations (Marnada et al., 2021).

The study by Yassine et al. (2017) highlights also the significant role of advanced scheduling techniques in product management. It particularly emphasises the effectiveness of genetic algorithms (GAs) over traditional priority rules (PRs) in navigating the complexities of iterative and resource-constrained project environments. Genetic algorithms provide a robust tool for improving both schedule and resource allocation decisions during product development (Yassine et al., 2017). This is contrasted with the results indicating that while priority rules may be effective in simpler scenarios, genetic algorithms offer substantial advantages in more complex project settings.

Furthermore, these findings of Yassine et al. (2017) are supported by Carvalho et al. (2015), who underscore the importance of integrating advanced modelling techniques in production planning. This is particularly crucial in complex, project-driven environments such as ETO systems (Carvalho et al., 2015). By adopting these sophisticated modelling techniques, companies can significantly enhance their responsiveness to market demands, optimise resource utilisation, and improve overall operational efficiency. These collective insights reflect a clear trend towards the necessity of data-driven decision making also in product development. Utilising analytics and metrics to guide decisions ensures that product development processes are not only more efficient but also more adaptive to the dynamic market landscape.

Furthermore, Belkadi et al. (2017) emphasise the integration of information technology systems, like product lifecycle management (PLM), to support collaboration modes. This integration is crucial for managing data and process interactions across organisations, enhancing communication and operational efficiency. PLM systems facilitate the alignment of enterprise strategies with operational processes across collaborating organisations (Belkadi et al., 2017).

Building on the themes of advanced scheduling and modelling techniques and data-driven decision making discussed earlier, the next chapter transitions into exploring specific challenges in product management. The importance of integrating information technology systems such as PLM, as highlighted by Belkadi et al. (2017), sets the stage for

this discussion. The challenges that arise in ensuring effective collaboration, maintaining data integrity, and aligning diverse organisational goals will be thoroughly explored.

2.3.2 Challenges in product management

Despite the clear benefits of product management, there is a need for discussion about common challenges related to product management. The study by Tuli and Shankar (2015) discusses the challenges involved in collaborative efforts, such as aligning different organisational goals, managing communication, and ensuring effective integration of contributions from various stakeholders. One more specific but still significant challenge identified is also the over-scope requirement, which occurs when project goals are not clearly defined, leading to unreasonable and unsystematic change requests (Marnada et al., 2021). One of the challenges of product development projects is also that the customer's power can dictate organisational configurations, which emphasises the need for product managers to understand the power dynamics of customer relationships and adapt to it (Raja et al., 2018).

In exploring the challenges and strategies of OEM-supplier integration, various studies have provided insights that are crucial for understanding and improving these relationships. The study by Wlazlak et al. (2019) underscores the significant challenges during the production ramp-up phase, which are caused especially from late and frequent engineering changes. These disruptions not only affect suppliers' preparation for production but also impair crucial information exchange and collaboration between OEMs and their suppliers.

Addressing these challenges from OEM companies’ point of view, the research by Koppenhagen & Held (2021) proposes a structured process for integrating suppliers, balancing the benefits of economies of scale with the risks of over-dependence on single suppliers. By strategically selecting and engaging suppliers, OEM companies can ensure more robust supply chain networks and optimise supply costs. The dynamics within these interactions are further complicated by power structures, as evidenced by the findings of Mosch et al. (2021). Their study reveals that digital servitisation tends to reinforce the position of the more dominant party in the OEM-supplier relationship. Suppliers lacking in digital capabilities may find themselves increasingly dependent on OEMs, who control crucial data and are closer to the end-users.

Adding another layer to the complexity of managing OEM-supplier relationships, Raja et al. (2018) identified integrated project teams (IPTs) as an effective organisational design for handling dominant customers or complex projects. Even though IPTs are related to project management, it can be concluded that for high-value and complex offerings,

where customer engagement is critical, product managers could consider highlighting the benefits of IPTs in the product managements point of view. The study by Matheus et al. (2017) highlights also the crucial role of different power dimensions in effective knowledge integration. For product managers, understanding these dimensions and fostering an environment where knowledge is freely integrated can drive innovation, leading to more innovative and effective product solutions. Collectively, these studies provide a comprehensive view of the challenges and strategies in OEM-supplier integration, emphasising the need for strategic engagement, understanding power dynamics, and fostering innovative environments to enhance overall supply chain efficiency.

In exploring the dynamics of OEM-supplier interactions, Belkadi et al. (2017) introduce a structured framework that identifies three main modes of collaboration based on varying levels of trust and interaction. This classification is crucial for understanding how different approaches to collaboration can influence the efficiency and innovation within supplier relationships. The three levels presented by Belkadi et al. (2017) are as follows:

- The first mode termed "Free Mode," is characterised by low trust and minimal interaction, typical of traditional client-provider relationships. In this setting, engagements are primarily transactional, with suppliers adhering to specific, well-defined requirements without extensive collaboration or deep communication. This mode often limits potential innovation as it constrains the exchange of ideas and restricts synergistic opportunities.
- The next level in the framework, the "Coordination Mode", involves medium trust and sees suppliers collaborating under a structured and coordinated approach to meet OEM requirements more effectively. This mode facilitates better alignment of goals and processes between the OEM and suppliers, enhancing the overall efficiency and responsiveness of the supply chain.
- At the highest level of collaboration is the "Project Mode," where high trust prevails, involving close collaboration on shared projects with common goals and resources. This mode is often found in partnerships aiming for high-stakes innovation and complex problem-solving. It fosters a dynamic environment where both parties can contribute to and benefit from shared knowledge, leading to more innovative solutions and stronger, more resilient partnerships.

Each of these modes presented by Belkadi et al. (2017) offers distinct advantages and challenges, making it essential for product managers and supply chain strategists to carefully consider the most appropriate level of collaboration in alignment with their stra-

tegic goals and the specific contexts of their projects. The integration of product management tools and approaches in managing collaborative projects offers insights into how project managers can enhance coordination, data sharing, and process synchronisation among stakeholders (Belkadi et al., 2017).

In conclusion, the exploration of challenges in product management, particularly in the context of OEM-supplier interactions, underscores the importance of strategic engagement and adaptability. The research discussed throughout this chapter highlights that effective product management requires not only a keen understanding of power dynamics and organisational structures but also a deliberate approach to supplier integration and collaboration. By selecting appropriate modes of collaboration organisations can optimise their interactions and enhance both efficiency and innovation within their supply chains.

2.4 Integrating project and product management

In the MPE, the integration of project and product management is increasingly recognized as essential for driving successful project outcomes, especially in the manufacturing industry (Eslami & Lakemond, 2016). This synthesis chapter aims to gather together the insights from project and product management discussed in previous sections. It aims to provide a unified framework that addresses the complex demands of MPE and NPD from overall project managements perspective.

The integration of project and product management begins with strategic alignment, which is foundational in effectively navigating modern business challenges. The challenges of MPEs, as highlighted by Apaolaza & Lizarralde (2020), demand a robust project management framework that can handle multiple, concurrent projects efficiently. Simultaneously, Tuli & Shankar (2015) and Yassine et al. (2017) discuss the need for iterative design and resource optimisation in NPD, which is often present when talking about projects in manufacturing industry. Especially in iterative NPD where product development is complex, the complexity creates challenges for organisation, and requires flexibility in internal integration approaches (Eslami & Lakemond, 2016).

By aligning the structured methodologies of project management with the flexible, iterative approaches of product management, organisations can achieve enhanced efficiency and effectiveness. This strategic alignment not only streamlines operations but also maximises resource utilisation across both project and product lifecycles. This approach to integrating project and product management functions creates a need to explore best practices that can significantly improve efficiency in complex MPEs.

2.4.1 Leveraging best practices for enhanced efficiency

To address the complexities and dynamic nature of managing multiple projects and products, organisations should adopt best practices from both disciplines. The integration of Lean and Six Sigma methodologies, as suggested by Aqlan & Al-Fandi (2018), provides a framework for continuous improvement and operational excellence in both project and product management. These methodologies help in minimising waste and optimising processes, thereby aligning with the strategic goals of the organisation, and enhancing customer value. In addition to Lean and Six Sigma, the integration of Agile methodologies is also critical. These policies are tailored to operating environments that require the company's operations to be flexible and quick to react to changes, such as an environment where multiple projects are managed as an OEM supplier (Osadchiy et al., 2021).

In order to quickly and efficiently adapt to such operating environments, the application of advanced scheduling techniques and an agile methodology may be useful, as Kadenic & Tambo (2023) and Patrucco et al. (2022) state. Vos et al. (2016) also note that Agile methodologies support the decentralisation of decision-making and emphasise quick iteration and continuous feedback, which are crucial in today's fast-paced MPE conditions. Agile practices help organisations stay adaptable and responsive, enhancing their ability to manage and deliver projects successfully under varying conditions. In addition to adaptivity, effective project management also involves applying advanced scheduling techniques that consider the complexities of MPE. Techniques such as those discussed by Ben Issa et al. (2021), which focus on resource-constrained project scheduling problems (RCPSP), are crucial for optimising resource allocation and ensuring that projects are not only completed within budget but also adhere to timelines without compromising the quality. By combining Lean and Six Sigma for process optimisation, Agile for flexibility and adaptability, and advanced scheduling for effective resource management, organisations can establish a robust framework that enhances efficiency and aligns with their strategic goals.

2.4.2 Emphasising communication and collaboration

In addition to flexibility and adaptability, effective communication and collaboration are pivotal in managing the intersection of project and product management. As Nyameke et al. (2020) outline, the communication infrastructure is crucial for the success of project execution, which also applies to product management where early supplier involvement and cross-functional teamwork are essential (Tuli & Shankar, 2015). Implementing a standardised communication framework that facilitates information flow across all levels

of project and product teams can mitigate risks associated with misalignments and enhance collaborative efforts.

Communication and collaboration should not only be emphasised between supplier and customer operations, but also in internal collaboration. One of the most complex aspects of merging project and product management involves handling resources across multiple projects and product lines. Ben Issa et al. (2021) and Carvalho et al. (2015) stress the need for an integrated approach to resource management. This approach not only optimises resource allocation and reduces costs but also prevents resource conflicts, ensuring that projects do not suffer from resource scarcity and that product development can proceed without delays.

Effective resource management involves sophisticated scheduling tools that can handle the complexities of multiple overlapping projects and product timelines. This approach should include tools for resource-constrained project scheduling problems (RCPSP) (Ben Issa et al., 2021; Gómez Sánchez et al., 2023), and multi-project scheduling problems (RCMPSP) for effective resource distribution (Wauters et al., 2015; Ben Issa et al., 2021; Gómez Sánchez et al., 2023). By leveraging these tools, organisations can ensure that resources are allocated efficiently and effectively, thereby minimising delays and enhancing the overall productivity of projects and product development cycles.

In addition to sophisticated scheduling tools, the integration of comprehensive methodologies like VSM further exemplifies the potential for enhanced efficiency in managing projects and products. Tuli & Shankar's (2015) study is an example of how integrating VSM into project management can significantly improve product development processes. By adopting a collaborative and lean approach, organisations can streamline their operations, reduce waste, and accelerate time to market, effectively bridging the gap between the theoretical framework of project management and the practical needs of product management. Their methodology demonstrates the profound impact of strategic collaboration and lean methods in achieving superior product development results, highlighting the importance of these practices in modern project management.

2.4.3 Maximising outcomes through integrated management

The synthesis of project and product management is more than merging two disciplines together. It's a strategic approach that leverages both of their strengths to tackle the multifaceted challenges of MPE. This approach integrates the structured methodologies of project management with the agile processes of product management, enhancing operational efficiency and responsiveness to market changes, which occur in MPE. While maintaining the adaptability, continuous improvement and evaluation are essential to

ensure the effectiveness of the integrated management approach. Project and product management are two distinct disciplines, each with its own scope, responsibilities, and goals. The Figure 9 visually represents what each management type includes and excludes, providing a clear differentiation.

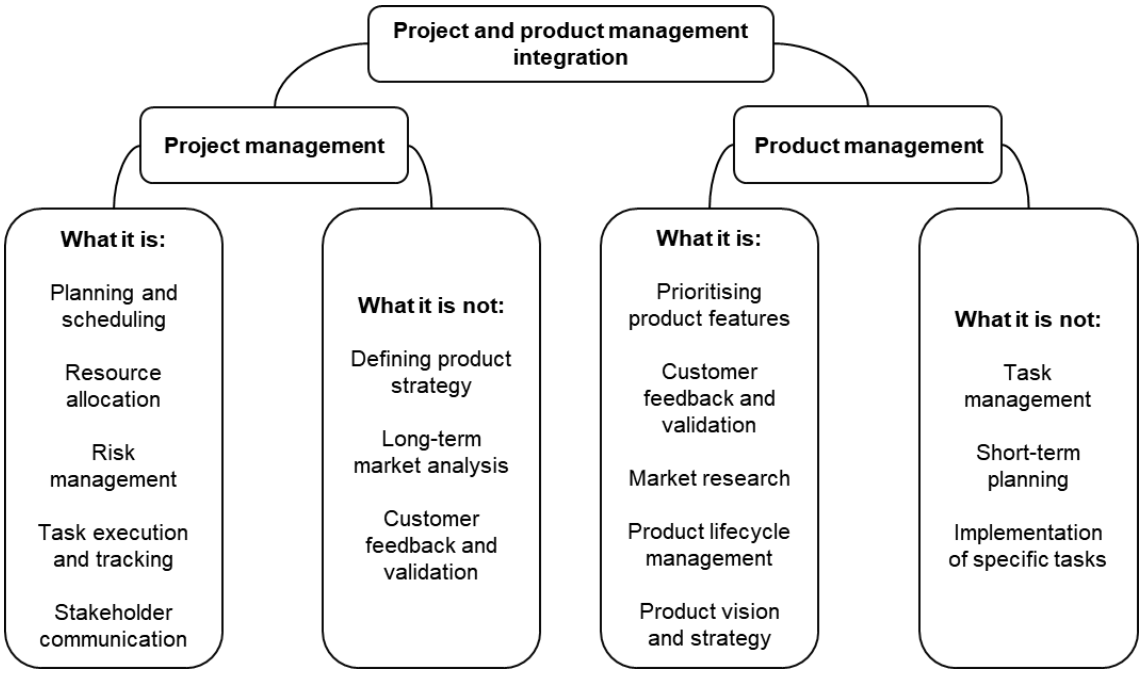

Figure 9. Project and product management responsibilities (authors own elaboration).

Product management is primarily about defining the product vision and strategy. Product managers are responsible for overseeing the product throughout its lifecycle. They conduct market research to understand customer needs, analyse market trends, and assess the competitive landscape. Gathering and analysing customer feedback is crucial to ensure the product meets user needs and expectations. Based on this feedback and strategic goals, product managers prioritise features to develop and improve, balancing customer needs with technical feasibility and business impact. However, product management is not about task management or short-term planning. Product managers focus on the overall vision and strategy rather than the day-to-day management of tasks. They oversee the product's development but do not typically get involved in executing specific tasks, which is usually handled by project managers or development teams.

In contrast, project management focuses on planning and scheduling to ensure that projects progress on time and within scope. Project managers allocate resources, including personnel, budget, and materials, to ensure tasks are completed efficiently. They identify potential risks and develop mitigation strategies, oversee the execution of tasks, track progress, and ensure milestones are met. Communication with stakeholders is a key part

of their role, ensuring clear communication and managing expectations. Project management does not involve defining the product's long-term strategy or vision. Project managers do not engage in market analysis or long-term planning related to the product's market position. While they may interact with customers for project-specific needs, ongoing customer validation and feedback are not part of their core responsibilities. By understanding these distinctions, organisations can better allocate responsibilities and ensure both project and product management functions effectively contribute to the success of their projects.

Chapter 2 has explored how methodologies like Lean, Six Sigma, and Agile can collectively enhance operational efficiencies, optimise resource allocation, and improve responsiveness to market changes. Regular reviews, feedback loops, and performance metrics should be employed to assess the efficiency of project and product management integration. Learning from each project and product cycle can lead to refinements in processes and strategies, enhancing future performance and adaptability. Effective communication and robust collaboration further underpin this integrated approach, ensuring that strategic alignments translate into concrete outcomes.

Organisations that proactively adopt this holistic management model not only manage but thrive in the dynamic and demanding areas of project and product delivery. The principles discussed here serve as a model for maintaining competitive advantage and promoting innovation in project and product development. By continually adapting and refining these strategies, companies can anticipate challenges more effectively and deliver solutions that meet and exceed the evolving expectations of their markets. In summary, organisations that embrace this comprehensive approach to integrate project and product management in their operations are better positioned to handle the demands of MPE, leading to successful project and product outcomes that foster sustainable growth and maintain a competitive edge in the marketplace.

3. RESEARCH APPROACH

This chapter presents the research methodological choices that are made in this study, which are always to be presented in studies in order to ensure the validation and repeatability of the study. After presenting the methodological choices, the strategy and design of the study are presented. In addition to the methodological choices and research strategy and design, also the data collection and analysis process conducted in this study is presented in a detailed level.

The primary goal of the study was to explore the relationship between project management and product management with a specific focus on how these disciplines are integrated in the target company operating within an MPE. In order to examine this in the context of the target company of this study, a literature review was conducted and after that, the personnel of the target company was interviewed. It is also appropriate to mention that the author of this study worked in the target company for about a year before conducting this study, and this year of observation served as a comprehensive preliminary investigation phase of this study.

3.1 Research methodology

This study is conducted by following **pragmatic philosophy**, which is usually followed when the aim of the study is to focus on problems, practices and relevance, and the source of acceptable knowledge is study proven theories and knowledge (Saunders et al., 2019, p. 144-146). In this study the goal is to study a particular phenomenon at a particular time, which means that the time horizon of this study is **cross-sectional** knowledge (Saunders et al., 2019, p. 212). Also, the time horizon of this study, which is approximately one year from the beginning of observation to the finish of the study, indicates that longitudinal study would be challenging to conduct (Saunders et al., 2019, p. 212).

The study was conducted as a **qualitative case study** with a **deductive approach**. The use of the deductive case study approach was particularly appropriate in this case. This is because deductive approach enables an in-depth comparison between a real context and existing literature (Juhila, 2021). With this approach, it is possible to address the complexity and dynamic integration of these management fields in real life scenario and compare that to existing knowledge. This supports the goal of this study, which aims to

focus on the situation of the target company, and analyse it compared to previous theories and research findings (Juhila, 2021). The case study material was collected by conducting **semi-structured interviews**, which was chosen as data collection method of this study. To illustrate all methodological choices made in this study, the overall picture is presented in a simplified form in Figure 10. This figure is constructed using as the model of Saunders et al. (2019, p. 130), which is called the research onion.

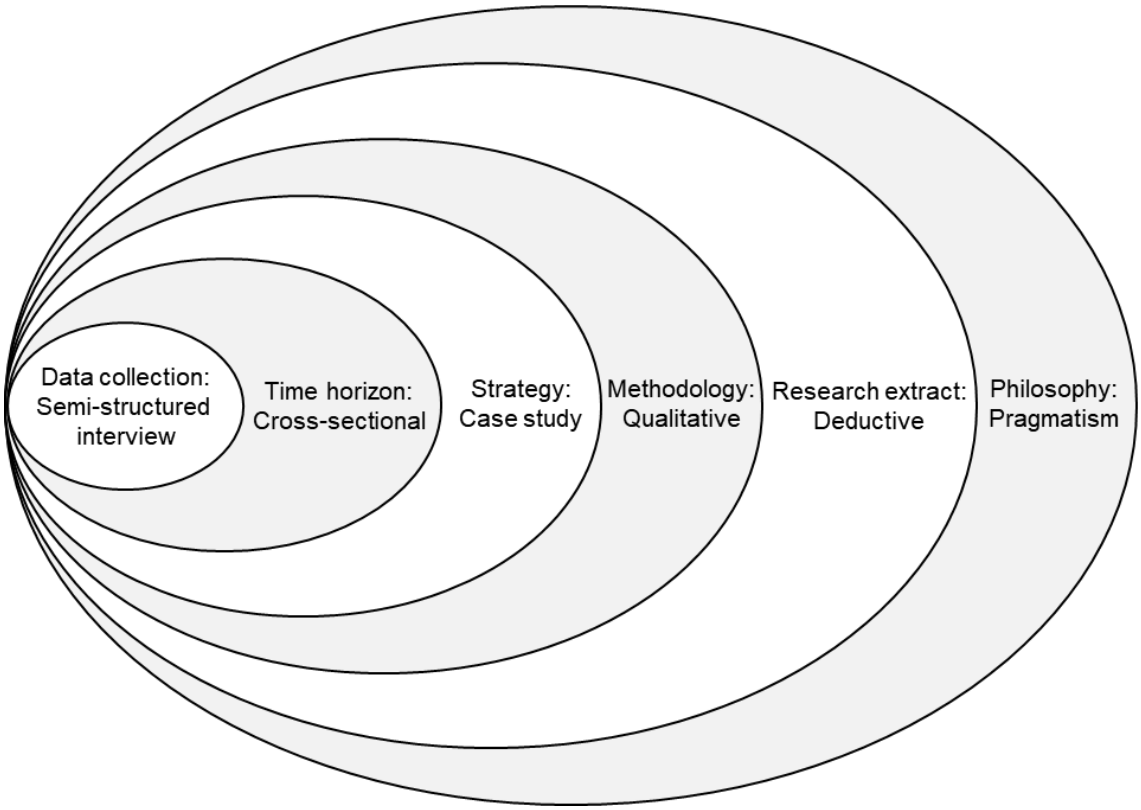

Figure 10. Methodological choices of the study (adapted from: Saunders et al., 2019, p. 130).

3.2 Research strategy and design

The study adopts a qualitative case study approach, which is ideal for a comprehensive, systematic, and in-depth study of a contemporary phenomenon in its real-life context. This approach is particularly suited for studying organisational practices where multiple variables and their interrelations need to be considered. (Vuori, 2021.) The case study method will enable the study to delve deeply into the organisational structures, processes, and culture that facilitate or hinder the integration of project and product management within an MPE.

In this case study, interviews were used as the main data collection method. The interview as a research data collection method was chosen because interviewing is a flexible method that is suitable for many starting points and purposes (Hirsjärvi & Hurme, 2022).

In a more detailed level, the choice of interviews as a methodology was made for the following reasons, which are also supported by Hirsjärvi and Hurme (2022):

- It is known that the subjects in this study produce multi-directional answers, so interviews are e.g. better method then queries for acquiring information on these topics as widely as possible.
- The interview as a research methodology gives the opportunity to ask the interviewee to justify her answer, in which case the information obtained can be further deepened.
- The interview as a research methodology also gives the opportunity to ask the interviewee to clarify the answer by answering to question “Why?”.

In the preliminary examination phase with the target company, before the actual research process began, different methodologies were compared. For example, the use of interviews and surveys was compared, and the possibility of a quantitative research was also mapped. In the initial review with key stakeholders of the target company before starting the research, it became clear that quantitative data was difficult to obtain and therefore a qualitative approach was chosen as the conclusion. The final decision to use interviews as a research method was done based on the following points presented also by Hirsjärvi and Hurme (2022):

- With an interview, it is more likely to motivate the interviewees to give more detailed and extensive answers compared to e.g. surveys.
- With the use of interviews, it is easier to get more detailed descriptions of example cases from the interviewees.
- In interviews the order of topics is controlled by the interviewer, and therefore the latter topics and questions of the interview won’t affect the interviewees answers to the prior questions.

After the interview was selected as the main data collection method, it was necessary to decide the type of interviews to be conducted. To make the decision, first it needs to be determined what are the options, and how they differ from each other. In structured interview the questions are the same for every interviewee, and all questions have predetermined answer options that are presented to the interviewee after presenting the questions (Hyvärinen et al., 2021). This type of interview seemed to be narrowing the answer options to much considering the interview topic and goal of the interview. Also, although the influence of the interviewer can be minimised with structured interview, there is no

information about how the interviewees understood the questions and how they thought they would answer (Hyvärinen et al., 2021).

Originally, structured interviews were thought to be the most suitable data collection method because precise questions work well when, like an expert interview, the goal is to get facts about what has happened or what is currently going on, so that the interviewees don't just chat comfortably off the topic (Hyvärinen et al., 2021). After examination of the defined research problem, it was decided that a slightly less structured interview is a more appropriate method since the goal was to collect as much explanatory information as possible from the target company within the limits of this study (Saunders et al., 2019). A semi-structured interview was chosen as the most suitable interview method, so that the interviewees would have room to give in-depth answers and the interviewer could ask varying follow-up questions during the interviews. The interview time was not strictly limited, and interviews were continued until the topics of the interview had been covered.

To support the design of the interview questions, this research utilised a literature review as a methodology, addressing the research question by aggregating key elements from prior studies and examining how the findings from various investigations relate to one another (Salminen, 2011). Typically regarded as a potent approach for research, the literature review is favoured for its ability to synthesise fragmented information from the study's field into a succinct and reader-friendly presentation of findings (Salminen, 2011). The literature review was aimed to form a comprehensive reference point, which would be compared to the target company’s situation.

While designing the interview themes and questions, it was intended that they will deeply explore current practices, identify areas for integration of new product management approaches, evaluate the impact of external demands, and suggest future strategic directions. The development of these questions was directly guided by the research questions and the outcomes of the literature review. It was decided that four different themes should be covered during the interviews.

The first theme, assessment of current project management processes, focuses on evaluating the existing project management processes. This theme is critical, as understanding what works well and what does not, can directly influence strategic improvements and adaptations in management practices. Questions within this theme ask interviewees to identify effective parts of the current process and discuss the challenges faced. This dual focus helps pinpoint actionable areas while considering successful elements that

can be preserved or expanded. The literature review highlighted the importance of continuous assessment in dynamic business environments, particularly in industries like OEM manufacturing, where efficiency and adaptability are essential for the suppliers as presented in the introduction chapter.

The second theme, integration of the new product management approach, addresses the integration of new product management approaches. This is based on literature that discusses the evolution of product management processes in response to changing market demands and technological advancements. By questioning the potential smoothness of integration for new practices and the challenges, the questions aim to gather insights that can lead to more effective implementation strategies. This theme is particularly significant as it aligns with the strategic direction of evolving with industry standards and practices, ensuring that the company remains competitive.

Within the third theme, future directions and recommendations, the questions seek recommendations for modifying the project management framework to better support new approaches, alongside exploring potential obstacles. This directly ties into strategic decision-making and long-term planning, which are crucial for sustaining growth and adaptability in project business. The literature review underscores the importance of forward-thinking strategies in project management, particularly in how they can enhance responsiveness and innovation in product development.

The final theme, effects of operating environment on management practises, investigates how external factors, specifically the demands and schedules of OEM clients, impact project management and product development. This theme is vital as it addresses the direct influence of client requirements and market changes on operational strategies. These questions are designed to explore how the company adapts to these external pressures, an area heavily emphasised in the literature as critical to maintaining client relationships and ensuring project success.

Each question and theme was designed to discover detailed and relevant information that will support the comprehensive research goals. By understanding both the internal functionalities and external influences on project management and product development, the company can better strategize its practices to enhance efficiency, effectiveness, and customer satisfaction. This semi-structured interview approach will ensure that every aspect of the target company’s operational framework is thoroughly evaluated, providing a robust foundation for informed strategic planning.

3.3 Data collection and analysis process

This chapter details the data collection and analysis process used in this research. The objective was to systematically extract, interpret, and utilise insights to improve project management and product development processes. The primary data collection method was semi-structured interviews, chosen for their flexibility and ability to elicit in-depth information. This approach allowed for the exploration of complex issues and the collection of rich, qualitative data. The interview questions were developed based on the research objectives, guided by relevant theoretical frameworks and existing literature, and piloted to ensure clarity and relevance.

Interviewees were selected using purposive sampling to include key stakeholders of the target company with relevant experience and insights. Criteria for selection ensured a diverse range of perspectives from both product and project management fields. Ethical approval was obtained prior to conducting the interviews. All participants provided informed consent for the use of their comments in the study and for the recording of the interviews. Confidentiality and data security were maintained by processing the collected material in electronic form on a secure drive, and data was handled according to ethical guidelines to mitigate potential risks. All 11 interviews (Table 3) were conducted using Microsoft Teams, each lasting between 1 hour and 1 hour 35 minutes. Interviews were transcribed immediately afterwards to ensure accuracy.

After the interviews, the interview data was thematised and coded to further analyse the results effectively. The thematic analysis was a critical component of this study, aimed at systematically organising and interpreting the qualitative data obtained from the interviews. The process involved several structured steps to ensure that the analysis was thorough, reliable, and aligned with the research objectives.

The interview data was first transcribed to capture the full extent of interviewees responses. Transcriptions were then reviewed multiple times to ensure accuracy and familiarity with the data. The initial step in the thematic analysis involved open coding, where each transcript was coded line by line. This method ensured that no detail was overlooked and allowed for the identification of as many potential themes as possible.

Within each predefined theme, sub-themes were identified to capture more specific aspects of the data. For example, under "project management practices," identified subthemes included "communication", “manging changes”, "resource allocation," and "risk management." Once the themes and sub-themes were finalised, the data was further analysed in relation to the theoretical framework and existing literature. This step involved comparing the study's findings with established theories and previous research

to highlight consistencies, contradictions, and new insights. For instance, the analysis explored how the identified themes related to established project management methodologies and best practices in product development.

Table 3. Conducted interviews in the data collection phase.

Interviewee	Main field of responsibility	Duration of the interview
I-1	Product management	1h 10min
I-2	Project management	1h 15min
I-3	Product management	1h 10min
I-4	Product management	1h 30min
I-5	Project management	1h 35min
I-6	Project management	1h 5min
I-7	Product management	1h 25min
I-8	Project management	1h 25min
I-9	Project management	1h 15min
I-10	Product management	1h 25min
I-11	Product management	1h 25min

Codes generated during the initial coding phase were then grouped into themes and subthemes. This was guided by predefined themes that were aligned with the research questions. The predefined themes included the following areas:

- Project management practices: Identifying effective and ineffective practices.
- Challenges and opportunities in product management: Understanding possibilities and common obstacles faced by the target company.
- Improvement opportunities: Highlighting potential areas for process enhancement.
- Effects of the operating environment: Identifying the main factors that the operating environment has.

Through this comprehensive analysis, major and minor themes were identified. Major themes were those that appeared frequently across multiple interviews and had significant implications for the research questions. Minor themes, while less prevalent, provided unique insights or highlighted specific issues that were relevant to particular contexts or individuals. The identified themes were crucial for understanding the effectiveness of current project management practices within the target company. Major themes often reflected widespread challenges or successful strategies, whereas minor themes offered more nuanced perspectives or highlighted exceptional cases.

The findings from the thematic analysis are presented in more detail in Chapter 4, which includes:

- A summary of each major theme, supported by direct quotes from the interviewees to illustrate key points.
- An exploration of how these themes relate to the theoretical framework and existing literature.
- A discussion on the implications of the findings for the target company's project management and product development processes.

The thematic analysis aimed to provide actionable insights that could drive informed decision-making within the target company. By systematically organizing and interpreting the interview data, the analysis highlighted key areas for improvement and potential strategies for enhancing project management and product development practices. These insights formed the basis for the specific recommendations and action plans detailed later in the study.

The study acknowledges limitations in the data collection and analysis process. These include potential biases in self-reported data, which might be subjective. Additionally, the findings have limited generalisability due to the specific context of the target company.

4. IMPLEMENTATION OF NEW PRODUCT MANAGEMENT APPROACH

In this chapter, the results of the analysis of the interview results are presented, and the chapter is organised according to themes identified during the analysis of the interview transcriptions. The interview was structured to examine the implementation of the new product management approach from the project management perspective. This approach allows for a comprehensive understanding of the key insights provided by the interviewees on what the implementation of the new product management approach will require from the project management process and what can be done in project management to support this new approach.

The chapter aims to form a clear view of the interview results, offering a detailed overview of the themes that emerged. These themes will be explored and discussed thoroughly to highlight the perspectives and experiences of the target company's personnel. In chapter 5, these results will be analysed in more depth, comparing, and contrasting them with theoretical frameworks and concepts identified in the literature review presented in chapter 2.

By organising the interview findings thematically, this chapter not only presents the raw data but also begins to interpret and contextualise it, setting the stage for the more detailed analysis that follows in the next chapter. This approach ensures that the reader gets a clear understanding of how the new product management approach is perceived and planned to be implemented in the target company. It paves the way for a more in-depth discussion presented in the next chapter.

4.1 General overview of the interview results

Based on the interviews of the target company key personnel, in project management, clear communication and close customer cooperation are seen as key factors for efficiency and success. Fluent communication internally and in customer communication helps to understand the customer's needs, optimising processes, and reduces misunderstandings during the project. Technical know-how and process control are also seen essential. With standardised processes and strong technical competence, projects can be managed seamlessly and efficiently from start to finish.

Challenges in project management are often related to change management and communication in new product development projects. Lack of flexibility in processes and

challenges in managing customer changes are often highlighted during a project, which can lead to delays and inefficiencies. Tight customer schedules and resource management limitations due to the size of the target company are also common problems that affect the smooth running of the project and the development process of new products and components.

New approach to product management offers opportunities for operational efficiency, but the integration between project management and new product management approach is seen to require careful planning and adaptation. The advantages of the new approach are believed to be seen in a faster response to customer needs and more efficient internal processes. At the same time, target company will face challenges such as resistance to change and the need to strengthen their negotiating position with OEMs.

Being a supplier for large OEMs is seen to entail significant risks, such as tight schedules and substantial contractual penalties for deviating from these schedules. Adapting to evolving requirements is essential to mitigate these risks. Additionally, maintaining flexibility in project and product management is crucial to avoid conflicts and costly late fines during the projects.

In conclusion, interviewees see that successful project management for large OEMs as a supplier requires effective communication, technical competence, flexibility in process management, and the ability to manage and anticipate risks. All target company customer projects also have some new product designing, which must be managed according to a carefully planned product management process alongside the actual project management process. Balancing and continuously developing these elements are seen essential for the success of projects and the long-term success of the target company.

4.2 Project management perspective

From a project management perspective, the interviewees emphasised the importance of managing complex schedules, resources, and customer relationships effectively. Respondents highlighted the need to improve schedule management and resource allocation to better meet project requirements. Project management must also be flexible to adapt to customer requirements and change requests effectively. As I-11 stated, handling customer relations during projects is crucial and is considered one of the strengths of the target company's project management:

"Customer communication and good management of the customer interface during the entire project is important and in general we have succeeded in this with high quality." (I-11).

Respondents also acknowledged that the current project management process generally supports operations effectively. The requirements of the International Railway Industry Standard (IRIS) create a strong foundation for the target company's project management process (I-7). The part of the project management process that starts after the initiation phase and ends when the product design is frozen is seen particularly effective:

"When the project has started, the first meetings with the customer have been held and we know roughly the interfaces. From then on until the time when we start aiming for a 3D freeze for the plans. That part works well and it's efficient." (I-7).

The primary factor contributing to the success of the project management process in the target company appears to be the predetermined review practices, which serve as the backbone of the project management process in the target company. These review practices ensure that all relevant topics are addressed at the appropriate times throughout the project. However, there still seems to be room for more accurately identifying the most critical topics during different project phases:

"The project management process is described well through the reviews and the whole can be clearly visualised." (I-4)

"The review protocols serves as the backbone of project management, the importance of which should be emphasised more than at present." (I-8)

"Review protocols deserve weight value as a positive thing. In inspection practices, we have accumulated know-how and knowledge potential." (I-11)

"It should perhaps be marked in the reviews which are the most critical points in every phase that must be reviewed with the customer or our organisation." (I-2).

One additional factor supporting the effectiveness of project management process is the efficient and straightforward cooperation between the project manager and the design team, which was mentioned by five out of eleven respondents:

"Cooperation is mostly good throughout the organisation, but project management cooperation works especially well with design team." (I-11)

"The cooperation between project managers and design team is functional and efficient throughout the project." (I-10)

"Once the project has started, the collaboration between the project manager and the designer assigned to the project plays a key role in the process-oriented design iteration work, and this is really working well." (I-7)

"Communication between the project manager and the project design team, as well as communication towards the customer, is very effective." (I-4).

"The cooperation between the project manager and the designers works well because the exchange of information is straightforward and clear." (I-1).

However, respondents also noted that the project management process is not always strictly followed by personnel, particularly in busy situations. It seems that processes may not be followed when situation is hectic. The current project management process seems to be somewhat flexible, and it supports quick responses to product-related customer change requests during projects, which is seen as beneficial:

“The processes are well described and of high quality, but compliance with the processes is variable, especially in busy situations.” (I-5)

"The specialty of our project organisation is the ability to react effectively to sudden change requests presented by the customer." (I-11)

"We react to change requests very flexibly and are good at adapting. Sometimes we value change flexibility even more than sticking to our own schedule." (I-9).

I-7 further highlighted that the strong capability to react to change requests should be seen as a competitive advantage compared to other suppliers:

"The attitude towards change requests should be changed from negative to positive. We should see opportunities here, as we gain a competitive advantage over our competitors when we implement challenging change requests with agility." (I-7).

Despite effectively handling customer change requests, respondents view these requests as a challenging aspect of the project management process. Change requests can sometimes disrupt the process, especially after the design is frozen. As I-11 stated, the process should be followed, despite the urgency of customer requests, to avoid unnecessary disruptions. Additionally, resource allocation is challenged by customer change requests, especially when multiple change requests occur simultaneously in parallelly ongoing projects:

"When a customer requests a change, despite the urgency, the change request should be carried through in a controlled manner according to the process. Otherwise, the change request will disrupt the process." (I-11)

“Until the design freeze, the changes are manageable, but after the design freeze, change management causes challenges in projects both in terms of resourcing and the schedule.” (I-1)

"When simultaneous changes occur in several projects running in parallel and all our resources are in use, at the latest at this stage, the customer's change requests usually mess up the process, when the process discipline suffers in the rush." (I-6).

In summary, the interviewees provided valuable insights into the project management process within the target company (Table 4). Effective management of complex schedules, resources, and customer relationships was emphasised as crucial. The importance of predetermined review practices and efficient cooperation between project managers and design teams was highlighted as key factors contributing to the overall success of project management. However, challenges such as inconsistent adherence to processes, especially during busy periods, and the disruptive nature of customer change requests were also noted. Addressing these challenges while leveraging strengths can enhance the project management process, ensuring both flexibility and adherence to established protocols.

Table 4. Identified key insights related to project managements perspective.

Identified theme	Key insight	Representative quote
Schedule management	Importance of improving schedule management and resource allocation.	*"…after the design freeze, change management causes challenges in projects both in terms of resourcing and the schedule." (I-1)*
Communication and collaboration	Communication with customers during the project is seen successful.	*"Customer communication and good management of the customer interface during the entire project is important and in general we have succeeded in this with high quality." (I-11).*
Project management process	Effectiveness of the current project management process, particularly after initiation until design freeze.	*"The part from initiation to design freeze works well and is efficient." (I-7)*
Project management process	Significance of predetermined review practices.	*"Review protocols serve as the backbone of project management." (I-8)*
Communication and collaboration	Efficient cooperation between project managers and design teams.	*"Cooperation between project managers and the design team is functional and efficient." (I-10)*
Project management process	Variability in adherence to processes, especially in busy situations.	*"Compliance with processes is variable, especially in busy situations." (I-5)*
Project management process	Flexibility and challenges in handling customer change requests.	*"We react to change requests very flexibly." (I-9)* *"Until the design freeze, the changes are manageable, but after the design freeze, change management causes challenges in projects both in terms of resourcing and the schedule." (I-1)*
Competitive advantage	Ability to react to change requests seen as a competitive advantage.	*"We gain a competitive advantage when we implement challenging change requests." (I-7)*

4.3 New product development during projects

Coordinating product development and project management presents some challenges in the target company. Respondents I-2, I-7, and I-9 indicate that product development activities often take place in a hurry in connection with projects and could be more managed activities:

"We have tried to stick to the way of operating that product development would mainly take place in projects, and there would be no separate product development projects except in special cases." (I-2)

"In the projects, product development activities are carried out mainly in order to correct the challenges occurred in the project's products during testing etc. This is usually done in a hurry." (I-7)

"In projects, project product designing, and product development are carried out at the same time, which puts a lot of stress on design team, and product development has not always been a very managed activity." (I-9).

Personnel from the target company have observed that a certain level of product development during a project is manageable, but as the level of product development increases, it poses challenges for project management. A potential solution is to distinguish between product development activities and other tasks more accurately:

"The project management process is the same as the product development process. Product development is done in customer projects. I think the functionality of this depends on what is being developed. A small amount of product development can easily be done within the current project management process, but the situation changes quickly if the level of product development increases." (I-4)

"We should recognise at what point product design clearly turns into product development, or at what point it should turn into product development." (I-11).

The target company has review practices as mentioned in the previous chapter, and these practices also have questions that support on defining the level of product development needed in projects, enabling project management to prepare project planning accordingly. However, this does not always resolve issues, particularly during the testing phase, where new solutions may be required if tests fail:

"The review practices have questions about whether there is a need for product development in the project. However, this does not always help. Especially when there are new types of products, there may be situations during the project design phase where the basic solution does not work for some reason, and new solution is needed." (I-4).

Currently, the project management process does not adapt based on the level of product development, but the process remains the same for every project:

"The project management process is exactly the same for every project, although the degree of product development varies." (I-5).

Under the current approach, new product development is perceived to result in higher quality products than required because testing is usually performed on assemblies rather than individual components. Respondents also note that testing involves scheduling risks, and clear communication is essential:

"Carrying out product development in projects causes excess quality in design, when testing takes place by testing new entities, and not individual components." (I-3)

"Since new solutions are developed during the projects, it would be particularly important that the purchases related to testing and the related communication about schedules go as smoothly as possible, because our testing activities involve schedule risks." (I-1).

In summary, integrating product development within the project management process presents both opportunities and challenges (Table 5).

Table 5. Identified key insights related to new product development.

Identified theme	Key insight	Representative quote
Product management process	A manageable level of product development is possible within projects, but increased levels pose challenges.	*"A small amount of product development can easily be done within the current project management process." (I-4)*
Product management process	Existing review practices include questions to help define the level of product development needed, though they are not always effective.	*"The review practices have questions about whether there is a need for product development in the project." (I-4)*
Project management process	The project management process does not adapt to the level of product development, but it remains the same for all projects.	*"The project management process is exactly the same for every project, although the degree of product development varies." (I-5)*
Project and product management	Product development often takes place hurriedly within projects and could benefit from more structured management.	*"Product development is carried out mainly to correct challenges in the project's products during testing." (I-7)*
Communication and collaboration	Clear communication and efficient handling of testing-related purchases and schedules are crucial to minimise risks.	*"It is particularly important that purchases related to testing and communication about schedules go as smoothly as possible." (I-1)*

While current practices allow for simultaneous project execution and product development, there is a need for more structured management of product development activities. Clearly identifying and limiting product development tasks is proposed. Additionally, while review practices provide some support, further measures to anticipate and manage new development needs during testing phases can mitigate disruptions. Clear communication and efficient handling of testing-related purchases and schedules are also crucial to minimise risks and ensure project success.

4.4 Integration of new product management approach

Integrating a new approach to product management with project management presents numerous opportunities and challenges. Respondents highlighted the necessity of well-designed links between the two processes to handle change requests more efficiently. By ensuring a strong connection between product and project management, organisation can respond to changes promptly and maintain project momentum:

> *"Integrating a new approach to product management can provide a solution for example faster handling of change requests. This requires that the link between product management and project management is well designed." (I-7).*

To facilitate this integration, it is suggested that information exchange mechanisms be embedded within existing frameworks such as FMEA and project reviews. This could enhance coordination and ensure that changes are managed effectively throughout the project lifecycle:

> *"Information exchange from the project to product management could be integrated into FMEA and project reviews. Integration with product management could also be considered through change reviews." (I-5).*

Following a structured change process is seen as essential for maintaining efficiency in product management. Currently, change reviews are pivotal points where the link between product and project management is most apparent, highlighting the importance of these reviews in the overall process:

> *"The change process should be followed in order for product management to be as efficient as possible. Change reviews are the only links in the current process where product management and project management are clearly linked." (I-7).*

Moreover, integrating product management into project management at an operational level is crucial. This ensures that product management considerations are embedded in day-to-day project activities, leading to better alignment and more cohesive project execution:

“New product management is perhaps not so much a process, but product management is integrated into project management. Product management must be present at the operational level throughout the project.” (I-8).

For effective integration, a clear product management framework is needed within which changes can be assessed. This framework should align with the boundaries set by product management to maintain control and consistency:

“Project management needs a clear product management framework within which changes can be assessed while considering the boundaries set by product management.” (I-3).

However, finding a balance with the constraints set by product management can be challenging. There are concerns about the reduction in flexibility and the potential backlash from customers. Customisation, a key aspect of customer satisfaction, must be balanced with commitment to product management standards:

“The share of product management-compliant components in the products must be maximised, but at the same time it must be accepted and recognised that not all components will meet the requirements of product management, because we produce customised products for our customers.” (I-2)

“Finding a balance with the constraints set by product management can be challenging. The risk is that the reduction in flexibility with the new approach to product management may cause a backlash from customers.” (I-11).

Additionally, complex projects have raised challenges from the perspective of product management. High degrees of product development within projects require the organisation to adapt and respond to new challenges that standard projects may not present:

“Complex projects have recently raised challenges from the point of view of product management. When the degree of product development of the project's products is high, it challenges the entire organisation in a different way than the so-called standard products.” (I-1)

“Currently, product management does not support the project much. The solutions come from sales as specified. It is difficult to change these during the project.” (I-9).

Another critical phase for product management is the sales phase. Proper identification and integration of product management during sales can streamline processes and reduce changes during projects. This early involvement helps in setting realistic expectations and aligning the product development process with customer requirements from the beginning:

"The identification of the product development project has been a little lacking in the sales phase, and the maturity of the products has not been controlled much when the project is started." (I-4)

"The challenge has been to find solutions already in the sales phase that are the best for us from a product management point of view and at the same time meet the customer's requirements." (I-8)

"Already in the sales phase, you could try to guide the customer to use certain solutions that have been found to be good. In this case, product management would start from the point of sales, when the specs are reviewed and commented on based on product management." (I-2)

"The work of the new product management will be done strongly in the service of sales, so that during the sales phase sales have the best possible information available." (I-7).

Early clarity in product specifications and interface definitions can significantly reduce the number of changes required during the project, leading to smoother project execution and fewer disruptions:

"If at the beginning of the project it is clearer to the customer what the product is like, and the definitions of the interfaces are clear, the number of changes during the project will probably decrease." (I-9)

"Especially in the sales phase, product management must participate very actively, because a large part of the big lines regarding product design are drawn already in the sales phase." (I-9).

Operational changes and the impact of integrating a new product management approach are also significant. While there has been an improved understanding of the effects of product development on the product life cycle, challenges remain in the implementation. A systematic approach to project management that incorporates product management guidelines can help address these challenges:

"The understanding of the effect of the degree of product development on product life cycle management has improved. However, this product family-like new approach to product management has not yet had time to affect ongoing projects." (I-5)

"The project management process could be developed in such a way that it would direct project management to consider product management. This would support that

the guidelines of the new product management would also be considered in customer changes." (I-2)

"If the customer change results in a change that is not in accordance with product management, its risks must be assessed and considered in the project. For example, the effects on the documentation and type tests that are ahead of the project, and of course the effects on costs must be considered." (I-2).

Review practices are another area where integration can be enhanced. By considering both project management and product management perspectives, review practices can provide more comprehensive support without becoming overly burdensome:

"Review practices should be considered from both the perspective of project management and product management. However, the review practices must not become too burdensome." (I-8).

The role of the project manager is seen as pivotal in this integration. The project manager must be adept at recognising when changes are significant enough to require product management intervention and must work closely with the design team to ensure efficient implementation of product management practices:

"When the approach to product management changes, the project manager must be able to better assess when the change being handled is too much of a design topic for the project manager. From the point of view of the new product management approach, the project manager should be very closely involved in design decisions, so that product management can be implemented as efficiently as possible." (I-1)

"The most significant role in taking care of product management is played by the project manager, who receives change requests from customers. If all changes go from the project manager to planning, product management cannot be implemented in a controlled manner." (I-3).

When looking forward, the integration of a new product management approach aims to provide a more comprehensive technical and economic perspective, optimising product selection and integrating this mindset across the entire organisation. This holistic approach is expected to bring about significant improvements in both product quality and project efficiency:

"In the future, we aim to be able to look at products with the help of a new product management approach from a more comprehensive technical and economic point of view and to optimise our product selection." (I-5)

"The new product management mindset must be able to be integrated into the entire organisation." (I-10).

In summary, while the integration of a new product management approach within the project management process offers both opportunities and challenges, this approach is believed to create improved efficiency and quality through better coordination and structured management, it also requires significant adjustments in current practices and mindsets (Table 6).

Table 6. Identified key insights related to integration of new product management approach.

Identified theme	Key insight	Representative quote
Product management process	Integrating a new approach to product management can improve handling of change requests.	*"Integrating a new approach to product management can provide a solution for example faster handling of change requests." (I-7)*
Project / product management integration	Embedding information exchange within FMEA and project reviews enhances coordination.	*"Information exchange from the project to product management could be integrated into FMEA and project reviews." (I-5)*
Operational integration	Product management must be integrated into day-to-day project activities.	*"Product management must be present at the operational level throughout the project." (I-8)*
Project / product management process	A clear framework is needed to assess changes within set boundaries.	*"Project management needs a clear product management framework within which changes can be assessed." (I-3)*
Product management process	High degrees of product development in complex projects present unique challenges.	*"Complex projects have recently raised challenges from the point of view of product management." (I-1)*
Product management process	Early involvement of product management in the sales phase is crucial for setting realistic expectations.	*"Product management must participate very actively, because a large part of the big lines regarding product design are drawn already in the sales phase." (I-9)*
Project / product management integration	A systematic approach to project management incorporating product management guidelines is needed.	*"The project management process could be developed in such a way that it would direct project management to consider product management." (I-2)*
Project / product management integration	Review practices should consider both project and product management perspectives without becoming overly burdensome.	*"Review practices should be considered from both the perspective of project management and product management." (I-8)*
Project / product management integration	A comprehensive technical and economic perspective is aimed for future integration, optimising product selection.	*"In the future, we aim to be able to look at products with the help of a new product management approach from a more comprehensive technical and economic point of view." (I-5)*

Clear communication, early involvement in the sales phase, and a well-defined framework are crucial for successful integration. The involvement of project managers and the

entire organisation in embracing this new mindset will be vital in optimising product development and ensuring project success. Ultimately, a balanced approach that considers the constraints of product management while maintaining flexibility for customisation will be key to navigating these changes effectively. Identified key insights related to new product development.

4.5 Effects of the operating environment

According to the interviewees, the operating environment of the target company presents a range of challenges for product and project management, particularly due to the differing processes and requirements of customers. Respondents frequently noted the mismatch between their own processes and those of their customers, which creates significant challenges in resource planning and overall project execution:

“One of our 'number one challenge' is that the customer's and our processes don't meet. The customer's process requires something in a certain time span, and with us it is done or can only be done much later. This causes challenges in resource planning.” (I-11)

“One big challenge we usually have is that we are a little bit of passengers in the customer's process, and our process drifts along with the customer's process.” (I-2)

“Our customers' processes are different from each other, and they are also different from ours. This means that our process needs to be flexible, not our customers'.” (I-8).

The position of the company to be in between the OEM and the lower-level supply chain adds to the complexity, often necessitating a high degree of flexibility to ensure seamless cooperation and project continuity:

“The company's position as a supplier between OEM and the supply chain is challenging and this often leads to us having to be flexible with projects.” (I-3)

“We act as one small player from our customers' project perspective. This often means that we have to be flexible in order to achieve more seamless cooperation.” (I-5)

“Large customers often face internal information flow challenges. The person coordinating the customer's purchase may pressure us to stay on schedule, even though their train level design is in such a state that we cannot proceed with the desired schedule.” (I-1).

Additionally, the variations in customer processes contribute to challenges in aligning schedules and managing resources efficiently. When project processes between different customers differ, it often requires deviations from procedures in the target company, impacting project consistency and quality:

“One customer’s process is written one way, and another customer’s process in another, and then our process is written in a third different way. When these don’t match, that's the challenge.” (I-11)

“When the customer is significantly larger than us, the customer determines how the process proceeds. Reason: This causes us to often have to deviate from our own process.” (I-3).

The increasing demands and stricter requirements, particularly regarding sustainability, technical specifications, and documentation accuracy, further complicate project execution. Respondents highlighted the need for their processes to adapt to these growing demands to maintain project success:

“The demands are growing all the time. Sustainability aspects have also come to the fore in material matters.” (I-2)

“The requirements have become stricter in recent years. In particular, the technical requirements and the accuracy requirements for documentation have become stricter.” (I-6).

Another challenge mentioned was the lack of a dedicated supplier-specific project manager on the customer's side, which challenges effective communication and coordination, leading to potential misalignments and delays:

“The customer does not always have a supplier-specific project manager, which creates challenges in communicating these matters to the customer so that it can be ensured that the message is delivered to the right people.” (I-4).

Tight schedules often exacerbate these issues, as they lead to rushed processes and deviations from established procedures, impacting the overall quality and reliability of project outcomes:

“Schedules are often too tight for the requirements. Tight schedules affect how well the process is followed. Often, in a hurry, it starts to slip.” (I-10).

Interviewee I-5 also notes that in a multi-project environment, last-minute changes have a cumulative effect, straining resources and causing further challenges in resource planning and project management:

“The effects of last-minute changes are cumulative in a multi-project environment. Reason: When the same resources are used in other projects, the changes directly affect the whole, causing challenges for resource planning.” (I-5).

In conclusion, the operating environment of the target company poses several challenges for integrating product management with project management (Table 7). The differences in processes between the company and its customers, combined with the need for flexibility, stricter requirements, and tight schedules, necessitate a robust and adaptive approach. Addressing these challenges requires clear communication, flexible planning, and a proactive stance in managing both customer expectations and internal processes. By understanding and adapting to these environmental factors, the company can better align its processes with customer needs and achieve more efficient and successful project outcomes.

Table 7. Identified key insights related to effects of the operating environment.

Identified theme	Key insight	Representative quote
Project management process	The mismatch between the company's and customers' processes creates challenges in resource planning and project execution.	*"One of our 'number one challenge' is that the customer's and our processes don't meet." (I-11)*
Customer requirements	The company's position between OEM and supply chain necessitates a high degree of flexibility.	*"The company's position as a supplier between OEM and the supply chain is challenging and this often leads to us having to be flexible with projects" (I-3)*
Customer requirements	Increasing demands and stricter requirements, especially in sustainability and documentation, complicate project execution.	*"The demands are growing all the time. Sustainability aspects have also come to the fore in material matters." (I-2)*
Schedule Management / Customer requirements	Tight schedules lead to rushed processes and deviations from established procedures, impacting quality and reliability.	*"Schedules are often too tight for the requirements. Tight schedules affect how well the process is followed. Often, in a hurry, it starts to slip." (I-10)*
Customer requirements	Last-minute changes in a multi-project environment strain resources and complicate resource planning and project management.	*"The effects of last-minute changes are cumulative in a multi-project environment." (I-5)*

4.6 Current state of project and product management

From a project management perspective, the target company has developed a robust framework that supports the effective management of complex scheduling and resource challenges like RSMPSP, and customer relationships. Interviewees highlighted several strengths and areas for improvement within the existing project management practices. The target company's project management strengths lie in effective customer communication, structured processes, robust review practices, and strong team cooperation. Effective communication and management of customer interfaces are seen as key strengths, with high-quality interactions maintained throughout the project lifecycle. As

one interviewee noted, “Customer communication and good management of the customer interface during the entire project is important and in general, we have succeeded in this with high quality.” (I-11).

The project management process, particularly from the initiation phase to the design freeze phase, is well-structured and efficient. This segment is recognised for its effectiveness, with another interviewee stating, “When the project has started, the first meetings with the customer have been held and we know roughly the interfaces. From then on until the time when we start aiming for a 3D freeze for the plans. That part works well and it's efficient.” (I-7). Also, predetermined review practices are integral to the project management process, ensuring that all relevant topics are addressed at appropriate times. This approach is valued for its clarity and thoroughness: “The project management process is described well through the reviews and the whole can be clearly visualised.” (I-4). Efficient cooperation between project managers and the design team also facilitates effective project execution. Clear communication and straightforward information exchange contribute to this success, as highlighted by an interviewee: “The cooperation between project managers and the design team is functional and efficient.” (I-10).

Integrating product development activities within the project management process presents both opportunities and challenges. Interviewees identified the need for more structured management of product development tasks to ensure project success. A manageable level of product development within projects is possible and can be effectively integrated into the current project management process. One interviewee noted, “A small amount of product development can easily be done within the current project management process.” (I-4). Existing review practices include questions to help define the level of product development needed, although these are not always effective, particularly during the testing phase where new solutions may be required if tests fail.

Currently, the project management process does not adapt based on the level of product development, which can lead to inefficiencies and challenges. An interviewee observed, “The project management process is exactly the same for every project, although the degree of product development varies.” (I-5). Product development activities often occur hurriedly within projects, leading to stress on the design team and less structured management, as another interviewee mentioned, “Product development is carried out mainly to correct challenges in the project's products during testing.” (I-7). In addition, testing is typically performed on assemblies rather than individual components, resulting in higher quality than necessary and involving scheduling risks. This approach can be inefficient

and challenging, as noted by an interviewee: “Carrying out product development in projects causes excess quality in design, when testing takes place by testing new entities, and not individual components.” (I-3).

Integrating a new approach to product management with project management offers significant opportunities for improved efficiency and quality. Interviewees stressed the importance of designing well-integrated links between the two processes to handle change requests more efficiently. Embedding information exchange mechanisms within frameworks such as FMEA and project reviews can enhance coordination and ensure effective change management throughout the project lifecycle. One interviewee suggested, “Information exchange from the project to product management could be integrated into FMEA and project reviews.” (I-5). Integrating product management into day-to-day project activities ensures better alignment and more cohesive project execution: “Product management must be present at the operational level throughout the project.” (I-8).

Establishing a clear product management framework for project management to assess changes within set boundaries will help maintain consistency and control. However, balancing product management constraints with customer customisation needs can be challenging. One interviewee highlighted this issue, stating, “Finding a balance with the constraints set by product management can be challenging. The risk is that the reduction in flexibility with the new approach to product management may cause a backlash from customers.” (I-11).

High degrees of product development within complex projects present unique challenges that require the organisation to adapt and respond effectively. Early involvement of product management during the sales phase is essential for setting realistic expectations and aligning the product development process with customer requirements, as emphasised by an interviewee: “Product management must participate very actively, because a large part of the big lines regarding product design are drawn already in the sales phase.” (I-9).

In summary, the integration of a new product management approach within the project management process can lead to improved efficiency and quality through better coordination and structured management. Clear communication, early involvement in the sales phase, and a well-defined framework are crucial for successful integration. Balancing product management constraints with the need for customisation will be key to navigating these changes effectively.

5. DISCUSSION

The purpose of this chapter is to interpret and contextualise the findings presented in the previous chapter within the framework of the existing literature and the theories previously discussed in the thesis. The purpose of this study was to investigate the integration of the new product management approach and project management in the target company. The research focused especially on the operation of the project management process of the target company operating in MPE, as well as on the opportunities and challenges from the perspective of both, the new approach to product management, and project management.

Through a series of semi-structured interviews, qualitative data was gathered, providing insights into the current practices, difficulties encountered, and potential improvements based on the insights of the key personnel of the target company. This discussion will critically analyse these findings, compare them to established knowledge in the field, and highlight theoretical and practical implications. By doing so, this chapter seeks to bridge the gap between theory and practice, providing a comprehensive basis for practical recommendations that can enhance both project management and product management processes in the target company. In the following chapters, the key themes that emerged from the interviews are examined, their implications are explored, and detailed discussion on the integration of project and product management within the context of multi-project environments (MPE) will be provided.

5.1 Project management practices

The interview results consistently emphasised the importance of clear communication and close cooperation with customers as critical factors for project success. This aligns with Nyameke et al. (2020), who underscore that an effective communication infrastructure is essential for coordination and collaboration in project management. The findings highlight that fluent communication helps optimise processes, reduces misunderstandings, and ensures that customer needs are accurately understood and met.

Respondents noted that internal communication between project managers and design teams really efficient, which makes the implementation of projects particularly effective, which supports the assertion by Artto and Kujala (2008) that also resource and personnel management are crucial for effective project execution. The literature also points to the significance of communication in managing multi-project environments, where Ben Issa

et al. (2021) highlight that effective communication systems are necessary to address the complexities of scheduling and resource allocation. However, the interviewees also noted challenges related to communication with customers, especially regarding change requests and managing customer expectations and tight schedules. The respondents' experiences with tight customer schedules and resource limitations are common issues in MPEs, where effective communication and negotiation skills are vital for managing stakeholder expectations and project constraints (Project Management Institute, 2017).

The interviewees consistently highlighted the importance of predetermined review practices as a backbone of the project management process. These practices ensure that all relevant topics are addressed at appropriate times throughout the project lifecycle. This aligns with Kerzner (2017), who emphasises systematic planning and control mechanisms as fundamental to effective project management. However, a significant challenge identified by the respondents is the inconsistent adherence to these processes, particularly during busy periods. This inconsistency suggests a need for better process discipline, as highlighted by Wauters et al. (2015), who underscore the importance of maintaining process integrity even under pressure of MPE. Ensuring that processes are strictly followed can prevent deviations that lead to inefficiencies and project delays.

The review protocols, as described by the interviewees, serve as critical checkpoints to assess project progress, and make necessary adjustments. This approach is supported by the Project Management Institute (2017), which outlines the importance of regular reviews to monitor and control project performance. However, there is an opportunity to enhance these reviews by more accurately identifying and prioritising the most critical topics during different project phases. This can be achieved by integrating risk management and quality management principles into the review process, as suggested by Koppenhagen & Held (2021).

Effective management of customer change requests is highlighted as a key strength of the target company's project management practices. This capability is crucial in dynamic project environments, where flexibility and adaptability are essential for success (Habibi et al., 2023). The respondents noted that their ability to handle change requests quickly and efficiently gives them a competitive advantage, particularly in maintaining customer satisfaction. However, managing these change requests also presents challenges, especially when they occur after the design freeze stage. The literature emphasises the need for robust management processes to handle such requests without disrupting the overall project flow (Apaolaza & Lizarralde, 2020; Gómez Sánchez et al., 2023). The target company can benefit from developing a more structured approach to change management that balances flexibility with process adherence. This involves ensuring that all

change requests are evaluated, documented, and integrated into the project plan in a controlled manner.

The interviews suggest that the current project management process supports quick responses to change requests but may sacrifice adherence to the established process in the rush to accommodate customer needs, when there multiple change request from parallelly ongoing projects are emerging simultaneously. This finding aligns with the challenges of managing resource allocation and scheduling in multi-project environments, as discussed by Ben Issa et al. (2021). Usually, parallelly ongoing projects share common resources, which increases the complexity of managing planning, scheduling, and resource allocation (He et al., 2022; Ben Issa et al., 2021). To mitigate these challenges, the target company should consider implementing a formal change management framework that includes also predefined steps for assessing, approving, and implementing changes. This framework could help maintaining process discipline while ensuring that customer needs are met promptly.

Resource management and scheduling are seen as critical aspects of project management, particularly in multi-project environments (MPE). The target company's experience with managing complex schedules and resource constraints reflects the challenges discussed by Chen et al. (2022), who highlight the need for innovative approaches to scheduling in MPEs. The interviewees identified effective resource allocation and schedule management as areas needing improvement to better meet project requirements. This aligns with the literature, which emphasises the importance of resource planning and scheduling techniques to optimise project performance (Carvalho et al., 2015).

The ability to adapt to changing project requirements and customer needs is also a recurring theme in the interviews. The respondents emphasised the importance of flexibility in project management, particularly in handling customer change requests and managing resource constraints. This aligns with the literature's emphasis on adaptive project management practices in dynamic environments (Apaolaza & Lizarralde, 2020). To enhance flexibility and adaptability, the target company should consider adopting agile methodologies that support iterative development and continuous feedback (Vos et al., 2016). Agile practices can help the target company stay responsive to changing project conditions and customer demands, ensuring that projects remain aligned with strategic goals and deliver value to stakeholders.

In summary, the target company's project management practices reflect a strong foundation in systematic planning, effective communication, and flexibility. However, there

are opportunities to enhance process adherence, change management, resource allocation, and scheduling by integrating advanced techniques and frameworks from the literature. By addressing these areas, the company can further improve its project management capabilities and achieve greater success in managing complex, multi-project environments.

5.2 Integration of product and project management

Based on the interviews, the integration of product and project management is crucial for enhancing operational efficiency and ensuring successful project outcomes in an MPE. The insights from the interviews provide a comprehensive understanding of the challenges and opportunities associated with this integration, which aligns with the theoretical frameworks discussed in the literature review.

The interview findings indicate that product development often occurs concurrently with project execution, which can strain resources and lead to rushed activities. This scenario reflects the challenges highlighted by Tuli and Shankar (2015), who emphasise the need for distinguishing between product development activities and other project tasks. The target company's experience suggests that a more structured approach to managing product development within projects is required to mitigate these challenges. Implementing structured product management practices, such as VSM, can help the target company identify and eliminate waste in the product development process (Tuli & Shankar, 2015). By adopting VSM, the target company can visualise the entire process flow from concept to completion, enabling better planning and prioritisation of product development tasks within projects. This approach can reduce the strain on resources and ensure that product development activities are managed more effectively.

The interviews reveal that while current review practices support identifying product development needs, further measures are needed to anticipate and manage new development requirements effectively. This finding aligns with the literature's emphasis on the importance of systematic product management tools within the project management framework (Tuli & Shankar, 2015). The importance of early communication and collaboration in product development is also highlighted by Tuli & Shankar (2015) and Matheus et al. (2017). To enhance the integration of product and project management, the target company should consider adopting a structured product management framework that aligns with the project management process. This recommendation is supported by findings from Belkadi et al. (2017) on the necessity of structured frameworks in managing

data and process interactions across organisations. By doing so, the company can improve the coordination between product and project management, leading to better alignment and project execution.

Effective coordination and information exchange between product and project management are essential for managing change requests and maintaining project on track. The interviewees highlighted the necessity of well-designed links between the two processes to handle change requests more efficiently. This finding supports the literature's emphasis on the importance of integrated communication and collaboration mechanisms in managing MPEs (Bzdyra et al., 2015; Nyameke et al., 2020). To facilitate this integration, the target company should embed information exchange mechanisms within existing frameworks, such as FMEA and project reviews. This approach can enhance coordination and ensure that changes are managed effectively throughout the project lifecycle. By integrating product management considerations into these reviews, the company can ensure that all relevant aspects are addressed, leading to more comprehensive support for both project and product management.

One of the key challenges identified in the interviews is balancing the constraints set by product management with the need for flexibility to meet customer requirements. The literature highlights the importance of maintaining flexibility in project management while adhering to product management standards to ensure quality and consistency (Apaolaza & Lizarralde, 2020; Tuli & Shankar, 2015). The target company should develop a clear product management framework within which customer changes can be assessed, considering the boundaries set by product management. This framework should allow for flexibility in customisation while maintaining control and consistency on a component level. By finding this balance, the company can navigate the challenges of integrating product and project management effectively, ensuring that both standards and customer needs are met.

The interviewees emphasised the importance of product managements early involvement in the sales phase to streamline processes and reduce changes during projects. This finding aligns with the literature's emphasis on the significance of early stakeholder involvement in the product development process (Tuli & Shankar, 2015; Matheus et al., 2017). By involving product management early in the sales phase, the target company can set realistic expectations and align the product development process with customer requirements from the beginning of the project. This early involvement can help in identifying the best solutions from a product management perspective, ensuring that the project starts with a clear understanding of the product specifications. This approach can

reduce the number of changes required during the project, leading to smoother execution and fewer disruptions.

The role of the project manager is pivotal in integrating product and project management. The interviewees highlighted the need for project managers to recognise when customer changes are significant enough to require product management intervention. This finding aligns with the literature's emphasis on the importance of project managers in coordinating and managing the integration of product and project management (Project Management Institute, 2017; Kerzner, 2017). Project managers should be trained to assess the impact of changes on product management and work closely with the design team to ensure efficient implementation of product management practices (Tuli & Shankar, 2015). By doing so, they can ensure that product management considerations are embedded in day-to-day project activities.

The integration of product and project management within the target company presents both opportunities and challenges. By adopting structured management practices, enhancing coordination and information exchange, finding balance between flexibility and standardisation, and promoting an organisational culture that embraces continuous improvement, the company can navigate these challenges effectively. The involvement of project managers and early stakeholder engagement are crucial for successful integration, ensuring that product and project management considerations are aligned throughout the project lifecycle. This integrated approach can lead to improved efficiency, quality, and overall project success, positioning the company for long-term growth and competitiveness in the marketplace.

5.3 Characteristics of the operating environment

The operating environment of the target company presents several challenges that affect project management practices and overall performance. The insights from the interviews provide a detailed understanding of these challenges, which align with the theoretical frameworks discussed in the literature review.

One significant challenge identified in the interviews is the misalignment between the target company's process and the processes of its customers. Respondents noted that the customer's process often requires deliverables within specific timeframes that do not align with the company's schedule based on their process, leading to resource planning difficulties. This misalignment creates significant challenges in resource allocation, coordination, and overall project execution. The literature recognises this issue, noting that effective project management requires alignment of internal processes with external

stakeholder requirements (Pacagnella et al., 2019). The target company's need for flexibility to adapt to customer processes reflects the adaptive strategies discussed by Chen et al. (2022), who emphasise the importance of flexibility in managing MPEs. To address this issue, the target company should consider developing adaptive strategies that allow for more seamless integration with customer processes as it is highlighted in the literature and also by the interviewees (Figure 11).

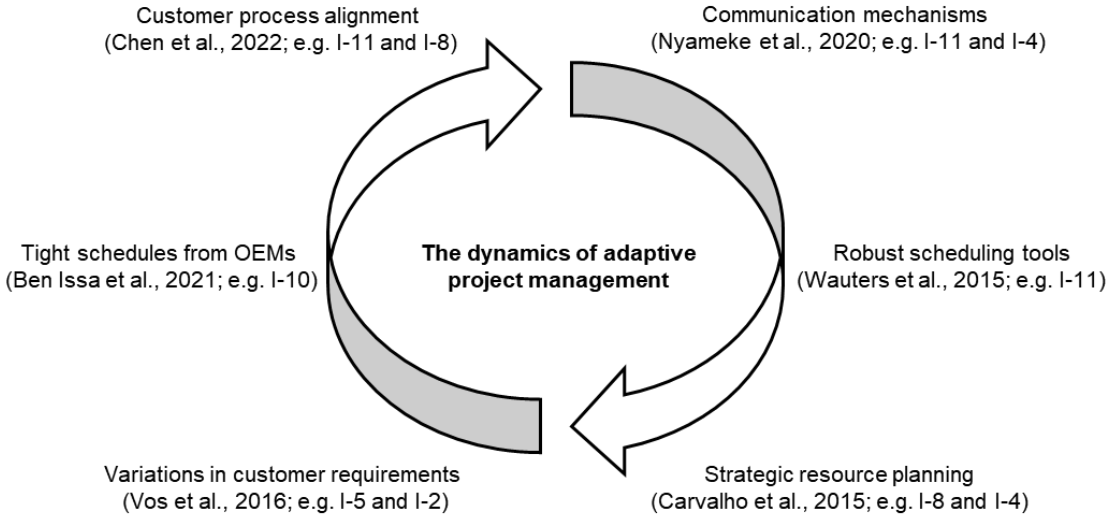

Figure 11. The dynamics of adaptive project management based on literature and interview result analysis (authors own elaboration).

The company's position as a supplier between OEMs and the lower-level supply chain adds complexity to project management. This often necessitates a high degree of flexibility to ensure seamless cooperation and project continuity. The interviewees highlighted that being a small player in larger customers' projects often requires the company to adapt quickly and flexibly to changing demands. To navigate this complexity, the company should ensure that communication and coordination mechanisms with both OEMs and lower-tier suppliers are at a sufficient level. Establishing clear communication channels and regular update meetings can help ensure that all parties are aligned and informed about project progress and any changes that may occur. Nyameke et al. (2020) emphasise that robust communication systems are critical in facilitating the flow of information among project teams and stakeholders. Additionally, Pacagnella et al. (2019) discuss the necessity for flexibility and adaptability in project management within manufacturing environments, while Wauters et al. (2015) highlight the importance of managing overlapping tasks and effective resource management.

The interviews reveal that variations in customer processes contribute to challenges in aligning schedules and managing resources efficiently. Different customers have different requirements, which often necessitates deviations from the company's established

procedures. This inconsistency can impact project consistency and quality. The target company should consider developing a flexible project management framework that can be tailored to meet the specific needs of different customers while maintaining core project management principles. This approach would help ensure that projects are executed efficiently and consistently, regardless of the specific customer requirements. Vos et al. (2016) suggest that embracing flexibility in project management methodologies is crucial in today's dynamic project environments. The literature also underscores the need for ongoing adaptation and continuous improvement in project management practices (Apaolaza & Lizarralde, 2020). Additionally, Carvalho et al. (2015) highlight the importance of strategic resource planning to align resources with project needs and optimise performance.

Tight schedules given by OEMs were frequently cited as a significant challenge, often leading to rushed processes and deviations from established procedures. These tight timelines can compromise the overall quality and reliability of project outcomes. The cumulative effect of last-minute changes in a multi-project environment further strains resources and complicates resource planning. The company should implement more robust scheduling and resource planning tools to manage tight schedules effectively. These tools can help prioritise tasks, allocate resources efficiently, and ensure that projects stay on track even when unexpected changes occur. Advanced scheduling techniques and resource allocation strategies are seen as critical in managing complex project portfolios (Ben Issa et al., 2021; Wauters et al., 2015; Chen et al., 2022).

The operating environment of the target company poses several challenges that require strategic adjustments and enhanced project management practices. By developing adaptive strategies, enhancing communication and coordination between stakeholders, and implementing robust scheduling and resource planning tools, the company can navigate these challenges effectively. Balancing flexibility with standardisation and advocating for better coordination with customer project managers will further enhance the company's ability to manage projects successfully in a complex and dynamic environment.

5.4 Linkage between results and literature

Based on the interview results, there are several connections to the literature review that highlight the importance of integrating project and product management, particularly in MPE. Firstly, the challenges of scheduling and resource allocation in the target company's projects reflect the issues discussed in the literature regarding RCPSP and RCMPSP. The interviewees emphasised the need to improve schedule management and resource allocation, aligning with the RCPSP’s focus on planning and scheduling

project activities subject to resource and time constraints (Bzdyra et al., 2015). In an MPE, these challenges are amplified, as multiple projects compete for the same resources, as described by Wauters et al. (2015) and Ben Issa et al. (2021).

The literature review underscores the complexity added by managing multiple projects simultaneously, requiring sophisticated strategies to avoid inefficiencies and delays (Gómez Sánchez et al., 2023). The target company's experiences with managing customer change requests and maintaining process compliance during busy periods resonate with the need for adaptive and flexible project management practices in dynamic environments (Apaolaza & Lizarralde, 2020).

Integration of project and product management is another key theme. The interviewees highlighted the necessity of aligning these processes to handle change requests more efficiently and ensure cohesive project execution. This aligns with the literature's emphasis on the strategic alignment of project and product management to enhance operational efficiency and responsiveness to market changes (Tuli & Shankar, 2015; Eslami & Lakemond, 2016). Embedding information exchange mechanisms within frameworks like FMEA and project reviews, as suggested by the interviewees, mirrors the literature's recommendations for leveraging advanced scheduling techniques and integrating lean methodologies to streamline processes and improve efficiency (Aqlan & Al-Fandi, 2018).

Moreover, the interviewees' insights into the need for robust communication and collaboration between project managers and design teams reflect the literature's focus on the critical role of communication infrastructure in managing project execution (Nyameke et al., 2020). Effective communication is foundational for addressing the challenges posed by diverse project requirements and stakeholder expectations, ensuring alignment and informed decision-making throughout the project lifecycle.

The challenges of managing product development activities within projects also connect with the literature on the integration of product and project management. The interviewees' observations about the hurried nature of product development and the need for more structured management align with the literature's emphasis on the importance of systematic planning and prioritisation in NPD (Carvalho et al., 2015). Implementing structured yet flexible methods, such as VSM, could help manage product development tasks more effectively, ensuring that projects stay on track and within scope (Tuli & Shankar, 2015).

Lastly, the need for early involvement of product management in the sales phase, as highlighted by the interviewees, is echoed in the literature's discussion on the importance of early stakeholder engagement in aligning product features with market demands and

technical capabilities (Raja et al., 2018). Early involvement helps in setting realistic expectations and ensures that the product development process aligns with customer requirements from the beginning.

In summary, the insights from the interviewees provide practical examples of the challenges and strategies discussed in the literature review. They highlight the critical importance of integrating project and product management, leveraging communication and collaboration, and adopting flexible and adaptive practices to manage the complexities of MPE effectively. These linkages underscore the need for a comprehensive approach that aligns project and product management functions to achieve successful project outcomes and sustain competitive advantage in dynamic business environments.

5.5 Utilising value stream mapping in the target company

As it was mentioned in the previous chapter, the integration of VSM into the target company's project and product management processes could significantly enhance efficiency and effectiveness, particularly in handling MPE. When concluding insights from both the literature review and the interview analysis, VSM could be strategically applied to address various challenges and leverage the strengths identified in the company's current practices.

One of the primary benefits of VSM is its ability to provide a clear visual representation of processes, enabling better communication and understanding among stakeholders. The literature highlights the importance of effective communication in project management (Nyameke et al., 2020). In the target company, where efficient cooperation between project managers and the design team is a strength, VSM can further streamline communication. By mapping out the entire process from project initiation to design freeze and beyond, all team members can gain a shared understanding of the workflow, identify bottlenecks, and ensure that everyone is aligned on project goals and timelines.

VSM is a tool designed to identify non-value-adding activities and eliminate waste, thereby optimising processes (Tuli & Shankar, 2015). The target company can benefit from VSM by systematically analysing each step of their project and product management processes. For instance, during the design and testing phases, where hurried product development activities were noted, VSM can highlight inefficiencies and suggest areas for improvement. This aligns with the need for more structured management of product development tasks, as identified by interviewees. By visualising the process, the company can pinpoint unnecessary steps, reduce cycle times, and enhance overall productivity.

Effective resource management is crucial in multi-project environments, as discussed in the literature regarding RCPSP and RCMPSP (Bzdyra et al., 2015; Wauters et al., 2015). VSM can aid the target company in better allocating resources by providing a comprehensive overview of where resources are being utilised and where they might be over or under-allocated. This is particularly beneficial in managing concurrent projects that compete for the same resources. By visualising the flow of resources through various project phases, the company can make more informed decisions about resource distribution, thereby minimising conflicts and ensuring that critical tasks are adequately supported.

The ability to manage and adapt to change is a recurring theme in both the literature and the interview insights. VSM can support the target company in handling change requests more efficiently by providing a clear framework for assessing the impact of changes on the overall process. The structured approach of VSM allows for the mapping of potential changes and their effects on the project timeline, resources, and deliverables. This can help in maintaining process discipline, even when urgent customer requests arise, ensuring that changes are implemented in a controlled manner without disrupting the entire workflow.

The literature emphasises the importance of early supplier involvement and effective collaboration in new product development (Tuli & Shankar, 2015; Belkadi et al., 2017). VSM can facilitate better collaboration with suppliers by clearly mapping out the stages of product development and identifying points where supplier input is critical. This ensures that suppliers are integrated into the process, contributing to more cohesive and streamlined operations. By involving suppliers early and mapping out their contributions, the target company can reduce delays and enhance the quality and reliability of their products.

Important implementation steps for VSM in the target company:

- Conduct training sessions for project managers, design teams, and stakeholders.
- Begin with a pilot project to create an initial value stream map based on the current project management process from start to finish.
- Identify non-value-adding activities, bottlenecks, and inefficiencies.
- Develop action plans to eliminate waste, streamline processes, and improve resource allocation.
- Implement changes and continuously monitor the process.
- Regularly update the value stream map and expand VSM to other projects and product lines.

By integrating VSM into its project and product management processes, the target company can enhance process visibility, improve resource management, support effective change management, and foster better collaboration both internally and with suppliers. This structured approach aligns with best practices from the literature and addresses the specific challenges identified in the company's current operations, paving the way for more efficient and successful project outcomes.

5.6 Additional strategic recommendations

To address the communication challenges identified, the target company should implement a standardised communication framework that facilitates information flow across all levels of project and product teams. This approach, supported by Nyameke et al. (2020), can mitigate risks associated with misalignments and enhance collaborative efforts. By ensuring that everyone is on the same page, the company can reduce misunderstandings and foster a more cohesive working environment, which is critical for the success of both product development and project management process execution.

Adopting structured product development management practices, such as VSM, which was presented in the last chapter, and advanced scheduling techniques, can help the target company manage the simultaneous execution of product development and project activities. This strategy is endorsed by Tuli & Shankar (2015) and Yassine et al. (2017), who advocate for systematic approaches to managing complex product development tasks within projects. By using these tools, the company can optimise resource allocation, streamline processes, and ensure that both project and product timelines are met efficiently.

The target company should continue to emphasise flexibility and adaptability in its project management practices, particularly in handling customer change requests. This approach aligns with the literature's emphasis on the importance of adaptive project management in dynamic environments (Habibi et al., 2023). Being able to quickly respond to customer needs and changes in this kind of market environment will not only improve customer satisfaction but also give the company a competitive edge compared to its competitors. Flexibility in project management allows the company to change the course when necessary, ensuring that projects remain aligned with business goals and customer expectations.

To better align with customer processes, the target company should develop adaptive strategies that allow for more seamless integration with external stakeholder requirements. This approach is supported by Pacagnella et al. (2019) and Chen et al. (2022),

who highlight the importance of aligning internal processes with external demands in MPEs. By developing strategies that consider the needs and processes of external stakeholders, the company can create more cohesive and cooperative relationships, leading to better project outcomes and higher customer satisfaction.

In conclusion, the integration of project and product management within the target company presents both opportunities and challenges. The findings from the interviews align with established theoretical frameworks, highlighting the importance of communication, flexibility, and structured management practices. By implementing a standardised communication framework, adopting structured product development practices, and emphasising flexibility, the company can better manage the complexities of simultaneous project and product management.

Moreover, by aligning internal processes with external stakeholder requirements, the company can enhance its overall efficiency and effectiveness. Adopting these strategic recommendations, based on the literature, will enable the target company to improve its project and product management processes, ensuring successful project outcomes and long-term organisational success. This discussion has provided a comprehensive analysis of the interview results, contextualising them within the broader theoretical landscape and offering practical recommendations for improvement.

6. SUMMARY AND CONCLUSIONS

This final chapter of the thesis provides a comprehensive summary of the research conducted, highlighting the key findings and their implications. The study aimed to investigate the integration of new product management approaches within project management processes, with a focus on identifying challenges and opportunities. Through an in-depth analysis of semi-structured interviews, valuable insights were gained into the current practices and potential areas for improvement.

This chapter synthesises the research process, discusses the contributions to both theoretical and practical knowledge, and offers practical recommendations for enhancing project management and product development within the target company. Additionally, it reflects on the research journey, acknowledging the limitations of the study, and suggesting directions for future research to further explore and address the complexities identified. By providing a thorough analysis and set of recommendations, this chapter aims to contribute to more effective project management practices in general.

6.1 Summary of the key findings

The key findings of the study provide comprehensive answers to the research questions by identifying specific areas for optimisation, highlighting necessary modifications, and recommending best practices. With the guidance of these, target company can enhance the integration and effectiveness of the new product management approach. The research questions are presented below, followed by the key findings that contribute to each question.

Main research question:

- What specific elements of the current project management process can be optimised to better support the integration and effectiveness of the new product management approach?

Key findings addressing this question:

Importance of communication and cooperation: Emphasises the need for clear communication channels both internally and with customers. Optimising these communication mechanisms can significantly enhance the integration of product and project management. Clear communication helps optimise processes, reduce misunderstandings, and ensure that customer needs are accurately understood and met.

Resource management and scheduling: Highlights the critical need for effective resource allocation and schedule management. Optimising these elements ensures that project and product timelines are aligned, reducing resource overload, and enhancing efficiency. Effective resource allocation and schedule management are critical for meeting project requirements, especially in multi-project environments.

Sub-question 1:

- What are the key components of the company's existing project management process, and how effectively do they align with and support the goals of current product management practices?

Key findings addressing this sub-question:

Predetermined review practices: These are essential for assessing project progress and making necessary adjustments. However, inconsistent adherence indicates a need for better process discipline to ensure alignment with product management goals. Predetermined review practices serve as critical checkpoints, ensuring that all relevant topics are addressed throughout the project lifecycle.

Effective management of change requests: The ability to handle change requests efficiently is a strength, but managing these changes, especially after the design freeze stages, needs structured management to support product development effectively. Efficient change management is crucial in dynamic project environments to maintain flexibility and adaptability.

Sub-question 2:

- Which aspects of the project management process require proactive modifications to better accommodate and enhance the effectiveness of the new product management practices?

Key findings addressing this sub-question:

Structured management practices: The study indicates that a more structured approach to managing product development within projects is required. Implementing practices such as VSM can help in better planning and prioritising product development tasks. Structured practices like VSM enable the visualisation of the entire process flow, facilitating better planning and prioritisation.

Role of project managers: Project managers need to be trained to assess the impact of changes on product management and to work closely with design teams. This proactive modification will ensure that product management considerations are embedded in daily

project activities. Project managers play a pivotal role in integrating product and project management, ensuring efficient implementation of product management practices.

Adaptive strategies: Developing strategies that allow for the alignment of internal processes with external stakeholder requirements is crucial. This will better accommodate product management practices and enhance their effectiveness. Adaptive strategies help align internal processes with customer requirements, enabling more seamless integration.

Sub-question 3:

- What proven project management best practices should the company consider adopting or adapting to effectively complement and maximise the benefits of its new product management practices?

Key findings addressing this sub-question:

Adopting agile methodologies: The study recommends adopting agile methodologies to enhance flexibility and responsiveness. Agile practices support iterative development and continuous feedback, which are beneficial for product management. Agile methodologies help staying responsive to changing project conditions and customer demands.

Integration of product and project management: Implementing structured product management practices, such as VSM, and embedding product management considerations into review processes will ensure better alignment and execution. Structured integration practices facilitate better coordination and execution of both product and project management tasks.

Proven scheduling techniques: Advanced scheduling techniques and resource allocation strategies are critical for managing complex project portfolios. These should be adopted to optimise performance and better support product management. Advanced scheduling and resource allocation techniques help prioritise tasks and allocate resources efficiently.

The key findings of the study provide detailed insights into specific elements of the current project management framework that can be optimised to support the integration and effectiveness of the new product management approach. By focusing on enhancing communication, resource management, and adopting structured and agile practices, the company can better align its project and product management processes. These modifications and best practices will help the company navigate the complexities of multi-project environments, leading to improved efficiency, quality, and overall project success.

6.2 Conclusions

The integration of product and project management is essential for enhancing operational efficiency and ensuring successful project outcomes in an MPE particularly when aiming to utilise and implement the new product management approach effectively. In this chapter, a framework for product and project management integrated management is introduced. The framework illustrates the key components and benefits of integrating these two critical management processes. By adopting this integrated approach, the target company can streamline their operations, optimise resource allocation, and improve coordination between product development and project execution.

At the core of this framework is the integrated management framework, which seamlessly combines product and project management practices. Surrounding this core are essential processes that facilitate effective integration: communication mechanisms, resource planning, scheduling techniques, early stakeholder involvement, and feedback loops. The framework is presented below in Figure 12.

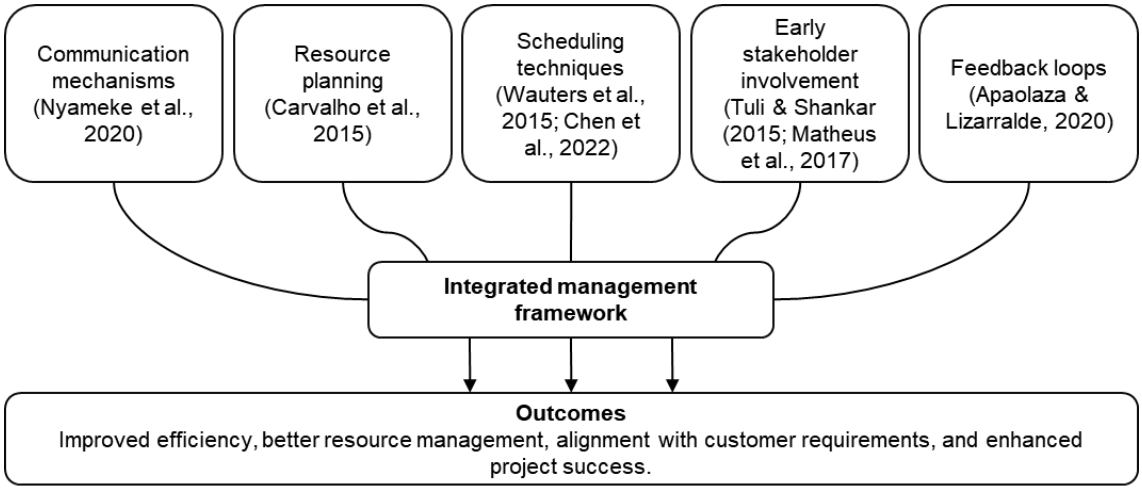

Figure 12. Integration framework for product and project management (authors own elaborations).

Robust communication systems are crucial for the effective flow of information among project teams, product management, and other stakeholders, ensuring that all parties are aligned and informed throughout the project lifecycle (Nyameke et al., 2020). Strategic resource planning aligns resources with project needs and optimises performance, ensuring efficient use of resources (Carvalho et al., 2015). Advanced scheduling techniques are critical for managing complex project portfolios, enabling the prioritisation of tasks and efficient resource allocation (Wauters et al., 2015; Chen et al., 2022). Involving stakeholders early in the product development process helps set realistic expectations and align development activities with customer requirements (Tuli & Shankar, 2015;

Matheus et al., 2017). Continuous feedback and adaptation are necessary for managing changes and maintaining project relevance in dynamic environments (Apaolaza & Lizarralde, 2020).

The outcomes of integrating product and project management through this framework include improved efficiency, better resource management, alignment with customer requirements, and enhanced project success. These benefits underscore the importance of structured management practices and strategic adjustments to navigate the complexities of MPEs effectively (Ben Issa et al., 2021; Kerzner, 2017). By adopting this integrated approach, the target company can enhance coordination, manage resources more effectively, and ensure that both product and project management considerations are aligned throughout the project lifecycle, leading to long-term growth and competitiveness in the marketplace.

As part of the project and product management integration, VSM could create diverse benefits in integration outcomes. VSM offers significant enhancements in efficiency and effectiveness, particularly in handling MPE. VSM provides a clear visual representation of processes, improving communication and understanding among stakeholders (Nyameke et al., 2020). By mapping out processes from project initiation to completion, the target company can align information between team members, identify bottlenecks, and streamline workflows.

VSM identifies non-value-adding activities and eliminates waste, optimising processes (Tuli & Shankar, 2015). This is crucial during the design and testing phases, where hurried product development activities were noted. VSM can highlight inefficiencies, reduce cycle times, and enhance overall productivity. Effective resource management is critical in MPEs. VSM aids in better resource allocation by providing a comprehensive overview of resource utilisation, helping to manage concurrent projects and minimising conflicts (Bzdyra et al., 2015; Wauters et al., 2015).

VSM supports efficient handling of change requests by providing a clear framework for assessing their impact on the overall process, maintaining process discipline even with urgent customer requests. Early supplier involvement and effective collaboration in new product development can be facilitated by VSM, ensuring cohesive and streamlined operations (Tuli & Shankar, 2015; Belkadi et al., 2017). By integrating VSM, the target company can enhance process visibility, improve resource management, support effective change management, and foster better collaboration both internally and with customers and suppliers. This approach aligns with best practices from the literature, addressing

specific challenges and paving the way for more efficient and successful project outcomes.

6.3 Significance of results

This study makes several significant contributions to the field of project and product management research, particularly within the context of multi-project environments (MPE). The study provides a comprehensive framework for integrating product and project management processes, which is particularly beneficial for manufacturing companies operating in MPEs. This framework offers a structured approach to enhance operational efficiency and project outcomes. By illustrating key components and benefits, the study lays the groundwork for future research to build upon and refine this integration model.

Through qualitative data from semi-structured interviews, the study identifies critical challenges faced by organisations in aligning product and project management. It also proposes practical solutions, such as the adoption of structured management practices and advanced scheduling techniques. These insights are valuable for both practitioners and researchers, offering a clear direction for addressing common issues in MPEs.

The study underscores the importance of clear communication and flexibility in managing projects and product development. By highlighting these elements, the research aligns with and expands upon existing literature, emphasising the need for effective communication mechanisms and adaptive strategies. This focus is particularly relevant in today's dynamic business environments, where rapid changes and customer demands necessitate agile and responsive management practices.

One of the key strengths of this study is its ability to bridge theoretical frameworks with practical applications. By critically analysing interview findings within the context of established theories, the research offers a robust analysis that enhances both academic understanding and practical implementation.

In summary, this study significantly advances the field of project and product management by providing a well-defined framework for integration, identifying key challenges and solutions, and offering practical recommendations. Its contributions to the literature on MPEs and its emphasis on communication, flexibility, and structured management practices are particularly noteworthy. The study not only enriches academic discourse but also provides valuable insights for practitioners aiming to optimise their management processes in complex environments.

6.4 Limitations, reliability, and validity of the study

While this study makes significant contributions to the field of project and product management within MPE, it is essential to acknowledge its limitations, and consider the reliability and validity of the findings. One of the primary limitations of this study is its cross-sectional design, which captures a snapshot of the integration of product and project management practices at a single point in time in a single company. This design does not account for the dynamic nature of MPEs and the evolving practices within organisations. Future research should adopt a longitudinal approach to track changes and developments over time, providing a more comprehensive understanding of the long-term effects and sustainability of the integration strategies.

Additionally, the study relies heavily on qualitative data from semi-structured interviews with key personnel within the target company. While this method provides rich, detailed insights, it also introduces potential biases, such as personal perspectives and recall bias of the researcher. Expanding the sample size and including quantitative data could enhance the generalisability and robustness of the findings.

The reliability of the study is increased by the systematic approach to data collection and analysis. Semi-structured interviews were conducted with a range of stakeholders, ensuring diverse perspectives on the integration of product and project management within the target company. The consistency of responses regarding key challenges and practices suggests a reliable depiction of the current state within the target company. However, the study's reliance on interviews may still introduce subjectivity. To mitigate this, future research could use multiple data sources and methods, such as surveys and observational studies, to confirm findings.

The validity of the study is supported by the alignment of interview findings with established theoretical frameworks and literature. By comparing the practical insights from the target company with existing research, the study demonstrates validity. The proposed solutions and recommendations are grounded in both empirical data and theoretical concepts, enhancing their applicability and credibility. The study's external validity may be limited due to the specific context of the target company. While the findings provide valuable insights for similar manufacturing companies operating in MPEs, they may not be fully generalisable to different industries or smaller companies. Future studies should consider a broader range of organisational contexts to validate the applicability of the proposed integration framework.

In conclusion, while this study offers significant contributions to the integration of product and project management in MPEs, it is essential to recognise its limitations and the need

for further research. By adopting longitudinal designs, expanding data sources, and considering diverse organisational contexts, future research can build on these findings, enhancing the reliability, validity, and generalisability of insights into effective management practices in complex environments.

6.5 Proposals for further research

Given the key findings of the study, several areas need further exploration to enhance the integration of product and project management in multi-project environments (MPEs). As this study was conducted as a cross-sectional study, future research should focus on longitudinal studies that track the impact of integrated product and project management practices over time. This approach can provide deeper insights into the long-term benefits and challenges of such integrations, helping to refine best practices and frameworks for sustained success.

Future research should examine the role of digital tools and platforms in facilitating the integration of product and project management. It is also essential to explore advanced scheduling and resource allocation techniques, particularly those leveraging artificial intelligence and machine learning. Understanding how these technologies can further optimise resource management and scheduling in MPEs will be crucial for developing more efficient and adaptive project management strategies.

Additionally, research should focus on the development of customisable project management frameworks that can be tailored to different industry needs and organisational contexts. This would involve examining how flexibility can be built into standardised frameworks to accommodate varying customer requirements and dynamic project environments. Investigating change management strategies within project management, with an emphasis on how project frameworks can adapt to and facilitate organisational changes, including the adoption of new product management approaches, is also critical.

The cultural and organisational change management aspects of integrating product and project management should be examined to understand how organisational culture impacts the adoption of integrated practices and how to effectively manage change. This can provide valuable insights for practitioners. By addressing these research areas, future studies can contribute to a more nuanced understanding of how to optimise the integration of product and project management in MPEs, ultimately leading to improved operational efficiency, project success, and competitive advantage.

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APPENDIX 1: INTERVIEW PROTOCOL

Theme 1: Current Project Management Process

Which parts of the current project management process are particularly effective?

What do you think are the reasons for these successes?

Which parts of the current project management process do you think pose challenges?

Can you describe a recent project where these challenges affected the outcome?

How does the current project management process integrate with the product development practices?

How does the project management process integrate with the product development practices?

Theme 2: New Product Management Approach

Which areas of the current product management process do you find the most challenging?

What specific problems occur in these areas?

In which areas does the new product management approach smoothly integrate into the project management process and why?

What challenges might the new product management approach face and what factors influence these potential problems?

Theme 3: Future Development Areas

What changes would you suggest to the current project management process to better support the new product management approach?

What potential obstacles might be encountered with these changes and how can these be overcome?

Which specific project management practices do you think could improve the current project management process?

Theme 4: Effects of the Operating Environment

How do the requirements and schedules of the OEM customers affect the practices of the current project management process?

How effectively does the current project management process adapt to OEM customers' change requests and last-minute requirements?

From the perspective of project execution, what do you consider to be the most significant risks associated with being a supplier to major OEM manufacturers?

How could the current project management process better meet OEM manufacturers' expectations, improving cooperation and project results?